A Dual Case Study of Adaptive Learning System (ALS) Onboarding and Integration within Classroom Interactions in Singapore

Cindy Choon Cheng ONG

Linacre College

University of Oxford

Supervised by Prof Jenni Ingram and Prof Velda Elliott

A thesis submitted for the degree of

Doctor of Philosophy in Education

Hilary 2026

Acknowledgements

I am deeply indebted to many who have supported me in the work reported in this thesis. My thanks first go to my supervisors, Jenni Ingram and Velda Elliott, who always encouraged, guided and supported me. I am grateful for their kindness and patience and am honoured for this opportunity to work with them.

I would also like to thank the teachers and students who participated in this study, as well as the school leaders and department heads who supported the project, for allowing me into their schools and classrooms. This is deeply appreciated given how busy schools were, emerging from the Covid pandemic. Without their support, this research would not have been possible.

I am also indebted to my friends and colleagues in both Oxford and Singapore, particularly the DPhil cohort of 2021 and my colleagues from the Educational Technology Division, for their encouragement and support. In many cases, the conversations with them offered insights into the development of this work. I am thankful for their gift of time, attention and affection without asking for returns.

I wish to also extend my thanks to my immediate and extended family, particularly my siblings and their spouses for their immeasurable support. My DPhil journey was marked by two major surgeries that my parents had undergone, and I would not have completed this thesis without the rest of my family (including my cousins) rallying around me. Thank you.

Last and perhaps the most important, I thank the Almighty God who led me to start on my DPhil and who has given me the desire and strength to complete this work.

Abstract

This thesis reports research on the use of an adaptive learning system (ALS) alongside classroom instruction to support development of reading skills in two Singapore classrooms, focused on onboarding and integration of such systems and the extent to which teacher-student interactions are influenced by their use. It builds upon previous research on ALS which tended to focus on system design by pivoting to examine how such systems can be situated within existing classroom practices.

Adopting a case study approach, the research seeks to surface benefits, challenges and complexities surrounding ALS use with classroom learning through the lens of activity theory. As such, lesson video data was selected as the main source of data. Interviews of teachers and students were also analysed for their views on the selected ALS, their onboarding experience, as well as teaching and learning during the ALS integration phase. Student usage data from the ALS was also used for triangulating students' ALS use and their views.

Based on students' ALS use and articulations of their perception of ALS and their ALS onboarding experience, it can be said that students' low usage and vague articulations of the tool were both indications that they were not quite onboarded. Further unpacking of students' perceptions using activity theory also surfaced *contradictions* between what students recalled and represented and those by their teachers of the ALS. Collectively, the findings suggest a need to reconceptualise the EdTech onboarding process for both students and teachers.

ALS integration phase findings centred on the types of academic activities observed, as well as frequently and rarely observed communicative acts. Interviews with teachers also surfaced challenges faced when attempting to integrate ALS with classroom learning, such as the need to balance between student agency and teacher control. Collectively, they revealed surface integration of ALS with classroom learning and that ALS use had little effect on teacher-student academic interactions.

Keywords: Adaptive Learning Systems, EdTech Onboarding, EdTech Integration, Classroom Interactions, Teacher-Student Interactions

Table of Contents

List of Appendices

List of Figures

List of Tables

1

Introduction

Chapter One starts by outlining the motivation for this research on an adaptive learning system (ALS) and classroom interactions, which is informed by developments in Artificial Intelligence (AI) for education, shifts in education such as the burgeoning interest in personalised learning using ALS, and the urgency for a better understanding of ALS-mediated personalised learning in classroom settings. This is followed by an overview of the Singapore education system, which serves as the context for this research, highlighting key moments in its EdTech and AIEd journey to date, as well as its unique language situation and approach to English language learning. Finally, this chapter closes with the envisaged contribution that this research makes as well as a brief description of each chapter.

1.1 Motivation

An announcement by the Singapore government in Nov 2019, to personalise learning through adaptive learning and assessment as part of its National AI Strategy caught my attention and made me curious about the basis of such an initiative. Given that Singapore was among the first countries to make such a bold step and in the absence of conclusive research evidence then, I had my reservations as to whether ALS can indeed bring about transformative learning. As Lead Specialist at the Ministry of Education then, I wondered about the wisdom of such nationwide deployment and was also curious what knowledge we could start to build, as we anticipate the eventual deployment of such technologies in schools. Rather than to wait for another to address these questions, I conceptualised this research, with a view to informing the implementation of ALS at scale in Singapore while creating knowledge on ALS use and integration in school and classroom settings.

These personal motivations led me to scan existing knowledge bases, whether it be academic literature or grey literature, and what I learnt further, particularly the real-world developments then, strengthened my resolve to embark on this research. Firstly, the range of AI capabilities that can potentially be applied to teaching and learning purposes is rapidly expanding, arising from rapid developments in these technologies. Secondly, social developments including increasing student diversity in classrooms and proliferation of EdTech tools, have also contributed to a shift toward personalised learning, which brings new opportunities and challenges for teaching and learning. Thirdly, growing deployment of ALS in schools and classrooms has also given rise to an urgent need to understand how the tool interacts with the various aspects of the classroom and the existing norms and practices within. These three motivators will be further elaborated in the following sections.

1.1.1 Developments in Artificial Intelligence for Education (AIEd)

Advancements in AI coupled with ubiquitous use and ownership of mobile computing devices have changed how humans live and work, as we transit from an industrial economy and society to a digital economy and society (Rzevski, 2023). The launch of ChatGPT in November 2022 not only brought global attention to Generative AI, but it also resulted in a renewed awareness of the extent to which AI (including Generative AI) was already integrated into many of the applications that we use in our daily lives. They included applications for web searching, scheduling, note-taking, transcribing, coding, and web design (Moore, 2024; Rebelo, 2024).

Education, likewise, is affected by these technological, economic and social developments, where a growing interest in AI in education has been observed. According to techreport.com, the AI in education (AIEd) market, which was worth $2.5 billion in 2022, is poised to reach $88.2 billion by 2032, at a compound annual growth rate (CAGR) of 43.4% (Sukhanova, 2024). In particular, the market for AI in personalised learning is forecasted to grow from $5.2 billion in 2022 to $48.7 billion by 2030, at a CAGR of 44.3%. These figures signal a huge and booming market for AI in education and more specifically in the use of AI in personalised learning, which makes it crucial that research in AIEd keep pace with the technological developments arising from the financial investments to build such technologies.

Furthermore, big tech companies have been actively shaping public and policy discourse around AI in education through a combination of product narratives, high-visibility partnerships, and targeted research funding that together privilege specific visions of what schooling should be and who should govern it. Corporate narratives often emphasise efficiency, scalability and 'personalisation' while framing technological solutions as neutral and inevitable, a rhetoric amplified when firms secure procurement deals, curricular integrations, or promotional pilots with school districts and ministries; these moves not only normalise platform logics in classrooms but also foreground metrics and uses that align with corporate interests (Selwyn et al., 2019; Williamson, 2018).

Industry funding of research, sponsorship of conferences, and close collaboration with university labs can accelerate innovation but also risk shaping research questions, methods and dissemination in ways that obscure conflicts of interest or de-emphasise equity, labour and pedagogical critique (Reich, 2020). The rapid marketisation of pandemic-era procurement further demonstrated how commercial priorities can outpace rigorous, independent evaluation, producing widespread adoption without commensurate evidence of long-term educational benefit (Selwyn et al., 2019).

Critical scholarship argues that this ecosystem cultivates an epistemic authority for corporate actors—via data infrastructures, proprietary algorithms and standardised metrics—that reconfigures professional judgement and public accountability in schooling (Holmes et al., 2019a; Williamson, 2018). For these reasons, there is an urgent need for neutral, independently funded research: studies free from commercial sponsorship that can ask different questions (about harms, equity, curricular coherence and teacher professionalism), apply rigorous evaluative designs, and make findings and data open for public scrutiny.

1.1.2 Shift in Education Toward Personalised Learning

Concurrent and related to the AIEd developments mentioned above is the shift toward personalised learning. Two key reasons can be said to have contributed to this shift. Firstly, rapid advancements in AI capabilities and the expanding interest in deploying AI for teaching and learning purposes have contributed to the mounting interest in personalised learning, which stands as a possible expression of learner-centred approaches to teaching and learning. Contemporary pedagogical frameworks such as Universal Design for Learning (UDL) and digital capabilities such as ALS increasingly support the design of learning environments that are responsive, engaging and capable of addressing learners' diverse needs, trajectories and learning contexts (Aleven et al., 2017; Fovet, 2021).

Secondly, the Covid-19 pandemic has also resulted in greater awareness that the world today is BANI, which stands for Brittle, Anxious, Non-linear, and Incomprehensible, where systems can collapse suddenly (i.e., brittle) and cause widespread anxiety, with information being disjointed (i.e., non-linear) and hard to grasp (i.e., incomprehensible) (Kruse, 2025). Alongside this is the growing diversity observed in classrooms around the world, where students are coming to schools from a wider range of backgrounds and experiences, with very diverse needs, interests, competencies and readiness to learn. This meant that the one-size-fits-all approach to education is no longer adequate and there is a greater need for personalised learning at scale.

While there is a clear rationale for personalised learning, enacting personalised learning with existing education structures such as schools and classrooms remains challenging. Firstly, personalised learning approaches often reshape formative assessment practices and classroom discourse, making careful investigation of how feedback, pacing and data dashboards influence student motivation, metacognition and long-term transfer vital (Black & Wiliam, 2009; Pardo et al., 2019). Secondly, technical limitations in learner modelling and algorithmic transparency further complicate claims about efficacy, where overly simplified representations of cognition may omit affective or cultural dimensions of learning, producing uneven benefits and potential blind spots for marginalised students (Pelánek, 2025; Selwyn et al., 2019).

The two reasons cited above thus both point toward a pressing need to observe personalised learning with ALS in situ and to clarify if and how use of adaptive learning systems (ALS) as part of formal learning may affect students' interactions with their teachers and classroom learning experiences.

1.1.3 Need to Contextualise ALS Deployment in Classrooms

Classrooms are dynamic environments that offer students opportunities to learn and are often guided by norms and values that could be implicit or explicit. They are part of the larger learning ecosystem, which has elements such as people (e.g., educators and researchers), places (e.g., classrooms, libraries and museums), activities (e.g., camps and internships), and artefacts (e.g., learning management systems, apps and books), that are dynamically interacting with each other (National Research Council, 2015) and influencing learning. These different layers of interactions create an intricate network of relations that serve to highlight the complexities involved in learning (Hecht & Crowley, 2020).

Viewed in this light, it becomes evident that the introduction of ALS does more than add a new technological tool to the classroom; it is likely to create a ripple effect, resulting in changes to existing interactions among the different elements in the classroom and potentially bring some form of disruption to existing norms and practices in the classroom. As such, to understand how the introduction of ALS can affect classroom learning, it is thus vital to consider such systems and their use vis-à-vis the other elements in the classroom environment and how these different elements (including the ALS) interact with each other during the learning process.

A key premise for the above-described view is that teaching and learning are "highly social activities" (Kim & Baylor, 2006, p. 574), where learning is taken to involve "a continuous reciprocal interaction between behavior and its controlling conditions" (Bandura, 1971, p. 39). Lave and Wenger (1991, p.93), in their theorisation of legitimate peripheral participation, also argued that "engaging in practice... may well be a condition for the effectiveness of learning." Collectively, these theories of learning allude to the "complex interrelations between the individual subject, i.e., the learner, and his or her community" (Engeström, 2001, p. 134), which suggests an imperative to explore and understand use of ALS in complex classroom environments, seeking to understand how effective use of ALS could look like in these settings.

1.2 Context

This research was conducted in Singapore, which was selected as the research site for various reasons. Firstly, since Singapore embarked on its EdTech journey in 1997, the jurisdiction has made advancements on many fronts including EdTech innovation and EdTech integration, making it a prime site for studying ALS in classroom enactment. Secondly, Singapore's language environment and its ensuing implications on English language education also makes it an interesting context for this research, particularly with reference to the latest 2020 English language syllabus by the Ministry of Education. These contextual considerations are further elaborated below.

1.2.1 Singapore Primed for Studying Use of ALS

Singapore is a high-performing education system (Deng & Gopinathan, 2016) that outperformed every other participating nation at the 2022 Programme for International Student Assessment (PISA) in all three subjects, Reading, Mathematics and Science (OECD, 2023). A forerunner in educational technology implementation, it is one of the first few education systems to introduce a national Artificial Intelligence in Education initiative, as part of the country's national AI strategy (Tang, 2019, p. 304). Since then, the Ministry of Education in Singapore has launched a short-answer feedback assistant that suggests grades and auto-generates feedback for open-ended, short-answer questions and essays to support English language learning, and an ALS for three primary Mathematics topics (Ministry of Education, 2023).

In 2020, the country announced a National Digital Literacy Programme (NDLP), which has helped every secondary student in Singapore to own a personal learning device (PLD) by the end of 2021 (Ministry of Education, 2020). Its EdTech Masterplan 2030, which seeks to enhance digital literacy and technological skills, leverages new technologies for learning and strengthens the culture of collaboration, was launched in 2023 and implemented from 2024 onwards (Ministry of Education, 2023). These announcements and initiatives place educational technology firmly as a key enabler for learning in Singapore, a view that appeared to have gained some traction with educators on the ground. It has been reported that close to half (45) of the 126 ICT-related innovation projects completed between 2010 and 2019 were led by teachers (Seow et al., 2020), pointing to the presence of ground-up innovations among teachers to leverage technological affordances for improving student learning.

The Singapore education system stands at the threshold of change as the country ushers in a new era of learning that leverages PLDs and AI-enabled learning tools such ALS. These policy shifts with ensuing implications for classroom learning have brought both new challenges as well as new possibilities, making Singapore an interesting site for this research. Furthermore, the 1:1 classroom learning environment, established culture of ground-up innovation in schools, and the national focus on AI in education suggest some propensity toward the use of ALS in Singapore schools. This would in turn enable an authentic investigation into the use of such systems in 'naturalistic' classroom settings.

1.2.2 Singapore's Intriguing Linguistic Environment and Its Ensuing Implications for Language Learning

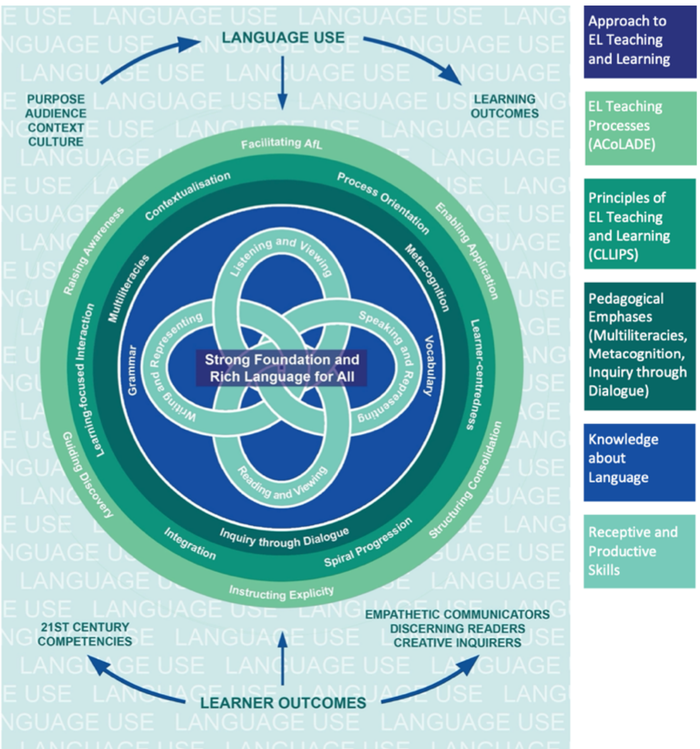
According to the 2020 Population Census, English is the most-frequently-spoken home language for 48.3% of Singaporeans aged 5 and above, suggesting that English is not the native language for at least half the population. This corroborates with the view in many parts of the world that Singapore is a non-native English-speaking country, despite its population obtaining a high proficiency in the language. However, English became the medium for instruction in all Singapore schools in 1987, where children enrolled in Singapore schools are expected to learn English as their first language and their official mother tongue e.g., Mandarin, Malay, or Tamil will be learnt as a second language. This thus creates an intriguing language situation where Singapore language learners are considered as L1 learners locally but globally, classified as L2 learners.

A local evidence synthesis of English language (EL) education between 2010 and 2020 found that Singapore teachers tend to emphasise task completion and linguistic accuracy over development of higher order thinking (Jones, 2021). This alludes to the tension faced by EL teachers in Singapore, between helping students obtain a passing grade for the subject, a requirement for progressing to the next academic level, and developing critical literacies, what teachers believe to be the "real work of English teaching" (Loh & Liew, 2016, p. 276). However, it is encouraging to note that a recent case study on the inclusion of student voice in teaching and learning reported both teachers and students recognising the importance of student voice for pedagogical, normative, and relational reasons (Fernandez et al., 2022). That said, the same study also surfaced challenges impeding such inclusion, citing reasons such as students' fear of rejection and teacher perceptions of student immaturity.

1.2.3 A Pivotal Moment in EL Education in Singapore

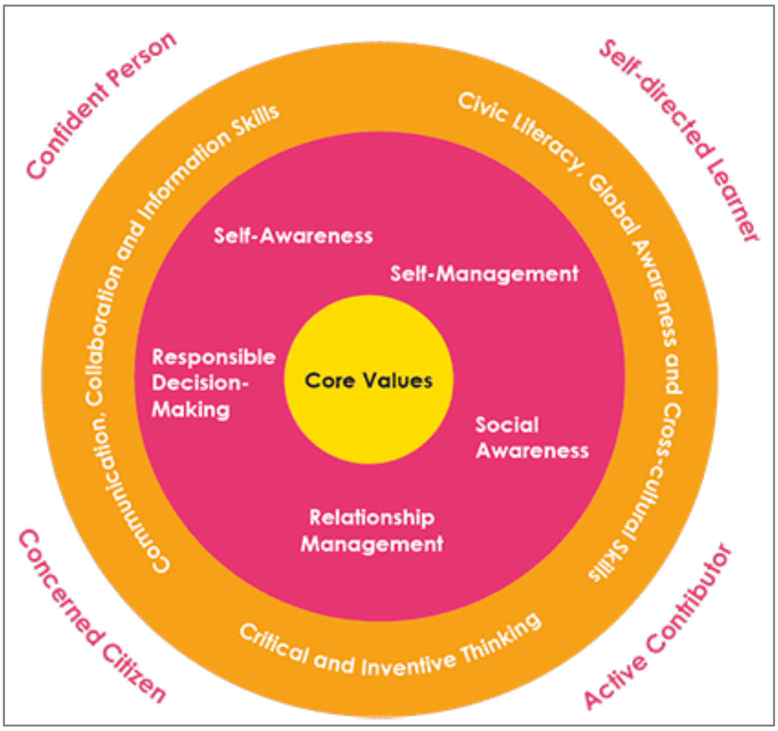
Mindful of the existing tensions in EL education in Singapore and the need to respond to the evolving language landscape, the 2020 EL Syllabus (Secondary) (Figure 1-1) made two locally unprecedented changes. Firstly, the syllabus articulated explicitly the desired learner outcomes, namely empathetic communicators, discerning readers, and creative inquirers, which embody an expanded view of literacy that incorporates multiliteracies. This sends a clear signal that linguistic accuracy is not the primary goal of EL education. However, it is unclear how teachers will respond to such articulation, e.g., whether how teachers design and enact EL lessons will change, particularly if formal assessment remains unchanged.

Figure 1-1 *Summary Features of EL Syllabus 2020* (Curriculum Planning and Development Division, 2020)



Secondly, this revised syllabus also establishes EL classrooms as sites for developing 21st century competencies (Figure 1-2), a list of competencies that are deemed essential for future-ready school leavers (Ministry of Education, 2021). This means that EL teachers are to create opportunities for students to develop the core values identified in the Framework for 21st Century Competencies (Figure 1-2). Coupled with the pedagogical emphasis on multiliteracies, metacognition and inquiry through dialogue, this syllabus appears to place new demands on teachers in terms of lesson design and enactment. It should also be mentioned that the launch of this revised syllabus coincided with the implementation of a PLD for every Secondary student in Singapore schools, which suggests that English language education in Singapore is on the cusp of a new phase, embracing e-pedagogies and multiliteracies.

Figure 1-2 Framework for 21st Century Competencies and Student Outcomes (Ministry of Education, 2021)



In summary, the Singapore education system stands at the threshold of change as the country ushers in a new era of learning that leverages PLDs and AI-enabled learning tools such as the ALS. Its curriculum outcomes for the English language have also evolved over the years to embrace a broader set of competencies beyond reading and writing skills. These policy shifts with ensuing implications for classroom learning has brought both new challenges as well as new possibilities, making Singapore an ideal case study for examining how ALS-mediated learning changes teacher-student interactions in EL classrooms.

1.3 Contribution

This research aspires to make two contributions to the sub-field of ALS and classroom learning through qualitative inquiry into the use of such systems in Singapore schools. Firstly, it seeks to introduce a new dimension, namely technology onboarding (see Section 2.4 for a working definition), to be considered when planning integration of new technological tools. While this concept is not new, commonly used in human resource sectors and by tech developers, it rarely features in EdTech discourse. As such, by examining teachers' efforts at ALS onboarding and students' response to the ALS and ALS onboarding experience, this thesis makes an argument for designing onboarding experiences that will help students incorporate the new technological tool into their learning routines and habits.

Secondly, this research seeks to characterise specific instances of ALS use in classroom settings by describing teachers' efforts at integrating the use of such a system with the delivery of an instructional unit and documenting students' use of the system and the ensuing teacher-student interactions during classroom learning. The thesis seeks to argue that an understanding of ALS use to augment classroom learning is necessary before one can measure the impact of ALS on student learning outcomes. Leveraging the activity theory, this research considers elements, and relations that were already present prior to the introduction of ALS, and explores how ALS use could influence and be influenced by these existing elements and relations in the classroom, enabling a balanced consideration of individual agency and influence of social cultural factors (see Section 3.5 for an explication of how activity theory is applied in this research).

The ambition of this research thus is to enrich current discourse on ALS by focusing on how these tools are experienced by teachers and students. Findings and recommendations arising from this research will not only add to current understanding on the relationship between ALS onboarding and integration and classroom learning experience but also invite real-world application in the design of ALS onboarding and integration as well as teacher professional learning to equip teachers with the needed technological and pedagogical knowledge to use ALS as part of their instructional practice.

1.4 Thesis Organisation

The final thesis is organised into seven chapters and the brief contents of each chapter are described below.

Chapter One opened with the motivation for this research on ALS and classroom interactions, namely real-world developments in EdTech and AIEd, a shift in education toward personalised learning and the urgent need to contextualise ALS deployment in classrooms. The chapter then situated the proposed research within the local context of schools and classrooms with a brief overview of the Singapore education system, by tracing key developments in EdTech and AIEd in the country, alongside a discussion of the jurisdiction's distinctive language environment and its approach to English language learning. Finally, the chapter concluded by articulating the envisaged contributions of this research and providing a brief outline of the structure and focus of each subsequent chapter.

Chapter Two reviews relevant literature on AI capabilities for teaching and learning before honing in on research evidence pertinent to ALS, highlighting key affordances of such tools as well as their risks and benefits for teaching and learning. In particular, a distinction will be made between individualised learning and personalised learning. This chapter also includes a discussion of current research on ALS onboarding and ALS integration, explicating factors influencing their effectiveness, how these two constructs relate to each other and their implications for student learning, particularly for teacher-student interactions. The chapter then examines pertinent literature on teacher-student interactions and their significance to academic learning, focused on the role of the teacher in orchestrating productive teacher-student interactions as well as the potential for technology in general and specifically ALS to influence teacher-student interactions and their implications for classroom learning. Finally, I will wrap up this chapter with a brief discussion of the various approaches to examining teacher-student interactions.

Chapter Three outlines the research design and the methodological approach employed for this research, together with the rationale behind key design decisions and how challenges were mitigated. It opens with an explanation of the case study methodology and the research questions guiding the inquiry, before detailing the two cases that constitute the focus of this study. A description of pre-research engagement was also provided to illuminate the local environment that constitute the research site for the two cases. The chapter then describes the procedures for data generation and data analysis in depth, including how activity theory will be applied in this research and the types of data that was collected and analysed. Finally, it concludes with reflections on ethical considerations, including efforts to ensure quality and trustworthiness of this research and its findings, and researcher positionality to further contextualise the research process and findings.

Chapter Four presents findings pertaining to ALS onboarding, starting with a description of the teachers' efforts to onboard students to the selected ALS, primarily through the onboarding lesson, followed by further analysis of these efforts through the lens of activity theory. Next, the chapter reports findings on students' response to these onboarding efforts, focusing on their perceptions of the onboarding experience. In addition to explicating how students recalled and represented this experience, a general reluctance among the interviewees to comment in detail was noted, accompanied by possible explanations for this reticence. Further analysis using activity theory revealed contradictions between students' recollections and their teachers' accounts of the onboarding process. The chapter then examined students' duration and frequency of ALS use during the onboarding phase, alongside their initial perceptions of the tool as expressed during their first interview. Overall, students' limited use of the tool and their generally vague articulations indicate that onboarding was only partially successful, which suggested that a poor foundation for ALS integration.

Chapter Five presents findings pertaining to ALS integration, focused on the classroom learning experience and the teachers' efforts to integrate ALS use with the selected lesson unit for this research. The chapter starts with an explication of the types of academic activities observed, as a means of sense-making the activities present in the classroom during this phase of the research, and as the context for interpreting the observed classroom interactions.

This is followed by findings on teacher-student academic interactions observed during lessons, highlighting some frequently and rarely observed interactions between the teacher and the students. This in turn offers a snapshot of the classroom learning experience, upon which interpretations can be made as to the extent that the ALS might have impacted classroom interactions. Where evidence permits, connections between student's use of ALS use and the observed interactions were made to distil implications for ALS integration, particularly aspects that could be further strengthened.

Chapter Six discusses key findings on ALS onboarding and ALS integration, starting with how teachers integrated ALS with classroom learning, with reference to key factors influencing EdTech integration. This is followed by an evaluation of the extent to which the selected ALS was effectively integrated and the implications on classroom interactions. Next, the chapter examines the observed classroom interactions vis-à-vis ALS integration, seeking to explain possible relationship between teacher-student academic interactions and ALS use, which alluded to the need for onboarding. The chapter then turned to focus on how the teachers from the two cases onboarded their students, which was contrasted with how their students responded to both the onboarding experience and the ALS. To wrap up the discussion, two proposals were put forth, namely a reconceptualization of ALS onboarding and ALS integration as a mutually reinforcing loop, and the unification the teaching and learning activity systems in the classroom to strengthen common ground between teachers and their students.

Chapter Seven concludes the thesis with a discussion of the implications for both the design of ALS and design of classroom learning experiences where ALS is used. It posits possible roles teachers can play in the process of learning with ALS and the help students may need to optimise their use of ALS. It will also briefly explore how ALS can be designed to encourage teacher-student interactions and expand these interactions from the physical classroom space to the digital space in ALS. Finally, limitations of this research will be acknowledged and areas for future research will also be suggested.

2

Literature Review

Chapter Two begins with a brief overview of AI capabilities that have been used for teaching and learning purposes, highlighting risks and benefits of such applications to both teachers and students, to provide the broad context before zooming into current discussions on ALS and its use for teaching and learning. This is followed by a discussion of current research on ALS integration and ALS onboarding, unpacking what they entail and highlighting factors influencing the effectiveness of these processes as well their relationship with classroom interactions. Finally, I will present an overview of pertinent literature on such interactions and their implications for student learning and student achievement as well as how ALS can disrupt teacher-student interaction patterns before wrapping up with a brief discussion on the various approaches to examining teacher-student interactions.

2.1 AI Capabilities Applied to Teaching and Learning

The widespread interest in AI has resulted in various taxonomies outlining AI capabilities and their applications across various sectors (e.g., AlAfnan, 2024; European Commission, 2020; Theofanos et al., 2024). In the field of education, AI capabilities applied to teaching and learning purposes typically take the form of adaptive learning systems, AI assessment tools and AI conversational tools (see Yue et al. (2022) for a comprehensive review of AI use in K-12 education). Adaptive learning systems (ALS) are systems that make customised learning recommendations for each learner user based on backend models such as the learner model and curriculum model. AI assessment tools are automated grading tools that assess students' submissions based on preset learning outcomes and provide immediate, targeted feedback. AI conversational tools are automated systems that simulate human conversation to answer user queries and/or respond to user instructions.

While ALS, AI assessment tools and AI conversational tools are listed as three distinct AI capabilities, it is possible for them to co-exist in the same tool. For example, ALS often incorporate some form of an AI assessment tool, e.g., for diagnosing students' learning progress, and/or AI conversational tool e.g., chatbots for self-help. Application of these AI capabilities to teaching and learning has been found to be associated with various categories of learning processes, such as motivation, attention and metacognition, bringing about both beneficial and detrimental consequences (Alhaif et al., 2025).

On the one hand, customised learning pathways in ALS, well-designed automated feedback by AI assessment tools, and immediate clarification and targeted assistance from AI conversational tools have been found to keep students in learning flow and encourage self-directed learning (Huang et al., 2023; Kasneci et al., 2023; Owan, Etta, et al., 2023). On the other hand, personalised recommendations that promote repeated practice, overly frequent notifications and excessive feedback, and continuous dependence on AI conversational tools for immediate responses can result in over-reliance on AI, leading to cognitive offloading and superficial learning, with longer term learner implications (Crompton et al., 2022; Oakley et al., 2025; Zhai et al., 2024).

Key among known detrimental consequences arising from AI use for teaching and learning is cognitive offloading, which has traditionally been defined as "the use of a physical action to alter the information processing requirements of a task so as to reduce cognitive demand" (Risko & Gilbert, 2016). In the context of AI use for teaching and learning, this occurs when students delegate cognitive tasks such as information processing and decision-making to external aids such as ALS and AI chatbots, and this is a concern as it can mean missing opportunities to develop key cognitive skills such as critical thinking and reflective thinking (Gerlich, 2025). When integrating AI capabilities such as ALS (the focus of this research) with teaching and learning, this is a risk that teachers would need to mitigate.

Cognitive offloading can also affect teachers, potentially leading to professional deskilling as they delegate cognitive tasks such as assessing students' work to AI assessment tools, resulting in missed opportunities to develop their professional competencies (Hughes, 2021; Luke, 2025). Other known detrimental consequences of AI use for teaching and learning include algorithmic bias privileging 'standard' responses, data privacy concerns and datafication of children as well as assessment validity and measurement issues (Baker & Hawn, 2022; Dieterle et al., 2024; Smith & de Villiers-Botha, 2023). These are issues that can be addressed at various levels; while these risks can also be addressed during instructional design and enactment, they are more likely to be dealt with during tool design and via legislation and/or policy regulation.

The flip side, i.e., the pros of AI use, would be AI-enabled automation of certain key teaching and learning tasks, resulting in greater efficiency and improved teaching and learning outcomes. For example, automated feedback has been found to have a medium effect on students' writing performance though this impact varies across students (Fleckenstein et al., 2023). This meta-analysis also reported that for language learning, automated feedback was found to have a large effect for L2 but medium for L1, similar to findings reported by Zhai and Ma (2023). These findings corroborate with earlier research reporting that specific and detailed feedback related to the learning task can reduce cognitive load and result in a positive effect on learner performance (Hattie & Timperley, 2007; Wisniewski et al., 2020).

This automation brought by AI can also support teachers in routine tasks such as drafting lesson plans that adhere to educational standards and benchmarks, generating lesson content and media resources, and first-cut grading of students' work, enabling teachers to focus on activities that cannot be carried out by AI, such as cultivating positive teacher-student relationships (Belloula, 2025; Tan et al., 2025). Other known benefits of AI use for teaching and learning include enhancing data analytics to leverage data-driven insights for early-warning and targeted intervention and enabling greater accessibility and inclusion through AI assistive tools such as speech-to-text, text-to-speech and image description interfaces (Holstein & Aleven, 2022; Voultsiou & Moussiades, 2025; Wu & Weiland, 2024).

Given that AI use for teaching and learning can result in both positive or negative outcomes, it is thus important to explore factors such as teacher support and students' self-regulated learning and digital literacy attainment that could influence the extent to which the use of various AI tools for teaching and learning is beneficial (Chiu et al., 2024). As such, following this broad level overview of the AI capabilities applied to teaching and learning for contextualisation, I will now turn to ALS, the topic of this research, and present our current state of understanding and knowledge gap in the use of such systems for teaching and learning.

2.2 Adaptive Learning Systems

Adaptive learning systems, as defined in Section 2.1, are systems that make customised learning recommendations for each learner user based on backend models such as the learner model and curriculum model. These systems promise to meet the distinct learning needs of every learner, "with the right experience at the right time" (Pearson & EdSurge, 2016, p. 8), delivering personalised learning at scale (Moskal et al., 2017). They also claim to put students at the centre of both learning design and the learning process (Brusilovsky, 2001); and are able to 'understand' where students are and 'do' what it takes for these students to progress to where they need to be, with assessment being a vital part of the learning process (Dziuban et al., 2017, p. 26).

Commonly cited advantages of ALS include system affordances to dynamically adjust the path and pace of learning in real-time based on students' needs and preferences (Premlatha et al., 2016; Weber, 2012), provide students who fall behind with multiple options to get back on track (Huang & Shiu, 2012; Kelly, 2008; Van Seters et al., 2012), and offer timely feedback as students make progress at their own pace to achieve competency (Dziuban et al., 2016; Matthews et al., 2019). Features of such systems identified as likely to bring about learning gains included error-sensitive feedback, mastery learning, adaptive spacing and repetition for drill-and-practice items, fading of worked examples for problem solving situations, or fading of demonstrations for behavioural tasks, and metacognitive prompting, both domain relevant and domain independent (Durlach & Ray, 2011).

While the jury is still out on the effectiveness of ALS, some research studies have shown that adaptive learning systems do live up to expectations, reporting significant learning gains for students who used such systems (e.g., Essa, 2016; Sari et al., 2024). These benefits, alongside potential detriments of ALS use for teaching and learning will now be discussed in the following section.

2.2.1 Benefits and Detriments of ALS for Teaching and Learning

A key benefit of ALS would be fine-grained individualisation at scale, which refers to the tailoring of instructional content, pacing and feedback to individual learners while meeting the learning needs of large and diverse student populations. Research has shown that adjusting to learner needs and competencies acknowledges students' diverse knowledge backgrounds and varied learning experiences (Donevska-Todorova et al., 2022; Finkelstein et al., 2013), and can potentially improve student engagement (Yaseen et al., 2025). Ahmed and Abdullah (2025, p. 1057) also found that ALS use "had a significant effect on the prediction of academic persistence" and attributed this to "learning assistance provide on a personalized level." Such individualisation is typically realised through ALS features such as dynamic task recommendations, immediate diagnostic feedback and individualised learning pace.

First, individualised learning pace in ALS is typically achieved through learner modelling, where students' knowledge states and misconceptions are inferred from their interactions with the recommended tasks. Based on these inferences, the ALS then taps the domain model[1] to provide learning tasks, hints and feedback that would be aligned with the learner's current level of understanding (Koedinger et al., 2005). Meta-analytic evidence suggests that such systems can approximate the effectiveness of human tutoring, underscoring the potential of ALS to scale individualized support beyond what teachers alone can feasibly provide during classroom learning. However, these positive effects are dependent on factors

[1] Domain modelling entails mapping of learning tasks to preset knowledge components and identify pre-requisites for each of these knowledge components (Pelánek, 2025).

such as alignment with curriculum and implementation fidelity and quality, all of which are related to ALS integration (Kulik & Fletcher, 2016; Leite et al., 2025).

Second, dynamic task recommendations by ALS, which refer to continual adjustment of task difficulty and feedback based on learner performance, enable sustained engagement with learning tasks and scaffolds that are within the learner's zone of proximal development, offering these learners optimally challenging learning experiences (Aleven et al., 2017; H. Liu et al., 2024). Unlike differentiated instructional strategies commonly applied to classroom learning, ALS can update instructional decisions in response to moment-to-moment evidence, thereby supporting fine-grained individualisation that would be difficult to maintain at scale solely through human effort.

Third, immediate diagnostic feedback, which is aligned with evidence that formative assessment and feedback are powerful drivers of learning (Hattie & Timperley, 2007), not only is beneficial in addressing specific errors or misconceptions, but also contributes to keeping students in learning flow, encouraging self-regulation and potentially persistence in learning (Aleven et al., 2016; VanLehn, 2011). VanLehn (2011) emphasises that the effectiveness of ALS is closely linked to their capacity to provide timely, context-sensitive feedback that addresses specific errors or misconceptions. Such feedback supports mastery learning approaches, allowing students to progress at their own pace while maintaining common learning goals.

In summary, current research evidence supports the claim that ALS can deliver fine-grained individualisation at scale through individualised learning pace, dynamic task recommendations, and immediate diagnostic feedback. While these systems do not fully replicate the breadth and effect of human tutoring, evidence from AIEd and learning sciences research suggests that they can meaningfully extend individualised instruction in K–12 contexts when thoughtfully designed and pedagogically integrated.

However, the use and integration of ALS is not without risks. One risk arising from the fine-grained individualisation described above is algorithmic bias, defined as systematic and unfair differences in model behaviour, predictions, or instructional recommendations across learner groups, often reflecting historical, social, or institutional inequities embedded in data and design decisions (Baker & Hawn, 2022). This in turn can give rise to unequal and unfair recommendations, to the detriment of student learning and learner development. Algorithmic bias in ALS primarily stemmed from three inter-related sources, namely data bias, modelling assumptions and contextual misalignment. Known algorithmic bias impacting educational algorithms include student ethnicity, nationality, gender, native language, urbanicity, parent educational background and socioeconomic status (Mehrabi et al., 2022; Santelices & Wilson, 2010).

First, data bias occurs because the data used to train adaptive learning systems are often incomplete and not representative. These datasets often encode prior inequities in access to high-quality instruction, assessment practices and learning opportunities. When adaptive models are trained on such data, they may learn the extant correlations between demographic proxies and performance, leading to differential accuracy or misclassification for marginalized learners (Gardner et al., 2019). Furthermore, Baker and Hawn (2022) have also shown that predictive models used in educational software can systematically underpredict future performance for certain student populations, which in turn may constrain the difficulty level, pacing, or feedback provided by adaptive systems.

Second, modelling assumptions which are embedded in ALS can exacerbate algorithmic bias when short-term performance metrics such as student response speed or accuracy are prioritised instead of the instead of long-term growth or deep learning, the latter being outcomes that are difficult to measure, both in classroom learning and via ALS (Pelánek, 2025). This is a concern as learning sciences research cautions against prioritising short-term student engagement which may lead to a devaluation of productive struggle, exploratory learning, or culturally diverse problem-solving strategies, all of which support deep learning and long-term growth, and potentially misclassify them as learning distractions or failures (Aleven et al., 2017; Kapur, 2025).

Third, contextual misalignment, a mismatch between design assumptions and real-world instructional environments, occurs as ALS are typically developed and validated in controlled research settings (e.g., Pelánek, 2025) yet they are increasingly deployed across heterogeneous K-12 contexts with varying curriculum, pedagogy, cultural norms and material resources. From a child development perspective, contextual misalignment is especially problematic because learning processes are influenced by social interaction, language, and developmental variability, which are difficult to capture in decontextualized data traces (Rogoff, 2003). Without teacher mediation, ALS that neglect these contextual dimensions risk over-attributing learning difficulties to individual deficits rather than to instructional or environmental factors (Holstein & Aleven, 2022; Moltudal et al., 2022).

In summary, while research evidence suggests that ALS holds promise, algorithmic bias if unaddressed risks reproducing or amplifying educational inequities, giving rise to detrimental student learning and development consequences. That said, this can be mitigated through further research into design and features of adaptive learning systems for next generation learning (e.g., Ennouamani & Mahani, 2017; Essa, 2016; Mavroudi et al., 2017; Zliobaite et al., 2012). However, to derive more fully the envisaged benefits of deploying such systems, it is also critical that attention is paid to how ALS would be used and integrated in schools. This is of pertinence as ALS, like most EdTech tools, will be situated within learning contexts with existing values, norms, and practices. It is therefore necessary to clarify known factors influencing ALS use and integration, as well as address some misconceptions regarding this learning approach.

2.2.2 Implications of ALS Use and Integration with Teaching and Learning

Following the previous discussion on the benefits and detriments of ALS, which was focused on system affordances for teaching and learning, I will now turn to review literature on the use and integration of ALS, focused on the implications of such use and integration on teachers and students, and factors known to influence the effectiveness of ALS to improve student learning experiences and outcomes. This is in acknowledgement of the reality that ALS are increasingly deployed in school settings and are part of the school learning activity system (see Section 1.1.3 for a discussion of ALS in classroom settings).

According to research commissioned or supported by ALS developers comparing human teachers to these ‘machine teachers’, the latter have been found to be comparable or even better than the former. For example, a study sponsored by Yixue Squirrel AI Learning Inc reported findings where students who used the Yixue ALS outperformed students taught by expert teachers (Cui et al., 2019). An evaluation of an interactive personalised virtual lab associated with Adaptemy reported similar findings, where students who learned with the virtual lab outperformed students who attended a teacher-led class (Ghergulescu et al., 2019).

While the above-mentioned findings may create the impression that ALS can potentially replace teachers in the classroom, such research has yet to demonstrate that the observed learning gains were not due to the novelty effect and could indeed be attributed to specific features of these systems. Until then, it remains to be seen if teachers should be replaced with such systems. That said, there is another body of research evidence suggesting that ALS functions most effectively when designed to complement teacher expertise rather than replace it, where teachers play a crucial role in interpreting system output, contextualising recommendations, and integrating adaptive pathways with broader curricular and socio-emotional goals (e.g., Holstein & Aleven, 2022).

Keuning and van Geel (2021) in their study of how ALS can support differentiated classroom instruction reported that the effective use of such systems hinged on teachers possessing the requisite knowledge and skills, such as the ability to interpret and prioritise data, and to incorporate learning data generated by these systems into their instruction. These findings echoed those of a meta-analysis of research from 2007 to 2020, which found that educator-driven, technology-supported personalised learning had a statistically significant though moderate positive effect size of 0.18 ($p = 0.001$) on learning (Major et al., 2021). This suggests that ALS can bring about learning gains if they are well used by teachers, who would likely play an instrumental role in personalising learning and ensuring the effective use of ALS.

Similar findings have been reported in a separate quasi-experiment examining the effects of online learning supported by an ALS. The study found the treatment group outperforming the control group in learning performance, attaining a statistically significant advantage of 6.83% ($p < 0.01$) and an effect size of 0.381 (Jia & Miao, 2021). However, the research also noted that the teacher's instructional design of a flipped classroom and attempts to individualise homework, i.e., assign homework based on students' learning progress, contributed to the reported learning gains. Collectively, the evidence presented above shows that the effectiveness of ALS hinges on how teachers use such systems and integrate them with classroom learning, which in turn is dependent on teachers' technological, pedagogical, and content knowledge, i.e., TPCK.

While teacher professional expertise seems to be a factor influencing the effective use of ALS, unchecked deployment can displace teacher decision-making (e.g., curriculum pacing, diagnosis of students' performance) and result in role ambiguity (Frøsig & Romero, 2024). Emerging evidence suggests that when pedagogical decisions such as task sequencing, remediation thresholds and feedback rules shift from being made by the teacher to the ALS, teachers shift from instructional design and diagnosing students' learning progress to monitoring and procedural supervision, with consequent narrowing of formative assessment expertise and instructional decision-making (Divanji et al., 2025; Frøsig & Romero, 2024), which thus suggests that the use and integration of ALS needs to be considered, among other things, from the lens of teachers' professional practice of instructional design and facilitation of learning (Celik, 2023).

Moving to explore ALS use and integration with reference to student learning experiences and outcomes, this sub-section will review literature relating ALS with students' engagement as well as their metacognitive and self-regulation competencies, which are dimensions that have been often studied as part of examining the effectiveness of ALS.

Starting with student engagement, based on the evidence available, ALS can be said to have a nuanced influence on student engagement and motivation where the potential for ALS to have a positive effect on student learning likely hinges on their design features. A systematic review by Létourneau et al. (2025) reported that ALS integrating gamification, interactive elements and real-world applications can increase motivation, and in turn enhances student interest and sustained learning. This builds on previous research evidence which suggests that gamification strategies can have a positive influence on student motivation. However, research also surfaced that in the long run, such motivation can decline, particularly when gamification strategies focus on extrinsic rewards (Ratinho & Martins, 2023). This is because extrinsic reward structures can undermine intrinsic motivation and executive control, yielding engagement without commensurate gains in long-term skills retention (Deci & Ryan, 1985; Reiss, 2012).

Next, ALS can potentially shape the development of metacognition and self-regulation through features such as timely and personalised prompts, and multimodal signals (e.g., dashboards) that make learning processes and progress visible and actionable. Recent empirical research has shown that self-regulated learning (SRL) prompts embedded within ALS can increase frequencies of metacognitive actions such as planning, monitoring, strategy use and, under experimentally controlled conditions, produce greater learning gains when SRL prompts are coupled with feedback and fading schedules (Azevedo et al., 2022; Dever et al., 2023; Sharma et al., 2024). However, many systems insufficiently model SRL processes, producing superficial gains in task performance without durable improvements in autonomous metacognitive control and self-regulation (Horvers et al., 2024; Molenaar et al., 2019). As a result, these systems may instead potentially undermine the development of these desired skills, e.g., adaptive learning pathways and/or comprehensive dashboards and notifications removing the need for students to monitor their own learning, thus offloading self-regulation from students.

Analytics research further shows that fine-grained log, eye-tracking, and affect data can reveal self-regulated learning trajectories and allow adaptive scaffolds to target moments of cognitive impasse or disengagement, encouraging metacognitive engagement and learning persistence, thus improving self-regulation (e.g., Li et al., 2023). However, there are field studies cautioning that system-driven scaffolds produce surface performance gains unless their design explicitly supports learning transfer, strategic calibration, and gradual fading of adaptive scaffolds (Ahmed & Abdullah, 2025; Azevedo et al., 2022; Essa, 2016). Sustained professional development and teacher mediation are frequently necessary to translate ALS-prompted SRL into durable autonomous metacognitive competence (Holstein & Aleven, 2022; Pelánek, 2025). Together, these findings indicate that ALS can foster metacognition and SRL but only within learning environments that align adaptive prompting, transparency, and instructional supports with progressive scaffold fading.

In summary, ALS, like all other AI and EdTech tools that came before, can lead to both positive and negative implications for teachers and students. Current evidence shows that effective ALS implementation hinges on systems design that embed sound pedagogical considerations and teacher mediation through instructional design and learning facilitation. These implications of ALS for teaching and learning, alongside known benefits and detriments of ALS (presented in Section 2.2.1), have been taken into consideration when shortlisting and selecting the ALS for this research.

2.2.3 Distinguishing between Individualised Learning and Personalised Learning

ALS affordance of individualised learning pace, often used by teachers to personalise learning for students has somewhat contributed to the interchangeable use of the two terms, i.e., individualised learning and personalised learning. This can create the misconception that the two terms are synonymous, which is not true. Individualised learning and personalised learning are related but distinct constructs, with different theoretical origins, operational implications, and design consequences for practice and technology. I will briefly unpack the two terms in this section and explicate the relationship between them, before presenting working definitions of these terms for the purposes of this research.

Starting with individualised learning, it refers to tailoring instruction to the learner's current performance level and learning trajectory, typically operationalised as adjusting pace, content sequencing, or task selection based on demonstrated mastery (Bloom, 1984). This learning approach has been in existence since the earliest days of apprenticeship and tutoring, in forms that are not necessarily mediated by technology. However, as educational technologies begin to mature, and as ALS gain popularity, individualised learning has increasingly come to be associated with such systems and take on a technology-mediated form (Shemshack & Spector, 2020).

According to learning sciences and AIEd literature, individualisation is realised through modelling, e.g., learner model and domain or knowledge models, where ALS can infer a student's knowledge state and adapt task recommendations and feedback to maximise learning gains (Aleven et al., 2017; Koedinger et al., 2005). Individualised learning is therefore primarily cognitive diagnostic; it presumes an instructional objective (e.g., conceptual understanding or skill development) and modifies the pathway to that objective in response to observable performance (Luckin et al., 2016; VanLehn, 2011). (See Section 2.2.1 for a brief description of how ALS delivers individualised learning.)

Moving onto personalised learning, it typically refers to tailoring learning experiences to student interests, needs and contexts, where students are placed at the centre of learning design and enactment. Unlike individualisation, personalisation goes beyond considering students' cognitive readiness to encompass affective, social and cultural considerations. It seeks to make learning experiences more relevant and engaging to the individual as a whole person, not solely as a knower of particular skills (Akintola et al., 2025). Technologically, personalisation may draw on recommendation engines, learner profiles, or affective sensing to select contexts, examples, or modes of presentation that resonate with a student. Thus, while individualisation optimises *what* and *when* a learner practices relative to curricular objectives, personalisation additionally attends to *why* and *how* learning is made meaningful to the learner.

From the above explication, it should become evident that both terms share the same focus on student-centred learning and have some form of adaptation, to address learner variability. However, they differ in terms of focus (cognitive mastery vs. motivational relevance), agency (algorithms and system models vs. teacher decision-making), and scope (micro-adaptive sequencing vs. broader learner identity features). Furthermore, in terms of actual enactment, individualised learning tends to be realised through the automated delivery of tailored learning experiences, e.g., through technologies such as ALS, while personalised learning emphasises the delivery of learning experiences (both tech-mediated and teacher-mediated) that consider individual learner characteristics beyond cognitive readiness (Graf & Kinshuk, 2012).

France and Tomlinson (2019) argue that the success of personalised learning hinges on the teacher and students, instead of on technologies like ALS. This is because personalised learning requires a learning environment that supports authentic learning experiences, student empowerment and reflection, which presupposes the teacher as an architect and facilitator of learning and students as active agents and owners of their learning.

For the purposes of this research, personalising learning using ALS is defined as a learning approach where the teacher intentionally incorporates known student interests, teacher-observed student needs and ALS learning data into classroom instruction, to encourage student empowerment and reflection and ensure authentic learning experiences. In the process, the teacher needs to balance individualised learning with ALS and classroom learning, either through teacher-led instruction or through various permutations of individual, pair and group work. In such a learning context, students are expected to not only participate actively in learning activities but also take a keen interest in their learning progress, reflecting on their strengths and areas for improvement.

This definition places teachers, not technology, at the heart of personalising learning with ALS, emphasising the pivotal role they play in the design and enactment of such experiences. It also presupposes students as active agents co-constructing knowledge with the teacher and with each other. More importantly, it situates individualised learning with ALS within the context of classroom learning, recognising that classrooms and schools are institutions that will likely remain in the foreseeable future as main sites of student learning. There is thus a need for us to understand personalising learning using ALS within the context of classroom learning. This is particularly important as education research findings are suggesting human-AI complementarity as a viable approach for effective personalised learning using technologies (Deckker et al., 2025; Holstein & Aleven, 2022).

Research has demonstrated that adaptive systems that implement individualisation are most educationally potent when integrated within differentiated classroom practice and when personalisation is used judiciously to support engagement without undermining equitable learning goals (Aleven et al., 2017; Koedinger et al., 2005). However, designing for such complementarity requires explicit alignment of system objectives with curricular goals, mechanisms for teacher interpretation and action, and attention to learner preferences as legitimate pedagogical input rather than purely optimization targets (Farhood et al., 2025).

For these reasons, it is necessary to next explore how technologies like ALS are integrated with classroom learning and school environments.

2.3 ALS Integration

ALS are a type of educational technology, and as such, integrating them into classroom learning needs to be understood through the broader lens of EdTech integration, which refers to the purposeful alignment of digital technologies with curriculum, pedagogy, and assessment to improve educational processes and outcomes. Related research emphasises curriculum coherence, pedagogical alignment, assessment integration, teacher readiness, and school leadership and culture as key success factors for effective EdTech integration, which shows that technology adds value only when embedded in instructional design and organizational improvement strategies.

2.3.1 Distinguishing between Integration and Use

Before proceeding further, it is important to distinguish between EdTech use and EdTech integration. EdTech use refers to the adoption or deployment of digital tools such as ALS to support existing instructional practices, often substituting or augmenting traditional activities (e.g., drill and practice) without altering underlying pedagogical assumptions (Clark, 1994; Cuban, 2001). Studies of classroom technology adoption show that EdTech use frequently emphasises efficiency, access, or engagement rather than learning transformation, resulting in limited or inconsistent effects on student outcomes (Cuban et al., 2001). In contrast, EdTech integration (as defined in the earlier paragraph) denotes the deliberate embedding of technology within curriculum, pedagogy, assessment, and classroom routines to advance pre-identified learning goals (Mishra & Koehler, 2006; Tondeur et al., 2017).

Integration requires teachers to redesign instruction so that technology mediates learning processes such as feedback, scaffolding, collaboration, and formative assessment, rather than functioning as an add-on (Dede, 2014; McKnight, 2016). Empirical research shows that integrated approaches are associated with deeper learning, particularly when technologies support inquiry, personalisation, and metacognition and when teachers possess the pedagogical and organizational capacity to orchestrate their use (Ertmer & Ottenbreit-Leftwich, 2010; Tondeur et al., 2017).

From an educational improvement perspective, integration is a systemic process involving professional learning, curriculum (re)design, and iterative refinement, whereas use reflects individual or episodic adoption decisions (Ertmer, 1999). This distinction is particularly salient in AIEd research, where studies increasingly caution that AI-enabled tools including ALS, generate learning gains only when integrated into classroom practices and teacher decision-making, rather than used autonomously or in isolation (Holmes et al., 2019b). Overall, the literature converges on the conclusion that EdTech use is a necessary but insufficient condition for impact, while EdTech integration represents a qualitatively different construct centred on pedagogical transformation and sustained instructional change.

2.3.2 Factors Influencing Effective Integration

Research consistently shows that EdTech integration is a complex, systemic process rather than a function of EdTech use, i.e., tool adoption alone. Learning sciences, classroom research, and educational improvement literature emphasise that technology influences learning only when it is deliberately aligned with pedagogy, curriculum, and assessment and enacted through teachers' instructional practices. Accordingly, scholars have identified multiple interacting factors that shape whether and how EdTech becomes meaningfully integrated in classrooms. These factors include pedagogical alignment, curriculum coherence, assessment integration, teacher readiness, and school leadership and culture (Seow et al., 2020; Shin et al., 2022; Sosa-Díaz et al., 2022).

The above-mentioned factors operate across multiple levels of the education system and jointly influence the depth, sustainability, and effectiveness of integration (Harrell & Bynum, 2018; Martin et al., 2025; Mekheimer, 2025). Framing EdTech integration through this multi-level lens enables a more precise understanding of why similar technologies produce divergent outcomes across contexts and provides a structured foundation for examining how emerging digital and AI-enabled tools can be embedded into classroom practice in ways that support educational improvement. Pertinent literature for each of these identified factors will be presented in turn below.

First, pedagogical alignment, a foundational condition for EdTech integration, refers to the coherent alignment of instructional strategies and technology use to support learning processes, e.g., attention, collaboration and retention, grounded in learning sciences. It operates as a mediating mechanism through which technology influences educational outcomes, shaping not only what tools are used but how they structure learning tasks, interactions, and assessment practices. Such alignment can be observed through teacher effort and tool design. Empirical classroom studies demonstrate that teachers who intentionally design lessons around these intersections are more likely to implement technology in ways that promote conceptual understanding, formative assessment, and learner engagement (Harris et al., 2009). Conversely, when technologies are introduced without consideration of instructional coherence, they tend to reinforce transmissive teaching or serve administrative functions with limited impact on learning (Ertmer & Ottenbreit-Leftwich, 2010; Tondeur et al., 2017).

Beyond teacher effort, EdTech tools that incorporate pedagogical considerations into their design, translating sound pedagogy into tool features is another avenue to ensuring pedagogical alignment. For example, Børte and Lillejord (2024) demonstrated using design-based research that pedagogy-led tool design can encourage teacher adoption of inquiry-based lesson planning. Mohseni et al. (2023) also reported that involving teachers in the design of a learning analytics dashboard produced visualisations that teachers could easily interpret, and this can potentially increase the likelihood of classroom uptake. From an integration perspective, these findings suggest that successful EdTech initiatives must prioritise instructional design processes that explicitly connect technological features to learning objectives and evidence-based pedagogical strategies, ensuring that technology use is purposeful, coherent, and responsive to the cognitive demands of learners.

Second, curriculum coherence, which refers to the alignment of learning goals, instructional sequences, and materials across lessons and year levels to ensure that technology use supports sustained learning progressions rather than isolated activities, is widely recognised as a critical condition for effective EdTech integration in K–12 contexts. It determines whether digital tools become embedded in everyday classroom practice or remain peripheral additions, and differs from pedagogical alignment, which is focused on the *how*, by focusing *what* of teaching and learning.

Research has shown that when EdTech tools are introduced without curricular alignment, teachers often struggle to reconcile them with mandated syllabi and assessment demands, resulting in fragmented or short-lived implementation (Penuel et al., 2011; Webb et al., 2013). In contrast, coherent curricula provide a stable structure within which teachers can integrate digital tools to support disciplinary practices, language development, and formative assessment. This issue is particularly salient in English language learning (ELL) classrooms, where studies demonstrate that technology enhances interaction, feedback, and language use only when integrated into coherent instructional sequences that link language objectives, tasks, and assessment criteria (Pennington, 2004; Warschauer & Kern, 2000; Warschauer & Meskill, 2000).

From an educational improvement perspective, curriculum coherence also legitimises EdTech use by aligning it with accountability systems and learning standards, reducing tensions between innovation and assessment pressures (Dede, 2014). Without such alignment, even well-designed technologies risk being marginalised or used instrumentally to rehearse low-level skills. Empirical studies across subject areas confirm that curriculum-embedded technologies are more likely to be sustained, scaled, and adapted over time because they fit teachers' planning routines and instructional goals (Penuel et al., 2011). Consequently, curriculum coherence functions as a structural mediator of EdTech integration, shaping not only how technologies are used but whether they meaningfully contribute to classroom interaction, language development, and long-term learning outcomes in K–12 settings.

Third, alignment between assessment practices and technology use is another central condition for meaningful EdTech integration in K–12 contexts, as assessment strongly shapes classroom activity, teacher decision-making, and student engagement. Research has shown that when assessment remains focused on decontextualised or summative outcomes, technology use is often constrained to low-level practice or test preparation, limiting its pedagogical potential (Black & Wiliam, 1998; Webb et al., 2013). In contrast, assessment approaches that emphasise formative feedback, process-oriented evidence, and learner reflection create opportunities for technology to support deeper learning and interaction.

Classroom research further indicated that misalignment between digital activities and assessment expectations discourages teachers from sustaining technology-rich practices, especially in high-stakes accountability environments (Bennett, 2011; Penuel et al., 2011). From an integration perspective, aligning assessment with technology use legitimises instructional innovation by signalling what counts as learning and by embedding digital practices into routine evaluative processes (Dede, 2014). This alignment also supports teacher orchestration, enabling educators to use assessment data generated through technology to adapt instruction and support learner progress.

Overall, the literature converges on the conclusion that EdTech integration depends not only on the presence of digital tools but on curriculum coherence, pedagogical alignment and assessment systems that recognise and reward the forms of learning those tools are designed to support, particularly in language-rich, interaction-focused classroom contexts. Apart from these teaching and learning considerations, two sociocultural factors – teacher readiness and school leadership and culture – are also known to influence EdTech integration. Both factors will be discussed in turn below.

Teacher related factors have been repeatedly found to be among the key mediators of EdTech integration, shaping how digital tools are interpreted, enacted, and sustained within classroom practice (Scherer et al., 2019). Research consistently shows that teachers' beliefs about teaching, learning, and technology strongly influence whether EdTech is used to support interactive, learner-centred pedagogy or to reinforce existing transmissive practices (Ertmer, 1999; Ertmer & Ottenbreit-Leftwich, 2010). In general, teachers who view technology as compatible with constructivist and communicative approaches are more likely to integrate digital tools in ways that promote dialogue, feedback, and learner autonomy than teachers who do not see how technology can enable such instructional approaches.

Professional capacity further moderates these beliefs, as effective integration requires not only technical skills but also pedagogical knowledge for orchestrating technology-mediated tasks, managing classroom interaction, and digital competencies such as interpreting digital assessment data (Ng et al., 2023). Frameworks such as technological pedagogical content knowledge highlight the interdependence of teachers' subject knowledge, pedagogical expertise, and technological understanding in enabling meaningful integration (Celik, 2023; Mishra & Koehler, 2006). Empirical studies demonstrate that sustained professional learning opportunities, collaborative communities of practice, and instructional coaching are associated with deeper forms of integration, whereas one-off training typically leads to superficial or episodic use (Reich, 2020; Tondeur et al., 2017).

Classroom research has also found that teachers' confidence and sense of agency can affect their willingness to experiment with technology and adapt it responsively to learners' needs, particularly in linguistically diverse classrooms (Henderson & Corry, 2021; Inan & Lowther, 2010). However, it should be noted that Petko et al. (2018) reported teacher readiness, defined by the authors as perceived skills and confidence, to be influenced by school readiness, which encompasses educational technology resources in classrooms, perceived importance of technology integration, goal clarity, head teacher support, as well as formal and informal exchange among teachers.

Among the various facets of school readiness, school leadership and culture, the final factor to be presented in this section, has been found to be a key mediating factor for EdTech integration (Beets et al., 2008; Keane et al., 2020). They influence whether digital tools are adopted superficially or embedded in sustained pedagogical change. Research emphasises that EdTech integration is not solely an individual teacher endeavour, but a collective process shaped by school-level norms, expectations, and structures (Beets et al., 2008; Dexter & Richardson, 2020). Instructional leadership that articulates a coherent vision for teaching and learning with technology has been shown to support alignment between digital initiatives, curriculum goals, and classroom practice (Dexter, 2011). In contrast, fragmented leadership or technology-driven mandates often result in inconsistent implementation and limited instructional impact.

Empirical studies indicate that school cultures characterised by collaboration, trust, and reflective practice enable teachers to experiment with technology, share pedagogical strategies, and refine technology-mediated instruction over time (Dexter & Barton, 2021;

Rojas Briñez et al., 2023). Such cultures are particularly important in English language learning contexts, where integrating technology to support interaction, dialogue, and multimodal meaning making requires coordinated approaches across classrooms and year levels. Leadership also shapes the material and temporal conditions for integration, including access to professional learning, planning time, and instructional support, which are consistently identified as prerequisites for meaningful classroom enactment (Ertmer & Ottenbreit-Leftwich, 2010).

School leaders influence integration by embedding technology use within routines for instructional inquiry, data use, and continuous improvement rather than treating it as a discrete innovation (Rogers, 2003; Schmitz et al., 2023). Building professional capacity through human resource management and professional learning among staff (including the leaders themselves) such as by providing individualised consideration are some additional critical dimensions of how school leadership and culture can mediate EdTech integration (Dexter & Richardson, 2020). Classroom research further shows that when leaders value pedagogical experimentation and align evaluation practices with instructional goals, teachers are more likely to sustain technology-rich practices that enhance student interaction and learning (Sosa-Díaz et al., 2022).

In summary, EdTech integration requires not only access to devices and software, i.e., EdTech use, but also a re-examination of existing curriculum, pedagogical and assessment practices, as well as a review of teacher readiness and school culture by the leadership. These anticipated changes to curriculum, pedagogy and assessment arising from EdTech integration also allude to the potential for EdTech tools such as ALS to impact teacher-student interactions (see Section 2.3.3. for a discussion of pertinent literature). From the above-mentioned discussion of current literature, it becomes evident that EdTech integration is not a one-dimensional or one-off training problem. Instead, it needs to be a research-informed, pedagogy-led (rather than technology-led), localised and systemic process. It also thus suggests a need for an onboarding process to prepare for such integration, to better realise the potential of EdTech tools, such as ALS, in and beyond classroom learning (see Section 2.4 for a literature review on ALS onboarding).

2.3.3 Impact of ALS Integration on Classroom Interactions

With ALS increasingly being deployed to schools, the potential of such systems to transform classroom interactions is beginning to emerge from related research. ALS features such as dynamic task recommendations, immediate diagnostic feedback and individualised learning pace can bring about both positive and negative effects on classroom interactions. I will elaborate on how each of these features impact classroom interactions, drawing from literature.

Individualised learning pace and dynamic task recommendations enable ALS to not only deliver learning experiences based on individual students' current mastery and pitched to meet their learning needs, it also enable students to learn independently, even when the teacher is not available to provide guidance on the next steps to undertake (Wang et al., 2020). In simple terms, ALS can attend to the learning needs of every student concurrently and in ways that even highly skilled teachers in classroom settings cannot. This can potentially alter classroom dynamics by flattening hierarchies, where teachers play a supportive, facilitative role when students drive their own learning with ALS.

One possible benefit arising from this flattened hierarchy would be the freeing of teachers' time and attention to focus on personalising support for struggling students, enabling them to provide one-to-one guidance and scaffolding to these students, while the rest of the class learn with ALS. During these one-to-one or one-to-few interactions, teachers can also leverage other ALS affordances (e.g., dashboard visualisations of learning progress) to engage students in practicing and strengthening their metacognitive competencies (Conati & Kardan, 2013). Furthermore, research has also found that in settings where ALS was used, teacher-student interactions tended to be characterised by closed questions followed by short responses, which encouraged student participation albeit in a limited form and served as an efficient means for teachers to check on their students' learning progress (Huang et al., 2025).

However, prevalent use of closed questions followed by short responses can potentially be disempowering, conditioning students to engage superficially rather than metacognitively with their own learning progress, as they rely on dynamic task recommendations to tell them what to do (Azevedo & Aleven, 2013). From the teachers' perspective, this automation afforded by ALS can be disempowering given that they typically have little to no means of influencing the recommendations made by an ALS. Teachers may feel they have less control over instructional decisions, and this not only creates friction in how they can guide their students' learning but also make it challenging for them to guide students' learning beyond the ALS (Simon & Zeng, 2024).

Next, arising from immediate diagnostic feedback is a potential alteration of classroom communication patterns and immediacy, changing who speaks, when and about what. Where teachers provided in-the-moment cues, hints, and error remediation when ALS is not used, ALS routinely supplies immediate, item-level diagnostics and stepwise feedback, enabling students to receive corrective information while learning and freeing teachers to attend to higher-order pedagogical tasks such as conceptual diagnosis, classroom discussion facilitation, and socio-emotional support (Aleven et al., 2016). This also means that when ALS is used, students are likely to be 'conversing' more with these digital interfaces for immediate feedback, while teacher-student interactions shift to debriefing, interpreting and verifying the analytics, and higher-order questioning (Bach et al., 2025; Owan, Abang, et al., 2023).

Crucially, because ALS feedback is typically constrained by the granularity of its student models and by domain-specific task representations, teachers must engage in epistemic work to validate algorithmic judgments, contextualize recommendations within curricular goals, and address unmeasured reasoning or affective states that the system may miss. Several qualitative studies further show that teachers experience increased cognitive load when interpreting dashboards and negotiating disagreements between their professional judgment and the system's suggestions, underscoring the need for professional development that builds diagnostic literacy and data-interpretation skills (Kim & Song, 2023; Simon & Zeng, 2024).

Furthermore, while rapid diagnostics can support more timely formative decision-making, researchers caution that overreliance on automated feedback risks deskilling aspects of teachers' formative-assessment practice unless systems are implemented within teaching and learning environments that preserve teacher agency and promote collaborative interpretation of diagnostic output (Dever et al., 2023). Thus, immediate diagnostic feedback transforms teacher–student interactions into a triadic, socio-technical exchange in which pedagogical authority is continuously negotiated among student, teacher, and algorithmic feedback.

In summary, ALS integration entails not only changing what is taught, but how teachers and students connect, offering affordances that can personalise learning but requiring thoughtful implementation to ensure technology enhances, rather than diminishes, vital human interaction and teacher agency. It thus suggests then that prior to integrating ALS, it may be vital to have a separate process that prepares both teachers and students how to use this tool and use it optimally, both to ensure effective ALS integration and quality of classroom interactions, particularly teacher-student interactions (the importance of the latter will be presented in Section 2.5). This process, termed onboarding, will be discussed in the next section.

2.4 ALS Onboarding

Onboarding is a term frequently used by Human Resource practitioners and researchers to refer to a process of organisational socialisation "designed to ease the movement of employees through the organizational threshold to become productive contributors and team members in the least possible time" (Chillakuri, 2020; Davila & Pina-Ramirez, 2023). However, Klein et al. (2012, p. 268) distinguishes between socialisation and onboarding, where the former is a process that focuses on changing a person to fit into their new environment, while the latter focuses on "structuring newcomers' early experiences" to facilitate socialisation. The authors have also defined onboarding as "all formal and informal practices, programs, and policies enacted or engaged in by an organization or its agents to facilitate newcomer adjustment"(Klein et al., 2012, p. 268).

Technology onboarding (also known as software onboarding and software training), is an aspect of employee onboarding that focuses on ensuring new hires are equipped with the knowledge needed to use the organisation's technology to effectively perform their role and become productive members of the team. It is a multifaceted process that could involve access to technology and related documentation, provision of training resources, availability of coaching and mentorship, and opportunity for feedback. Such onboarding is increasingly appropriated and used by tech developers to mean something similar but intended for new customers instead of new employees. For example, Scoro, a software company defined technology onboarding as a journey that "a customer go through in between making the decision that you want to use new software, and being a fully set up user of this software, knowing exactly how to extract the most value from the new tools" (Scoro, n.d.).

In education settings, onboarding literature tended to focus on students' transiting from secondary to higher education. Onboarding interventions studied ranged from use of digital onboarding platforms to programmes related to developing social belonging or targeting psychological stress. For example an onboarding intervention for first-year students in higher education focused on providing them with information, fostering interactions among newcomers, facilitating connection with older students and helping these students resolve problems encountered during this initial phase of their higher education was found to increase students' informedness, improve study-related self-efficacy and reduce dropout rate (Schilling et al., 2025). Separately, onboarding programmes related to mental health and well-being have also been found to have a positive effect on the students' self- and social competencies (Limarutti et al., 2021).

EdTech onboarding, which ALS onboarding falls under, typically focuses on onboarding teachers and is often conceptualised as a coordinated set of activities, including initial training, sustained professional development, coaching, and enactment supports, designed to enable teachers to adopt, adapt, and integrate educational technologies into instruction in ways that produce measurable learning gains (McBride, 2021). Within this paradigm, effective onboarding is thus conceived as sustained professional development with clear learning goals, active learning, coherence, and follow-up (Desimone, 2009). Such onboarding would need to simultaneously address first-order barriers such as resources, infrastructure, policy and second-order barriers such as teacher beliefs, pedagogical practices because EdTech deployment without attention to teacher cognition and context frequently yields low-fidelity or superficial use of tools (Ertmer, 1999).

Specific to ALS onboarding, research has indicated that algorithmic tutors and analytics-driven supports can produce substantive learning gains only when implementation fidelity, teacher facilitation, and contextual adaptation are attended to during onboarding and ongoing integration (Holstein & Aleven, 2022; VanLehn, 2011). As such, ALS onboarding should also entail cultivating teachers' capacity to interpret and act on algorithmic outputs (e.g., mastery estimates, next-problem recommendations, learning-analytics dashboards). This corroborates with earlier research that empirical work on professional development indicates that structural design (e.g., follow-up, coaching) and substantive focus (e.g., discipline-specific pedagogy) predict whether teachers change instructional practice after training (Garet et al., 2001).

From the evidence presented above, EdTech onboarding, including ALS onboarding, often focuses on teachers, emphasising professional development, technical fluency, and shifts in pedagogical beliefs, guided by the underlying assumption that teachers are gatekeepers who translate technological affordances into classroom practice. Professional development frameworks thus dominate onboarding design, stressing content focus, active learning, coherence, duration, and collective participation aimed at changing teacher practice rather than directly reconfiguring student experiences (e.g., Desimone, 2009; Garet et al., 2001). However, given that ALS use and integration involves both teachers and students, ALS onboarding need to also focus on students, e.g., ensuring ALS access, and digital literacy, where the primary intervention is directly with learners.

The importance of student onboarding needs to be emphasised here. This is because the use of ALS often entails out-of-classroom engagement with the tool, and sustained self-directed use of ALS would necessarily hinge on students' access to devices and the tool, their ability to self-regulate and manage their time, as well as their motivation to learn with ALS. Furthermore, given that the purpose of onboarding is to prepare students for ALS integration with classroom learning, which has bearing on teacher-student interactions (to be reviewed in the next section) and student achievement, this is a gap that needs urgent remediation, not only from a research perspective but also for policy and practice purposes.

2.5 Teacher-Student Interactions

Teacher-student interaction here refers to verbal exchanges between the teacher and student(s) during learning activities such as whole class teaching, small group discussion and seat work. These interactions can be instructional (i.e., provide learning support), social emotional (i.e., create a positive learning climate), or organisational, (i.e., manage student behaviour) (Hafen et al., 2015). Interest in teacher-student interaction dates back as early as the late 1800s, which saw some initial theorising that related teacher-student interaction to human consciousness (James, 1900) and early research that sought to investigate student questioning skills development and student achievement (Konwar, 1900). The potential for teacher-student interaction to influence student learning experience and outcomes has been quite widely explored since these earliest efforts (e.g., Howe et al., 2019; Kumpulainen & Wray, 2002; Mercer & Littleton, 2007).

2.5.1 Significance of Teacher-Student Interactions to Academic Learning

Recent research demonstrated positive associations between quality teacher-student interactions and student achievement (e.g., Allen et al., 2011; Cadima et al., 2010; Lerang et al., 2019; Valiente et al., 2020). A longitudinal study carried out in 6 elementary schools and 3 middle schools in the US found evidence that supported an indirect link between "student experience of support and academic performance, through student engagement" (Klem & Connell, 2004, p. 270). This positive association between teacher-student interaction and student achievement is corroborated by Allen et al. (2011), a randomised control trial of a secondary school coaching programme with 78 secondary school teachers from 12 schools, which found that improved interactions between teachers and students predicted improved student achievement, regardless of the content area of instruction. More recently, Lerang et al. (2019), a study involving 1975 grade 8 to10 students from 11 schools in Norway, also found teacher-student interaction to be positively related to mastery orientation, where emotional support was significantly associated with mastery orientation at all three grade levels.

However, a meta-analysis synthesising 16 empirical studies (51 effect sizes) on teacher talk and student achievement in K–12 classrooms reported that dialogic talk was positively associated with achievement, but monologic talk, often a proxy for traditional teacher-student interaction, did not predict learning outcomes (Tao & Chen, 2024). This suggests that some forms of teacher-student interaction (e.g., monologic talk) may not independently influence academic achievement without engagement or dialogic processes. This echoes an earlier review on classroom talk and related research by Thi Diem Hang et al. (2019), which examined more than 300 studies conducted from the 1990s onwards and noted that productive teacher-student interaction can contribute to student learning and intellectual development, such as in terms of improving reasoning, problem solving and conceptual understanding. The review also highlighted the importance of teachers probing student thinking, which often encouraged more elaborated student ideas and supported internalisation, alluding to the critical role teachers play in orchestrating academically productive classroom interactions, which will be discussed in the next section.

2.5.2 The Critical Role Teachers Play in Orchestrating Productive Teacher-Student Interactions

The integral part played by teachers in creating an environment to support effective classroom interaction has been aptly articulated by Barnes (2008, p. 2), who argued that the "communication system that a teacher sets up in a lesson shapes the roles that the pupils can play, and goes some distance in determining the kinds of learning that they engage in". In a study of a fifth-grade teacher's talk, McNeil (2012) found that a dialogic space is created when the teacher responds contingently to student contributions, empowering students to use language and "exercise their voice" (McNeil, 2012, p. 402). This complements the claim that reflective discourse guided by the teacher is "essential for the full development of student capacities and dispositions for reasoned civic participation" (Resnick et al., 2010, p. 180).

Present research evidence suggests that teachers can exert a positive influence on student academic learning outcomes through their talk. A comparison of teacher talk in 20 high-growth and low-growth middle school classrooms found an association between naturally occurring metacognitive talk by the teacher and conceptual learning outcomes (Zepeda et al., 2019, p. 534). The study postulated that teachers' attempts to provide personal knowledge support through open-ended prompts appeared to be positively associated with students' engagement in metacognitive processing. Boden et al. (2020, p. 1234) also reported preliminary findings relating teacher talk in the classroom to conceptual learning, where "classrooms with more conceptual growth also had more mastery-focused achievement goal talk for the task and student evaluation."

More specifically, there seems also to be a growing body of evidence that suggests a significant positive relationship between teacher responsiveness to student ideas during teacher-student interactions and student learning (e.g., Bishop, 2021; Colley, 2018; Gray et al., 2022). For example, higher levels of discursive rigour (Colley, 2018) and authentic engagement and sense-making (Gray et al., 2022) were observed when teachers were responsive to students' ideas. Highly responsive teacher talk moves such as probing and revoicing have also been shown to be positively associated with student achievement (Bishop, 2021). In addition, Gray et al. (2022) demonstrated that it is possible for teachers to be responsive to student ideas while managing practical concerns such as limited lesson time, curriculum coverage demands and students leaving the class with incorrect ideas.

While research has demonstrated how teacher talk and teacher responsiveness can positively influence both students' learning experience and outcomes, teacher talk and teacher responsiveness is conversely influenced by latent factors such as teacher beliefs, and curriculum demands. For example, teachers can at times unintentionally perpetuate existing inequalities through their talk, inadvertently sustaining the 'vicious cycle' that they might have sought to break. A case study examining student talk in a large-size classroom in China found that, even though most students were given time to talk, "students with higher test scores tended to engage in potentially higher-order thinking than students with lower test scores" (Dong et al., 2019, p. 461). However, other research such as this case study on Korean classrooms (Sum & Kwon, 2020) has also shown that it is possible to encourage and engage students in academic discourse, leveraging the dominant societal ideology of Confucianism.

From this discussion, it is evident that there has been much research on teachers' efforts to orchestrate productive teacher-student interactions. However, the varied findings suggest a need to better understand the factors mediating teacher-student interactions, and one such factor would be how students receive and respond to these teacher efforts, an area which appears to be under-researched (Hunter, 2017). That said, based on what is already known, students' perception of teacher talk, including teacher responsiveness, appears to influence their participation in class discussions. For example, if students perceived their teachers as using more academically productive talk moves, they were more likely to listen to others' ideas and discuss these ideas, and more likely to "experience higher levels of enjoyment and lower levels of anxiety in the classroom" (Chen et al., 2020, p. 646). Similarly, it has been found that when students felt heard, their participation in class discussion increased and was more sustained (Boyd, 2015; Lim et al., 2020). All these thus point toward a need to better understand teacher-student interactions not only in terms of teacher talk moves but also how students contribute and participate in such interactions, and situating this understanding in the post-pandemic world where blended learning is the new normal (Cheng, 2020) and smart technologies like ALS are increasingly used for learning (OECD, 2021).

2.5.3 Importance of Student Talk for Academic Learning

The relationship between student talk and academic learning outcomes has been repeatedly demonstrated through research on classroom discourse, supporting the social cultural view of learning which asserts that social interaction is crucial to knowledge construction (Vygotsky, 1978). For example, an increase in the quantity of student talk has been found to be associated with substantial improvements in text comprehension (Murphy et al., 2009; Sedova et al., 2019), validating the call for greater engagement of students in classroom discourse (Cazden, 2001). Sedova et al. (2019) also noted a strong relationship between the quality of student talk and reading literacy, in sync with the positive association found between student elaboration and curriculum mastery (Howe et al., 2019). These findings demonstrate collectively that engaging students in meaningful and purposeful classroom discourse has a significant bearing on helping students "getting ahead in school and life" (Ardasheva et al., 2016, p. 684).

Beyond engaging students in classroom talk, there has also been research evidence suggesting that students can benefit from leading classroom interaction, where the teacher takes on the role of a participant and facilitator. In the context of learning English as a foreign language (EFL), Sybing (2021) found that allowing students to direct classroom interaction can encourage these students to be more engaged in the learning experience. This supports previous findings that student-led conversations better positioned students to engage in collaborative knowledge building (Boardman et al., 2018). Earlier research has also found collaborative talk to help students work through their understanding, and engage in an authentic negotiation of meanings and ideas (Purdy, 2008). However, these benefits are contingent upon the teacher's skilful facilitation and a willingness to let the lesson unfold based on student ideas and utterances.

2.5.4 Potential of Smart Technologies like ALS to disrupt Teacher-Student Academic Interactions

The pervasive use of technology has rendered it almost invisible in the classroom, being "consistently used, but rarely talked about" (Garcia et al., 2018, p. 413). Outside the classroom, research has made evident the power of technology to mediate human activity including teacher-student interactions (e.g., Bonk, 2009; Cazden et al., 1996; Pea, 1985). It has been argued that technology does more than amplify human cognition; it changes human activity by "reorganizing our mental functioning" (Pea, 1985, p. 168) In the context of classroom learning, Garcia et al. (2018) illustrated with examples from three 9th Grade English Language Arts (ELA) classrooms how technology has made it possible for students to disregard the teacher whilst creating new contexts for teacher-student interaction.

A review of studies published in peer-reviewed journals between 2005 and 2016 reported substantial changes to teacher-student interaction when technology was deployed, whether it was in the online space or in the physical classroom where technology was used (Harper, 2018). The review surfaced that, when technology was deployed, changes in the goal of face-to-face teacher-student interactions and the role of the teacher were observed, alongside greater student ownership of learning. These findings were also reiterated in a scoping review of peer-reviewed publications on classroom dialogue and digital technologies (Major et al., 2018) which surfaced that the use of technologies enhanced both dialogic activity and learner autonomy. These studies and reviews form a body of research that reflects the due attention given to unpacking how technology mediates and changes teacher-student interactions.

While technology affords expanded dialogic possibilities, such as widening and deepening the dialogic space (Collins & White, 2015; Wegerif, 2010), teachers remain an integral part of effective technological implementation for transformative learning (Blundell et al., 2020). This thus raises the question: how can teachers be better equipped to make optimal use of technology for learning and teaching? Recent research has repeatedly noted across education systems that teachers require professional development to make the necessary shifts in their pedagogical practice to deliver effective digital learning experiences (e.g., Aishah, 2017; Galway et al., 2020; Major et al., 2018; Padayachee, 2017; Seow et al., 2020). Beyond lesson design and enactment, teachers also need to rethink how they engage students during classroom learning, as technology empowers students toward learner autonomy; teachers need to balance between encouraging self-directed learning, leveraging technological affordances and provision of timely learning support (Cheng & Tsai, 2019).

Turning our attention specifically to ALS and classroom interactions, current use of ALS to personalise learning, leveraging features such as dynamic task recommendations and immediate diagnostic feedback (Pugliese, 2016), it would appear that ALS can potentially take over some instructional tasks performed by teacher, via these 'teacher-like' features that would appear, at first glance, to diminish the role of a teacher in students' learning and the need for teacher-student interactions. This is because ALS is designed to be used primarily for independent self-study through automatic delivery of tailored learning experiences. This makes it possible for students to learn even in the absence of a human teacher. However, as ALS are being increasingly deployed in support of classroom learning, where the teacher and ALS share the stage, there thus arises a pressing need to understand how ALS, the teacher and students interact within the classroom activity system, and its implications for classroom learning, teacher pedagogical practice and teacher professional development.

Some questions arising from the teacher-ALS partnership for classroom learning include the following: Firstly, if students have been assigned to independent self-study on the ALS, how would a teacher acknowledge and incorporate students' ALS learning experience during classroom learning? And how is that visible in the teacher's talk moves? Secondly, relatively little is known about how ALS learning experiences influence students' classroom learning behaviour. In the context of this research, one could ask if engagement with ALS learning materials would prepare students be more forthcoming during classroom discourse and be more comfortable sharing partially formed ideas, encouraging more frequent student talk; or, if students' learning experiences with the ALS would enable them to present more rigorous arguments to support their points of view and exhibit greater readiness to listen, engage and debate with each other in class, i.e., encouraging deeper sharing from students. These are pertinent questions given their implications for learning design, classroom orchestration and teacher-student interactions, all of which could affect students' learning experiences and outcomes.

In summary, classroom research has demonstrated that teacher-student interactions have a significant influence on academic learning. There has been much exploration on the role teachers play in orchestrating productive teacher-student interactions, where teacher responsiveness to student ideas has been found to exert a significant influence on students' learning experiences and outcomes. While there has been relatively less research on student contributions during teacher-student interactions, student talk in general has been found to be positively associated with academic learning. On the other hand, EdTech research has surfaced preliminary findings as to how technology affords learner autonomy and greater ownership of learning, changing both why and how teachers and students interact. Specifically, ALS with its 'teacher-like' features, raises questions about the teacher's role and teacher-student interactions during classroom learning, suggesting a potential to disrupt teacher-student interactions.

With ALS gaining ground in the education space as a tool for enabling mastery while creating more personalised learning experiences (Kabudi et al., 2021), there is increasing urgency for a closer examination of teacher-student interactions in ALS-mediated learning situations, and one of the purpose of this research is to redress this.

2.5.5 Approaches for Examining Teacher-Student Interactions

The study of teacher-student interactions has been undertaken in quite diverse ways, with researchers drawing upon a range of approaches from disciplines such as linguistics, sociology and anthropology, enabling the exploration of the complex relationship between such interactions and students' classroom learning experience (Kershner et al., 2020). Examples of such approaches include conversation analysis, discourse analysis, video-based micro analysis, and systematic analysis using standardised coding schemes. In this section, I will briefly review the pros and cons of each approach for the purposes of this research, drawing from pertinent literature.

First, conversation analysis (CA) offers useful tools for illuminating the micro-sequential organisation of classroom talk, such as tracing how instructional moves produce and transform student thinking in situ. By focusing on turn-taking, repair, adjacency pairs and uptake, CA enables fine-grained descriptions of how students respond to teachers' questions, prompts and feedback and how meaning is co-constructed moment by moment (Mehan, 2014; Sinclair & Coulthard, 1978). For example, researchers have used CA to show how student talk scaffolds conceptual development and collective reasoning (Mercer, 1995), and multimodal extensions of CA emphasise how gesture, gaze and artefacts contribute to learning interactions (Goodwin, 2000). These strengths mean that CA can generate rich, theory-laden explanations of interactional mechanisms that broader survey methods miss.

However, CA also has well-documented limitations. Its intensive focus on micro sequences often results in small-N studies that pose challenges for generalisability and for drawing direct causal links to long-term learning outcomes; establishing such links typically requires complementary methods or longitudinal designs (Mehan, 2014). Critics also caution that an exclusive CA lens can under-emphasise contextual, institutional and macro-cultural factors that shape classroom interaction (Walsh, 2006). Practically, researchers must therefore balance CA's explanatory depth with broader sampling or mixed-methods strategies if claims about prevalence or impact on learning outcomes are required.

Second, discourse analysis (DA) foregrounds how language functions as social action within institutional contexts. A key strength of DA lies in its capacity to connect micro-level linguistic choices to macro-level structures such as power, ideology and pedagogic norms. In classroom research, DA has been used to show how teacher authority and student identities are discursively constructed through questioning patterns, evaluative feedback and curricular framing (Christie, 2002; Fairclough, 2013). From a sociolinguistic perspective, DA highlights how contextualisation cues, registers and participation frameworks shape who can speak, how, and with what consequences for access to learning (Gumperz, 1982; Hymes, 1974). These strengths make DA especially suitable for studies concerned with meaning-making, equity and the cultural organisation of pedagogy.

However, DA also presents notable limitations. Its interpretive and theory-driven nature can restrict generalisability and make it difficult to establish direct links between discourse patterns and measurable learning outcomes (Bloome et al., 2005). Additionally, DA encompasses diverse traditions—such as critical discourse analysis, interactional sociolinguistics and systemic functional linguistics—that differ in epistemological assumptions and analytic focus, potentially limiting comparability across studies. There is also a risk that linguistic analysis may be privileged at the expense of material, embodied or technological dimensions of classroom interaction unless deliberately integrated with complementary approaches. Consequently, while DA offers deep explanatory insight into how teaching and learning are discursively organised, it needs to be combined with longitudinal, multimodal or mixed methods designs to address issues of scale, outcomes and the full complexity of classroom practice.

Third, video-based micro analysis affords a temporally precise, multimodal account of classroom events that audio or notes alone cannot capture. High-resolution video permits researchers to slow, freeze and replay episodes, revealing the fine-grained co-ordination of speech, gesture, gaze, bodily orientation and use of artefacts that jointly constitute pedagogic action (Goodwin, 2000). It enables analysis of how teachers' momentary moves scaffold student reasoning and collaborative sense-making (Sherin & van Es, 2005). Methodologically, video fosters analytic transparency and inter-rater reliability because segments can be revisited by multiple coders and by teachers themselves in stimulated recall or professional learning settings, thereby linking microanalysis to teacher cognition and professional development (Sherin & van Es, 2005).

Nevertheless, this approach also comes with drawbacks. Video-based micro analysis is resource-intensive: collecting, storing and ethically managing large volumes of footage demands technical infrastructure, careful consent procedures and substantial transcription labour, which can constrain sample size and the representativeness of findings (Peters et al., 2021). The intense focus on short interactional sequences can generate richly detailed but small-N studies that challenge claims about generalisability or causal impact on distal learning outcomes unless complemented by larger-scale or longitudinal methods. There is also a risk of over-interpreting visible conduct while under-attending to unrecorded contextual factors (institutional policy, curriculum constraints) unless the video is embedded within broader ethnographic or mixed methods designs (Jewitt et al., 2013; Knoblauch & Schnettler, 2012).

Finally, systematic analysis using standardised coding schemes such as the Classroom Assessment Scoring System (CLASS) and the Scheme for Educational Dialogue Analysis (SEDA) offers clear methodological strengths for researching teacher–student interactions. By operationalising interactional dimensions such as emotional support, instructional quality, or specific communicative acts, these instruments permit reliable quantification, comparability across classrooms and the efficient processing of large video corpora, which in turn supports programme evaluation and correlational work linking interaction patterns to student outcomes (Allen et al., 2011; Hennessy et al., 2016). Schemes like SEDA additionally foreground sociocultural context and dialogic function, allowing analysts to cluster communicative acts into meaningful sequences that are sensitive to cultural and curricular variation (Hennessy et al., 2016)

Nevertheless, this approach also has important limitations that must be acknowledged. First, categorisation necessarily reduces rich, sequential interaction to discrete codes, risking loss of nuance about timing, overlap, prosody and multimodal resources unless coding schemes are carefully adapted or supplemented with microanalytic methods (Hymes, 1974). Second, many standard instruments prioritise inter-rater reliability and comparability at the expense of contextual specificity: what counts as productive instruction in one socio-cultural setting may be interpreted differently in another, thereby complicating cross-contextual inference (Hennessy et al., 2016). Third, reliance on coded indices alone can encourage correlational interpretations that overstate causal links between observed interaction patterns and distal learning outcomes; robust claims usually require longitudinal designs or mixed methods that combine coding with ethnographic description and outcome measures (Mashburn et al., 2008).

Weighing the pros and cons of each approach (as presented in the above paragraphs), the most persuasive research integrates systematic analysis with standardised coding scheme and video-based micro analysis and contextualised qualitative inquiry: this pluralism preserves the scalability and comparability of coding schemes while retaining the interpretive richness necessary to understand how teacher–student interactions accomplish learning in situ and the social cultural character of classroom life. As such, this research will adopt a combination of analytic approaches to examine teacher-student interactions during ALS integration (see Section 3.5 for a description of the adopted data analysis methods).

2.6 Chapter Summary

In this chapter, I synthesised literature on AI capabilities applied to teaching and learning purposes, before moving on to review literature specific to ALS. The review first examined the benefits and detriments of ALS for teaching and learning, with reference to ALS affordances as enabled by features such as dynamic task recommendations, immediate diagnostic feedback and individualised learning pace. Implications of these affordances for teaching and learning, including the impact of teacher professionalism and teacher role, as well as student learning experiences and student learning outcomes were also briefly discussed. Here, an attempt was made to distinguish between individualised learning and personalised learning, two constructs which are closely related to ALS; and while these terms are sometimes used interchangeably, they are by no means the same.

As deployment of ALS in schools increases, I subsequently reviewed literature on ALS onboarding and ALS integration with classroom learning, through the broader lens of EdTech onboarding and EdTech integration. Here I highlighted the varying onboarding focus across different education settings and noted a gap in EdTech (ALS) onboarding, which is the neglect of student onboarding. I also presented key factors influencing the effectiveness of EdTech (ALS) integration after distinguishing between use and integration, where use is a necessary but insufficient condition for effective integration. The potential impact of ALS use and integration on classroom interactions was also briefly discussed, before I moved to examine literature pertaining to teacher-student interactions.

With reference to specific studies, I illustrated the critical role teachers play in orchestrating productive teacher-student interactions and the importance of student talk for academic learning before presenting emerging evidence that smart technologies like ALS can potentially disrupt teacher-student interactions, making a case for studying teacher-student interactions in EdTech (ALS) integration research. I then wrap up this chapter with a brief review of approaches for examining teacher-student interactions, as a lead-up to further discussion on the methodology for this research.

3

Methodology

Chapter Three presents the research design and methods adopted for this study as well as the rationale behind the design decisions made. The chapter begins with a description of the case study research design and the guiding research questions. This is followed by a rich description of the characteristics of the two cases for this research as well as details about specific research procedures including data generation and data analysis. Reflections on the ethical issues encountered and researcher positionality are also discussed at the end of this chapter for further contextualisation.

3.1 Research Design

The goal of this research was to obtain a nuanced understanding of how teachers and students use adaptive learning systems (ALS) in school settings and how they draw connections between these individualised online learning experiences and the more communal classroom-based learning experiences. To this end, a case study approach was adopted, leveraging the "epistemology of the particular" (Stake, 2005, p. 442). This was in recognition of the complexities of classroom learning in schools and followed from Sancho-Gil et al. (2020) which emphasised the importance of keeping in view the local context when attempting to make sense of EdTech initiatives, which here would refer to the use of ALS and its possible influence on teaching and learning experiences.

In this study, the boundaries between the phenomenon and context are not clear, given that ALS use by teachers and students cannot be separated from the classroom environment, teaching practices and student interactions. As such, a case study research design is appropriate for exploring ALS use and classroom learning within its authentic implementation context and enabling an in-depth and holistic understanding of this complex educational setting (Yin, 2018). Furthermore, the use of ALS in mainstream education was still in its early days, and as an emergent practice that had yet to stabilise, our current understanding about ALS use and classroom learning would be better served through building a critical mass of case studies upon which practical insights could be gleaned to inform future design experiments focused on "Engineering a working environment" (Brown, 1992, p. 142), and further down the road, inform translation and scaling of ALS-mediated learning.

Case study research is especially suitable for examining complex educational innovations, such as the integration of technology in classrooms. Such innovations involve interactions between pedagogy, the technological tool, and learner behaviour, which are difficult to capture using experimental or survey-based methods alone. Case studies allow researchers to examine these interactions in detail and to understand how and why certain practices occur (Flyvbjerg, 2006). This aligns with the aim of the present study, which is not only to describe the ALS use but also to understand how such systems are integrated into everyday teaching and learning processes.

Furthermore, case study research is widely used in education to study bounded systems, such as a classroom, a group of students, or a specific instructional intervention (Baxter & Jack, 2008). For the purposes of this study, the "case" is defined as the implementation of an adaptive learning system within a particular classroom context. This bounded system includes the teacher, students, instructional practices, technological tool and community norms. By focusing on a clearly defined case, the research can provide detailed insights into how adaptive learning is enacted in practice.

The choice of case study is also supported by its flexibility in accommodating multiple sources of data. Educational case studies typically draw on a range of qualitative and quantitative data, such as observations, interviews, and documents, to develop a rich and comprehensive understanding of the phenomenon (Baxter & Jack, 2008). In this study, data are collected through lesson observations, teacher interviews, student interviews, and ALS log data. The use of multiple data sources allows for triangulation not only between what was said and done, and also across learning contexts, e.g., learning with ALS and classroom learning, and perspectives (see Section 3.4 and 3.5 for details on data generation and data analysis respectively), which strengthens the credibility and trustworthiness of the findings (Tellis, 1997; Yin, 2018).

Different methodological perspectives on case study research offer further justification for its use. First, Yin (2018) emphasises a structured and systematic approach, which is useful for designing the study, defining research questions, and ensuring rigour. Second, Stake (2005) highlights the importance of understanding participants' experiences and the meanings they construct, which is particularly relevant when examining how teachers and students engage with adaptive learning systems. Third, Merriam (1998) provides a practical framework for conducting case studies in educational settings, focusing on interpretation and the development of understanding. Collectively, these perspectives support the use of case study as both a rigorous and context-sensitive methodology (Yazan, 2015).

Another strength of case study research is its ability to generate context-rich findings that can inform both practice and theory, following from the earlier emphasis on keeping in view the local context when attempting to make sense of EdTech initiatives. Although case studies are sometimes criticised for limited generalisability, they can provide valuable insights through analytical generalisation, where findings contribute to broader theoretical understanding (Gerring, 2006; Yin, 2018). In the context of this study, the findings may inform how adaptive learning systems are implemented in similar educational settings.

Currently, the use of ALS is still in its nascent stage, which presents an opportune moment for learning not only how teachers use such a technology but also how teachers introduce it to their students. As such, this research examined both the ALS onboarding process as well as the integration of ALS with classroom learning. For the purposes of this research, the following definitions of ALS onboarding and ALS integration were adopted. Firstly, ALS onboarding refers to the *process* of ensuring that students, who are new to the tool, understand what ALS is, why they are using an ALS and how they should be making use of the tool. The desired outcome, i.e., product, of this process is for students to act upon this understanding, during both the initial onboarding phase and the subsequent lesson integration phase and make use of the ALS as part of their learning. Secondly, drawing upon the definition of integration by (Sosa-Díaz et al., 2022), integration of ALS with classroom learning in this research focuses on the micro level considerations such as individual responsibility of teachers and students, which would include teachers' pedagogical decisions and teacher-student interactions during classroom learning.

The research questions guiding this research thus reflected the two phases of ALS onboarding and integration by the participating teachers, as defined in the preceding paragraph.

1a. How does a teacher design and enact the ALS onboarding experience for students?
1b. How do students respond to the ALS onboarding experience and the selected ALS?
2. What are the characteristics of the observed teacher-student academic interactions during classroom lessons for the period of ALS integration?

(See Table 3-12 Summary of Research Procedures for a summary of the data generated and analysed to address these research questions, which would be discussed in Sections 3.4 and 3.5 on data generation and data analysis respectively.)

This research was conducted in two secondary English language classrooms in two comparable Singapore schools, using a multiple-case design (Table 3-1). This was to replicate the typical conditions of technological implementation in Singapore schools, which were top-down initiatives through central provision and local innovations initiated by the school leader(s) or external researcher(s). In Case 1, the participating teacher could not choose which ALS he would be using, simulating central provision where the tool is deployed by the Ministry of Education. In Case 2, the participating teacher was given the option of choosing which ALS she would use, mimicking the school- or researcher-initiated approach to classroom innovation, where there would be more room for choice, compared to Case 1.

Despite the differing research conditions of central provision and local innovation, in both instances, the initiator of this intervention was not the teacher. Even though both participating teachers were consulted on their willingness to participate in this research, it was not clear if and to what extent the participating teachers' choices and agency were constrained, and if and to what extent they embraced learning with ALS or saw ALS as a solution to their existing instructional challenge(s). Research has shown that when teachers have limited input into design and implementation, they may adopt compliance-oriented practices, using tools superficially rather than integrating them pedagogically (Cuban, 2013; Selwyn, 2021). This also suggested a risk of misalignment between the intervention and the teachers' contextual knowledge, instructional goals, and classroom realities, reducing ownership and sustainability.

From the above, teacher agency can be said to be critical not only for meaningful integration but also for adapting innovations to support authentic learning and responsive classroom practice. As such, where possible, teacher choice and agency were preserved for this research. In both instances, the participating teacher could choose which topic to teach with ALS, mirroring the current situation of technological innovation and implementation in Singapore schools. Apart from the introduction of an ALS, no further imposition was made on the school in terms of when and how to use the ALS. This was intentional, stemming from the belief that an orientation toward teachers and students' daily practice in their natural habitats afforded the surfacing of implementation benefits, challenges and complexities surrounding the use of ALS in support of classroom learning, thus attaining the goal of this research. Furthermore, to address any potential misalignment, pre-intervention engagement was carried out to support teachers in understanding what ALS and learning with ALS entailed as well as sense-making how to integrate ALS with their instructional practices (see Sections 3.2.2.1 and 3.2.3.1 for details on pre-intervention engagement for the two cases respectively.)

Table 3-1 Multiple-Case Design

Condition	Case 1	Case 2
Context	Central provision of ALS-mediated personalised learning	School/ Researcher-initiated ALS-mediated personalised learning
Choice of ALS	By researcher* or head of department **Simulating the role of a policymaker*	By participating teacher
Choice of lesson topic	By participating teacher	By participating teacher

3.2 Case Characteristics

3.2.1 Participant Recruitment

An email was sent to 10 secondary schools inviting them to participate in this research. These schools were purposefully shortlisted from 101 government secondary schools[2] offering standardised fees and curriculum. The rationale for focusing on government schools was twofold. Firstly, government schools form most of what was commonly known as 'mainstream schools' and account for close to 70% of secondary schools in Singapore. Secondly, the student population of these schools tended to be heterogeneous, whether it was in terms of ethnicity, learning readiness or home situations. This diversity mirrored the socio-economic circumstances of the country and offered an authentic and rich context for researching teaching and learning in Singapore schools. As such, situating this research in government secondary schools would suggest that the reported findings may potentially have some applicability to other government schools with similar demographics.

The criteria for shortlisting these schools were informed by research on EdTech integration (see Section 2.3.2), and included researcher access, school leadership endorsement, supportive school culture and teacher availability. Researcher access here considered

[2] The other types of secondary schools in Singapore included government-aided, independent, specialised independent and specialised schools. These schools were excluded primarily due to unsuitable student demographics (e.g., relatively homogenous enrolment of very high performing students or students with special educational needs) and/or they were not offering the standardised curriculum. As of Nov 2022, there were a total of 148 secondary schools in Singapore.

whether I would have an opportunity to pitch my project to the decision makers and the likelihood of my invitation being accepted. This assessment was made primarily with reference to my previous working relationship with the principal or the vice-principal of the school and if that was a positive experience for both parties. Given that researcher access was a necessary pre-condition for the research to proceed, it was one of the first considerations to be applied. School leadership endorsement here considered the principal, vice-principal and department head's stance on two counts, technology use for teaching and learning and pedagogical innovations in the classroom. This was extrapolated from information published on school websites and backend checks with colleagues and friends who might have worked with or in the school or had children who studied in the school. School leadership endorsement was critical as it could influence the extent to which school-based resources could be mobilised for this research. These resources could be in the form of offloading participating teachers from other duties or sharing of school-based instructional materials and student learning data with the researcher.

A school culture supportive of technology-enabled learning and pedagogical innovations was also desired to minimise any dissonance that participating teachers and students may experience if the school culture was otherwise. This was gleaned from the schools' track record in classroom innovations through reviewing relevant press releases from the Ministry of Education and news features in the local newspapers, and their involvement in related professional learning communities, such as the SgLDC[3] on Facebook. Finally, teacher availability was also considered, and this was in terms of the number of external and internal projects[4] that the school and the department was currently managing. This was intended as a safeguard against over-commitment by the school and to avoid the awkward situation of

[3] SgLDC refers to the Singapore Learning Designers' Circle which was established in 2017 by the Educational Technology Division, Ministry of Education, Singapore. A closed Facebook group, it functions as an online networked learning community for educators in Singapore discuss and share information on use of technology for teaching and learning.

[4] Examples of internal projects included school-based curriculum review, development of niche learning programmes and organising large scale school events. Examples of external projects could be in the form of research collaboration with local academics from the National Institute of Education (NIE) or pilot studies with the Ministry of Education.

participating teachers having to juggle multiple research projects. Apart from the rationale given for each of these considerations, the latter three – school leadership, school culture and teacher availability – have also been found to be critical success factors for school-based innovations in Singapore (Seow et al., 2020).

Eventually, two of the 10 secondary schools that I contacted via email accepted my invitation to participate in this research. The research participants, comprising one experienced teacher and one class of lower secondary students from each school, were nominated by the school leaders. The only criterion for teacher selection was that the teacher should have more than two years of teaching experience[5]. A more experienced teacher was preferred on the assumption that such teachers would have over the years honed their subject mastery and pedagogical expertise and were also more likely to have overcome issues related to student and classroom management. The absence of other criteria was intentional, to minimise the halo effect and any undue pressure on the part of the nominated teachers to 'live up to expectations.'

In both schools, teacher participation was voluntary and supported by their respective department heads and principals. By voluntary, this meant that prior to the school's acceptance of my invitation, nominated teachers were consulted on their interest to participate, and they could decline to participate without stigma or penalty. This was because my proposed research was not commissioned by the Ministry of Education, and neither the school nor the teachers were under any obligation to participate. The support of the respective department heads and principals came in the form of formal recognition, where the teachers' involvement in my research constituted part of their official workload for the academic year. Adjustments were also made to their teaching duties, including being assigned to teach at least one lower secondary class.

---

[5] In Singapore, teachers with less than two years of teaching experience are beginning teachers and are expected to complete mandatory in-service training programmes within a given time frame. These teachers were not desired participants due to these training commitments that would also take up their time. Furthermore, being relatively inexperienced, they could still be grappling with issues of classroom management or lacking deep pedagogical knowledge that would take time to develop. As such, these teachers might be less ready to engage with the technology-enabled pedagogical innovation which would be the kernel of their involvement in this project.

The class of student participants was jointly selected by the department head and participating teacher. The department head was involved in this selection as it had implications on teacher workload and lesson schedules. Once the decision was made, the participating teachers spent some of their time in class explaining to students the purpose of this research, what it would entail and the role they would play. Parents' consent was also actively sought, i.e., opt-in, via Parents' Gateway, a national portal used by all Singapore schools to communicate with parents. Each teacher then selected six students from the class who would be interviewed three times for this research. Both teachers were given the same criteria for student selection, namely students' readiness to learn and students' participation during whole class interaction. These considerations were highlighted as the student interviews would focus primarily on students' perceptions on whether Fast ForWord had any effect on their classroom learning experiences and their mastery of the English language.

As far as possible, autonomy was given to the school principal, department head and participating teacher throughout the entire recruitment process. This was a deliberate move, firstly out of respect to these research sponsors (the school principal and department head) and research participants (the teacher), very mindful that my research was possible because they welcomed me into their local community. As such, I was very much guided by relational ethics, which "recognizes and values mutual respect, dignity, and connectedness between researcher and researched, and between researchers and the communities in which they live and work" (Ellis, 2007, p. 4). Secondly, having partnered schools over the past three years on various innovation projects, I have come to value school collaborators as equal partners and co-creators in the research process, as they bring practical creativity and tacit contextual knowledge to this research, pulling their weight as 'indigenous people' of the school (Gonzalez, 2000).

3.2.2 Case Study 1: Ubin Secondary School

Ubin Secondary School is a government co-educational school located in the northern region of Singapore. A school of choice for the local community, Ubin Secondary has been implementing school-wide differentiated instruction since 2016. It is also one of the first schools in Singapore to implement the Full Subject-Based Banding (Full-SBB), a national initiative that allows students flexibility to customise their secondary education based on their strengths and interests. Ubin Secondary School also actively leveraged technology to personalise student learning and deepen students' ownership of learning. One example of such efforts would be the use of Augmented Reality (AR) for learning Mathematics. Under the leadership of the incumbent principal, the school has worked tirelessly to create a positive learning environment for students and engage them with pedagogically sound technology-enabled learning experiences. Given the alignment between the school's goals and the proposed research, after discussing my invitation with the English Head of Department (to review staff workload and capacity to take on this project), the school decided to be part of this research.

The participating teacher, Mr Tan, has been teaching English language and English literature in Ubin Secondary School for more than 20 years. In the year that data was collected, Mr Tan was teaching two English language classes in Secondary One and Secondary Four and four English literature classes across Secondary One to Secondary Three. His total teaching hours each week were almost 17 hours, close to the national average of 17.7 to 18 hours per week[6] (Ministry of Education, 2025). In addition, he also had other related duties, such as leading a professional learning community on adaptive learning and overseeing students' co-curricular activity. His weekends were often spent creating lesson materials for his students. Despite his rather packed schedule, Mr Tan agreed to participate in this research project when approached by his Head of Department, as he was curious about adaptive learning and was keen to explore how technology could be better leveraged to improve student learning experiences and learning outcomes.

The Secondary One class participating in this research was a banded class, where students were drawn from two different form classes and grouped into this English language class based on their aptitude and interest for the subject[7]. The class comprised 29 students, of

---

[6] Singapore teachers reported an average of 17.7 to 18 teaching hours per week, lower than the OECD average of 22.7 to 23 teaching hours per week; however, the average working hours of Singapore teachers, which is 47.3, is higher than OECD's average of 41 working hours per week (Ministry of Education, 2025).

[7] This was in line with the Full Subject-Based Banding (SBB) policy that was progressively implemented in Singapore secondary schools. More information on this can be found at the Ministry of Education Full SBB microsite. https://www.moe.gov.sg/microsites/psle-fsbb/full-subject-based-banding/main.html.

whom 16 were boys and 13 were girls, and their ages ranged from 12 to 13 years old. These students were offering English language at G3, where G stood for General, the highest subject level students could offer for any academic subject at Secondary One. During the initial teacher interview, Mr Tan described the class as disciplined and responsive. All their parents gave consent for their child to be part of this research and for their lessons to be video recorded. From among these 29 students, Mr Tan selected six students (three boys and three girls) who would be interviewed, based on the given criteria of student readiness to learn and student participation during whole class interaction (see Table 3-2). On his own initiative, Mr Tan intentionally selected a balanced mix of boys and girls and students representing all three major ethnic groups, Chinese, Malay and Indian, in Singapore.

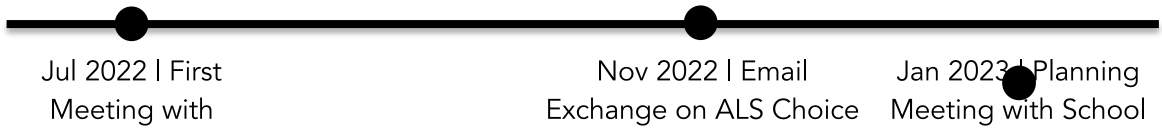
Table 3-2 Ubin Secondary Student Interviewees

Student Identifier	Readiness to Learn	Participation During Whole Class Interaction
F08	High	Vocal
M29	High	Quiet
F04	Moderate	Moderate Vocal
F01	Moderate	Moderate Quiet
M10	Low	Vocal
M15	Low	Quiet

3.2.2.1. Pre-Intervention Engagement

This section describes three key points of pre-intervention school engagement between Jul 2022 and Jan 2023, illustrating the circuitous path taken for research planning, which revolved around pedagogical and operational issues such as confirming the lesson observation time frame and lesson unit for ALS integration. These touchpoints (Figure 3-1) were highlighted to provide some background information on the work that the school had to do prior to the research as well as illuminate aspects of the school norms and culture that have implications for this research.

Figure 3-1 Pre-Intervention Engagement Milestones with Ubin Secondary School



Research planning commenced in July 2022, during my first meeting with the school, attended by the Department Head and Mr Tan, the participating teacher. The purpose of this preliminary meeting was to clarify any outstanding questions or concerns the school might have, surface possible lesson units that could potentially benefit from the integration of an ALS, as well as discuss operational issues such as identifying a suitable time frame for data collection. At this meeting, the school informed the researcher that they would be involving a class of Secondary One students in this research. This was motivated by the department's interest to progressively introduce adaptive learning across grade levels (from Secondary One upwards) if adaptive learning was found to be effective in supporting the development of language skills. We also arrived at a consensus to start data collection from 2023 Term 1 Week 5 onwards, taking into consideration that these students would be attending Orientation Camp in the first two weeks of term and potential disruptions to lessons in the form of Chinese New Year celebrations and public holidays in Week 4. The school had full autonomy in deciding the lesson unit for integration with the ALS and the data collection time frame. This was to minimise potential disruption and for better alignment with the school's plans and the department's programmes.

In November 2022, as I was finalising the ALS that would be used for this research over email with the school, I was alerted that the Secondary One students would not be receiving their Personal Learning Devices (PLDs) until the end of Term 1. While Mr Tan offered to explore "alternatives of using iPads and/or computer labs for them to access the system during class reading periods," I had some reservations as this meant that students would not be able to access the ALS in their own time and could curtail students' use of the system. After further email exchange, and in response to my question if there might be another suitable period for this research after students received their PLDs, Mr Tan counter-proposed postponing the data collection till Term 2. This decision was made after he consulted with the school's ICT Head and learnt that the 2022 cohort of Secondary One students received their PLDs in Term

2 Week 2. As that was the first year of implementation, the school was optimistic that students should be receiving the PLDs earlier in 2023, likely by the end of Term 1, and we should be good to start the research in Term 2.

In Jan 2023, Mr Tan and I met again to confirm the lesson unit for integration with the selected ALS, the subscription period for the ALS and the duration of the lesson observation. At that point, Mr Tan has yet to receive his ALS login credentials and was thus unable to share further on his plans for integration. However, we did work through his preliminary ideas for student onboarding. At this meeting, he also warned that there might be further delay to students receiving their PLDs, and we briefly discussed the adjustments that needed to be made to our plans as the school was unable to further postpone this research, with a packed school schedule for the rest of the year. We explored asking students to use their own devices but were uncertain if all students had access to a mobile device that they could use and bring to school when needed for learning with the ALS. To find out, Mr Tan polled the participating class and ascertained that every student would have access to a mobile device at home, though many of them were sharing that device with siblings or parents. In tandem with making alternative plans, I also engaged the vice-principal to find out if there was any possibility of issuing students with their PLDs earlier. While the vice-principal was very helpful and attempted to engage other stakeholders in the process, including the ICT Head, and the procurement team at the Ministry of Education in charge of ordering the PLDs, to expedite the process, the students still did not receive their devices until two days before the end of the classroom observation period.

While I acknowledge that such pre-intervention engagements were not a formal part of this research, these touchpoints with the school offered me insights into the school culture and its attitudes toward technology integration and classroom innovations. The consultative approach to decision-making adopted by the principal, the department head and Mr Tan throughout this engagement process suggested a school culture that was somewhat egalitarian and empowering. During my meetings with the Department Head and Mr Tan, there was active participation from both parties though I observed that the Department Head would often step back and let Mr Tan lead the conversation. This created a safe space where Mr Tan could explore his ideas and be generative. In fact, Mr Tan has emailed on a few occasions outside of our meetings with more ideas that he would like to try, such as implementing adaptive learning beyond the ALS and instituting an in-house reading programme prior to research in Term 2 to develop students' language skills and nurture their love for the language. These suggestions from Mr Tan not only reflected his creativity and confidence but also alluded to a school environment that was supportive of technological integration and classroom innovations. The efforts on the part of the vice-principal and ICT Head to speed up the issue of PLDs to students, though unsuccessful, was further testimony to the school's overall supportive environment.

3.2.3 Case Study 2: Kusu Secondary School

Kusu Secondary School is an autonomous[8] government co-educational school located in the northeast region of Singapore. Since its founding in the mid 1900s, the school has over the years acquired a reputation for being an excellent educational institution and was among the first schools to be awarded autonomous status by the Ministry of Education. The school presently offers four signature programmes related to computational thinking, perspective taking, community service and leadership development, aimed at holistic student development. Its rigorous academic programmes were also designed using their in-house teaching and learning framework. Since the second half of 2021, the school has been implementing home-based learning day once a fortnight, in tandem with the implementation of Personal Digital Learning Programme (PDLP), a nationwide initiative to equip every secondary student with a personal learning device (PLD) when they start Secondary One. The school participated in this research as it was aligned with the school's ongoing efforts to make better use of PLDs for classroom learning as well as an interest to explore how ALS can support the development of critical reading and critical thinking skills among lower secondary students.

---

[8] Autonomous schools here refer to government or government-aided schools that autonomous status. In addition to offering the standardised curriculum, these schools have the flexibility to offer their own signature programmes aimed at providing students with a wider range of learning experiences and opportunities to develop their talents. Students enrolled in these schools would need to pay an additional monthly autonomous school fee that ranges between SGD$3.00 to SGD$18.00.

The participating teacher, Ms Aliyah, worked in the private sector in various capacities before becoming a teacher. She joined Kusu Secondary School after completing her Post-Graduate Diploma in Education (PGDE) and has taught in the school for slightly more than 10 years. In the year that data was collected, Ms Aliyah was assigned a teaching load of four English language classes, namely two Secondary Four (graduating) classes, one Secondary Two class and one Secondary One class. Her total teaching hours per week were approximately 12 hours. She was the Form Teacher to one of the Secondary Four classes and conducted Character and Citizenship Education (CCE) lessons for the class once a week. Ms Aliyah also had other related duties including overseeing students' co-curricular activity and representing the department at the school's Information and Communication Technology (ICT) Committee. The latter was the primary reason for her participation in this project, as the role motivated her to learn more about different technological affordances and how the various tech tools can be used to support language learning.

The Secondary Two class participating in this research was a banded class, where students were drawn from two different form classes[9] and grouped into this English language class based on FSBB guidelines. The class comprised 35 students, of whom 15 were boys and 20 were girls, and their ages ranged from 13 to 14 years old. All students in this class were on the Express course, except for one girl who was on the Normal (Academic) course[10]. During the first interview with Ms Aliyah, she described the class as rather quiet and lacked confidence in public speaking. Even though she only started teaching this class three months ago, she noticed that they sometimes would need an extra nudge to do their work. Three girls were excluded from this research as their parents did not give consent for their child to be video recorded. As such, only 32 students from the class participated in this research. From among these students, Ms Aliyah selected six students (four boys and two girls) to be interviewed, based on the given criteria of student readiness to learn and student

[9] These were mixed form classes comprising students offering different courses – Express, Normal (Academic) and Normal (Technical), which was part of the Full-SBB initiative that was being piloted in the school since 2020.

[10] The Express Course is a four-year academic programme leading to Singapore-Cambridge General Certificate of Education (GCE) O-Level certification. The Normal (Academic) course is a four-year academic programme that culminates in the Singapore-Cambridge GCE N(A)-Level certification. Students who do well can progress to Secondary Five to take the O-Level examination.

participation during whole class interaction (see Table 3-3). In addition, Ms Aliyah also considered students' readiness to share candidly during interviews, and intentionally selected students who were more likely to speak up during interviews, particularly for students who were quieter in class.

Table 3-3 Kusu Secondary Student Interviewees

Student Identifier	Readiness to Learn	Participation During Whole Class Interaction
M17	High	Vocal
M32	High	Quiet
F27	Moderate	Moderate Vocal
M34	Moderate	Moderate Quiet
M18	Low	Vocal
F26	Low	Quiet

3.2.3.1. Pre-Intervention Engagement

This section describes three key points[11] of pre-intervention school engagement between Aug 2022 and Mar 2023, providing snapshots of the journey that was undertaken by both the school and me as the researcher at this initial stage of the research. It also illustrates how contextual and operational issues could bring to bear on research and pedagogy, such as the final selection of the lesson unit for ALS integration. These touchpoints (Figure 3-2) were also highlighted as they not only offered a view of how the school was managing this research but also illuminated aspects of the school norms and culture that have implications for this research.

Figure 3-2 Pre-Intervention Engagement Milestones with Kusu Secondary School

[11] The process of selecting the ALS (i.e., Email Exchange on ALS Choice) will be discussed in the next section on ALS selection and thus will not be addressed in here.

My first meeting with the school took place in August 2022, and was attended by the Department Head and Ms Aliyah, the participating teacher. This meeting was conducted on Zoom as it was scheduled on the school's home-based learning day, and this was the only available meeting slot for the school. The purpose of this meeting was to clarify any outstanding questions or concerns the school might have, surface possible lesson units that could potentially benefit from the integration of an ALS, as well as discuss operational issues such as identifying a suitable time frame for data collection. However, we did not manage to discuss all the agenda items at this meeting and spent most of our time together clarifying the school's interests and concerns. At this meeting, the Department Head expressed the English department's interest in exploring how adaptive learning could be leveraged to improve student engagement during home-based learning days as well as be an avenue for students to develop their critical literacies. She also highlighted that the selected ALS should be safe and secure for student use, help teachers monitor students' progress and give feedback in a systematic and data-driven way. Ms Aliyah added that she would need to know more about the selected ALS before deciding on the lesson unit for integration with the use of this tool. By the end of this meeting, we agreed that adequate time and space should be catered for tool familiarization and for identifying a suitable lesson unit, so that the use of ALS would be purposeful and add value to students' learning experience.

Research planning commenced proper in January 2023, when I had my first meeting with Ms Aliyah. At this meeting, Ms Aliyah updated that a Secondary Two class would be participating in this research. This was a departure from the school's earlier communication in November 2022 via email that they would be involving a Secondary One class. Ms Aliyah explained that this was due to her finalised teaching load for this year as she was not assigned to teach any Secondary One class. Ms Aliyah also informed that she had selected the Narrative Comprehension lesson unit for integration with ALS use.[12] This unit would be taught over five weeks and culminate in a student-led project. During this meeting, I attempted to engage

[12] It should be noted here that I was subsequently informed, at the start of the lesson observation in Apr 2023, that there was a change in the lesson unit selected for integration. The lesson unit that I would be observing was Discursive Writing instead of Narrative Comprehension. At the point of this update, Ms Aliyah did not offer any reason for this change, and I did not probe further.

Ms Aliyah in a discussion of her plans for integrating ALS use with classroom learning. However, she reiterated her earlier response that plans could only be made after she had been given access to Fast ForWord and after having a better understanding of what Fast ForWord had to offer. However, teacher access to Fast ForWord would only be available one week prior to the start of the student subscription. By the end of this meeting, we agreed on the subscription period for the ALS, made preliminary plans for student onboarding and identified outstanding matters for follow-up, such as the selection of student interviewees. To address outstanding matters from this first meeting, Ms Aliyah and I met again in March 2023 to finalise plans for student onboarding as well as the students who would be interviewed.

The three engagements presented here were brief, lasting approximately 45 minutes per meeting. However, these touchpoints offered me a glimpse of the school norms and culture and foreshadowed how I would be working with the school during data collection. Firstly, I noted a good balance of school leadership and teacher autonomy through my interactions with the Department Head and Ms Aliyah. The Department Head exercised directive leadership during our first meeting in August 2022, as she drove the agenda with an elaborate introduction to the school and a rather detailed articulation of the school's agenda for participating in this research. However, soon after that meeting, the Department Head stepped back from this collaboration and Ms Aliyah took over as the school liaison. She was also given a free rein to experiment with both the use of ALS with her students and integrating it with classroom learning. Secondly, particularly during the two meetings with Ms Aliyah in January and March 2023, I noticed that Ms Aliyah was very cautious not to overpromise, reflecting a somewhat risk-adverse disposition. For example, she would rather delay responding to my queries than to offer a tentative reply, such as the earlier mentioned hesitation to share how she would integrate the use of ALS with the selected lesson unit. These suggested that, despite the autonomy given to Ms Aliyah, her inclination to err on the side of caution might propel her toward a more 'conventional' use of the ALS, as opposed to trying to be innovative.

3.3 ALS Selection

In accordance with the research design, Ms Aliyah, participating teacher from Kusu Secondary School (Case 2), was involved in the process of selecting the ALS. To support her in making the choice of which ALS to use, she was provided with a shortlist of three ALS (see Appendix A) from which she selected one that she would like to use for this research. This was in consideration of Ms Aliyah's lack of familiarity with ALS in general, the absence of consolidated information about ALS suitable for use with the Singapore curriculum, and a desire to avoid adding too much to Ms Aliyah's workload. Prior to the shortlist, Ms Aliyah was consulted on her preliminary thoughts about how an ALS might be beneficial to the profile of students that she was teaching and how she may wish to use and integrate the ALS with her existing practice. She shared that her students did not read very much and could possibly benefit from a reading programme. She also noticed that her students were not always ready to learn and thus she also hoped that an ALS would be able to improve students' learning readiness and motivation to learn. These input, alongside other operational considerations presented in the next paragraph, guided the shortlisting process.

The three ALS were shortlisted through a process of searching the Internet (e.g., searching Google) using keywords such as "adaptive learning systems", "adaptive learning apps" and "personalised learning platforms" and reviewing online recommender websites such as "Best Games, Apps, and Sites for Personalized Learning" by Common Sense Media. This search and shortlist exercise was carried out in Oct 2022 and at that point in time, there were not many adaptive learning systems targeted at language skills development. This attempt to shortlist was further complicated by firstly, local regulations that the selected ALS needs to be whitelisted by the Ministry of Education, Singapore before it can be used in school, and secondly, the preference by schools for an ALS that was managed by a local vendor for a smoother procurement process. Furthermore, given that Singapore is a non-anglophone country where students study and use English language as a first language in school, it is challenging to identify an ALS that allows students to develop reading mastery along the English as first language and second language continuum using the same platform.

The final shortlist comprised three ALS of which two had local distributers that were marketing the respective ALS to local schools; they were namely iReady and Fast ForWord. The third shortlisted ALS was Quindew, a free-to-use, browser-based adaptive learning programme that did not require any procurement or installation. It also required minimal student information, only an email address, for them to create an account on the platform. Information pertaining to each ALS's target audience, key features, teacher onboarding provisions and cost were presented on the shortlist. This information was curated taking into consideration known predictive factors affecting educational technology adoption, which included perceived enjoyment, technological complexity, computer anxiety and system accessibility (Granic, 2022). While the curated information was not a perfect match to these known predictive factors, it was intended as a proxy through which Ms Aliyah could assess which ALS was a best fit for her context.

Close to three weeks after receiving the shortlist, Ms Aliyah confirmed her choice of Fast ForWord. When communicating this choice, Ms Aliyah did not share her rationale for selecting Fast ForWord. She did later mention during the third interview that her choice was largely due to gamification features that Fast ForWord offered. When probed further, she did not explain why Fast ForWord was preferred over Quindew, which was not only free to use but also offered gamification features. It should also be noted here that while Mr Tan was not involved in the selection of ALS selection, his concurrence was subsequently sought, to ensure that he had no strong objection to the use of Fast ForWord.

As a result of Ms Aliyah's choice and Mr Tan's concurrence, Fast ForWord was the ALS used for this research. Fast ForWord is an adaptive reading programme developed by Carnegie Learning, whose founders were from Carnegie Mellon University, Pittsburgh, USA. The developers claimed that Fast ForWord is "one of the most researched interventions," where there have been "more than 300 research studies verifying its effectiveness" (Carnegie Learning, n.d.). The entire programme comprises Elements I, Elements II, Reading Level 1, Reading Level 2, Reading Level 3, Reading Comprehension, and Reading Assistant Plus, supported by Reading Progress Indicator, an assessment tool that measured phonological awareness, decoding, vocabulary and comprehension.

For the purposes of this research, only Reading Progress Indicator, Elements I and Reading Comprehension were made accessible to students. (See Appendix B for developer-provided description and scope of the Fast ForWord components used in this research.) Reading Comprehension was added partway during data collection in response to a concern raised by Mr Tan, the participating teacher from Ubin Secondary School. He gave feedback that Elements I was not aligned to the local curriculum and asked if reading comprehension exercises could be introduced instead. The local distributor of Fast ForWord, BrainFit thus gave students concurrent access to Reading Comprehension.[13] Even though Ms Aliyah, the participating teacher from Kusu Secondary School, did not raise this concern, for purposes of parity, Reading Comprehension was made available to both schools at the same time.

3.3.1 Overview of the Selected ALS: Fast ForWord

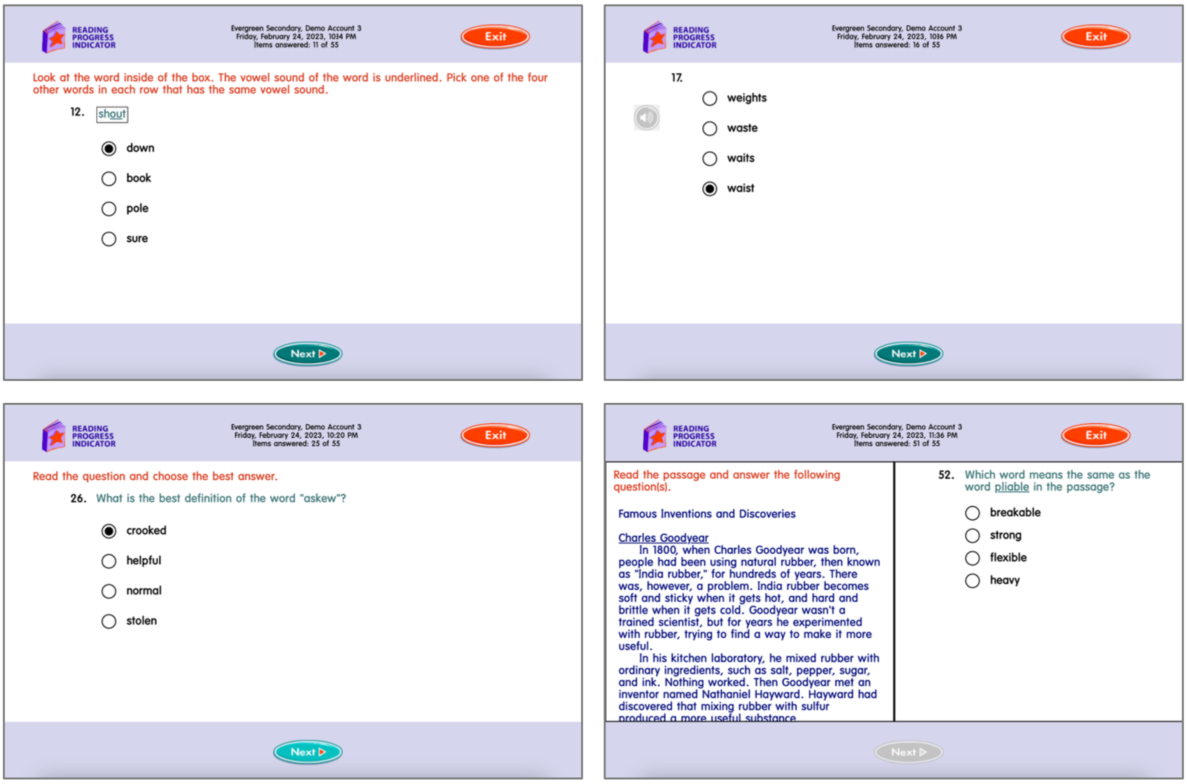
Fast ForWord is an adaptive, computer-based literacy intervention designed to strengthen both foundational reading skills and underlying cognitive processes such as memory, attention, processing, and sequencing. It provides personalised, one-to-one instruction through interactive, game-like exercises that continuously adapt to student performance, offering real-time feedback and targeted practice (Carnegie Learning, n.d.). The programme is structured as a sequence of modules progressing from foundational auditory and language skills (e.g., Elements 1 and Elements 2) to higher-order reading and comprehension abilities (e.g., Reading Comprehension and Reading Assistant Plus) (Learning, n.d.).

Students' first encounter with Fast ForWord would be the Reading Progress Indicator (RPI), (see Figure 3-3 for screen captures of sample RPI questions) which provided a standardised estimate of a student's likelihood of successfully comprehending grade-level texts. This metric served as a diagnostic and progress-monitoring tool, allowing teachers to track growth over time, identify students who required additional support, and make instructional decisions regarding readiness for more complex texts (Carnegie Learning, n.d.). In other words, the RPI translated in-programme performance into an interpretable measure aligned

[13] During the procurement process, BrainFit explained that there was a preferred sequence to accessing different components of Fast ForWord. However, for the purposes of this research, BrainFit made an exception and enabled concurrent access to Elements I and Reading Comprehension.

with broader literacy expectations, thereby bridging adaptive practice with classroom learning goals. However, as with many algorithmically generated indicators, its usefulness depended on students' utilisation and teachers' ability to interpret the metric in conjunction with other evidence of student learning, including classroom assessments and observations (This will be discussed in greater depth in Chapter 4).

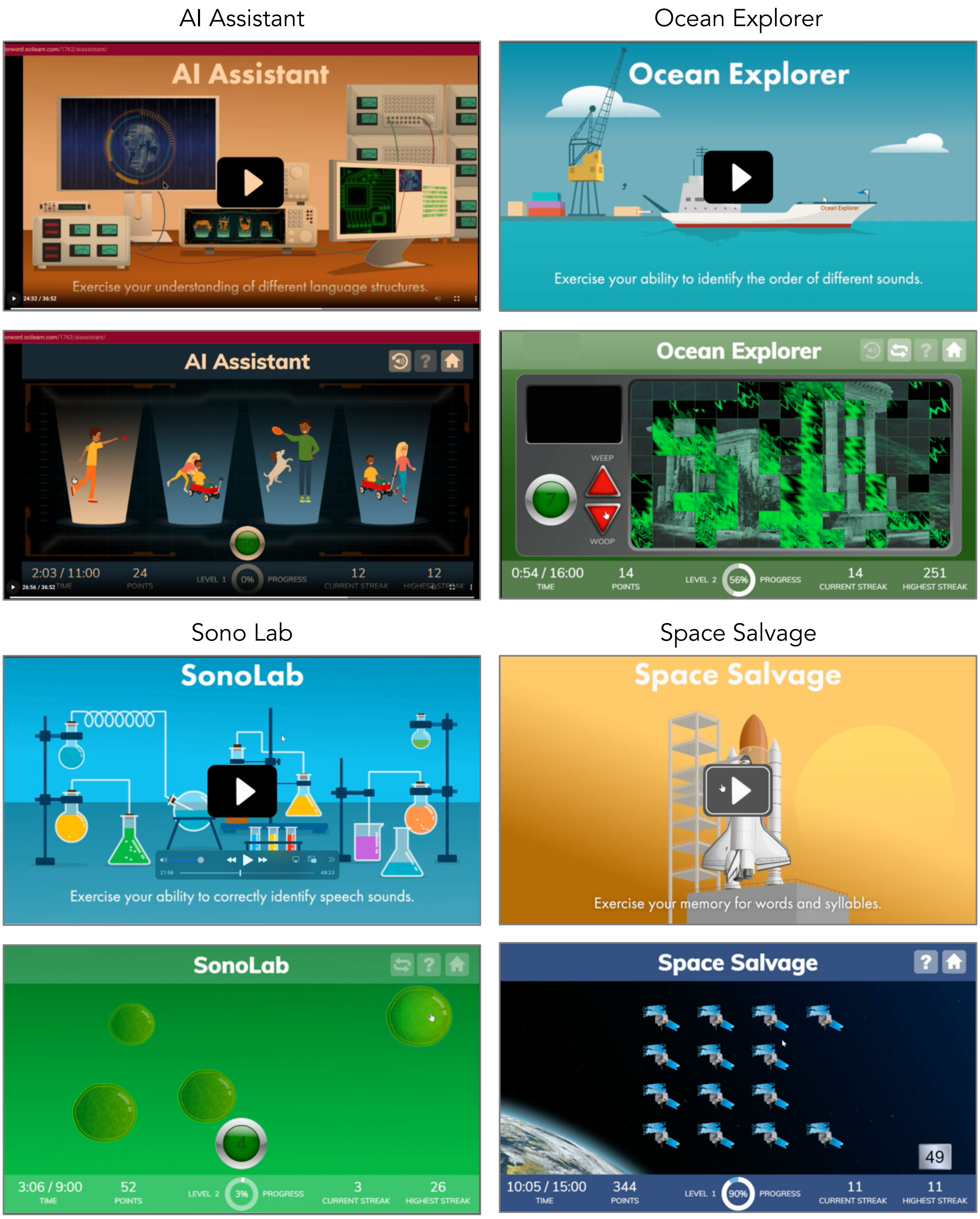
Figure 3-3 Sample Questions from the Reading Progress Indicator (RPI)



The above screen captures, show four types of questions featured in the 55-item diagnostic assessment instrument.

Upon completion of the RPI, students would progress to Elements 1, which comprised types of exercises, namely AI Assistant, Ocean Explorer and Sono Lab (see Figure 3-4 and Appendix B for screen captures and a brief description of each exercise type respectively). These exercises were designed primarily for adolescent learners, namely upper primary and lower secondary learners, and focused on building the cognitive and linguistic foundations necessary for reading comprehension. The targeted foundations included auditory discrimination, phonological processing, working memory, and language structures. The module also emphasised mastery-based learning through repeated, high-frequency practice and continuous assessment, and contained gamified elements, rewards, and progress tracking, which were used to sustain learner attention and persistence. Overall, the Elements module sought to strengthen the cognitive-linguistic foundations (e.g., sound processing, working memory) that underpin fluent reading and comprehension.

Figure 3-4 Screen Captures of Elements 1 Exercises



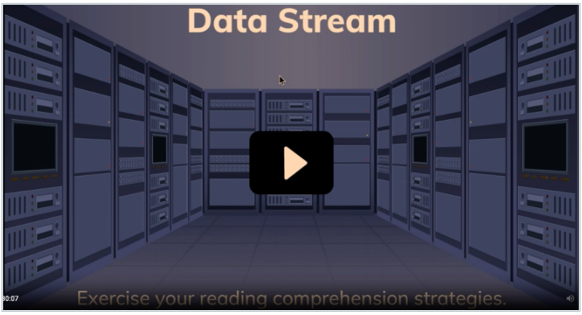
The other Fast ForWord module that students had access for this research was the Reading Comprehension module, which was added part-way during data collection at the request of Mr Tan. Five types of exercises, namely Art Walk, Cognobot, Data Stream, Print Shop and Road Trip, were available to students (see Figure 3-5 and Appendix B for screen captures and a brief description of each exercise type respectively). These reading comprehension exercises built on earlier modules by focusing on "reading to learn" skills, helping students construct meaning from increasingly complex texts. Tasks that students were asked to complete included use of graphic organisers to analyse and synthesise information from texts and structured comprehension tasks featuring literal and inferential questions and metacognitive understanding. Text length, task complexity, and cognitive demands increased progressively across levels, supporting gradual development of comprehension strategies. These activities also emphasised connecting new information with existing knowledge, a key process in comprehension development.

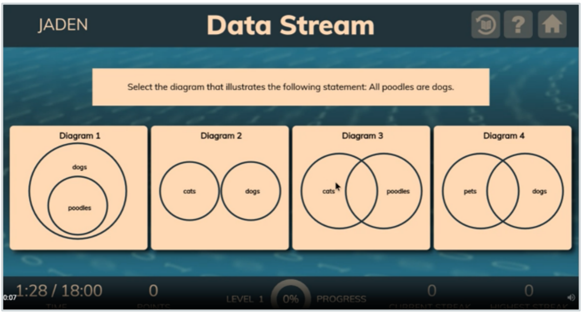
Figure 3-5 Screen Captures of Reading Comprehension Exercises

Art Walk

Cognobot

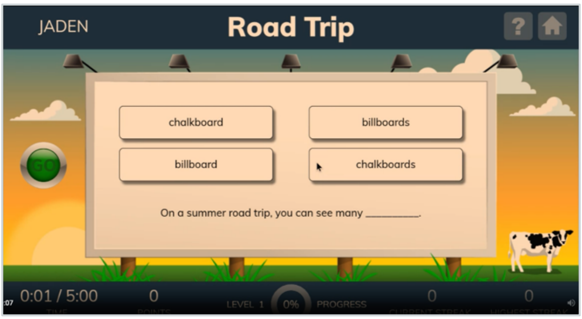
Data Stream





Print Shop

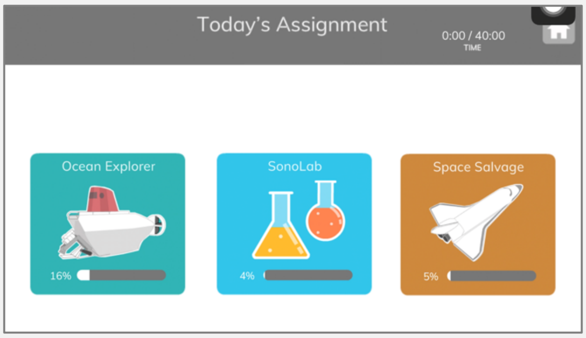
Road Trip



Overall, Fast ForWord modules aimed to transition learners from foundational decoding and processing skills to higher-order comprehension, supporting both academic reading and content learning across subjects. Through persistence usage, students were expected to show improvement in their reading comprehension skills; where persistence usage, as recommended by the developer entailed at least three logins of at least 30 minutes per week over a sustained period such as a term or a year (see Figure 3-6 for a sample student learning flow with Fast ForWord).

Figure 3-6 Sample Student Learning Flow with Fast ForWord

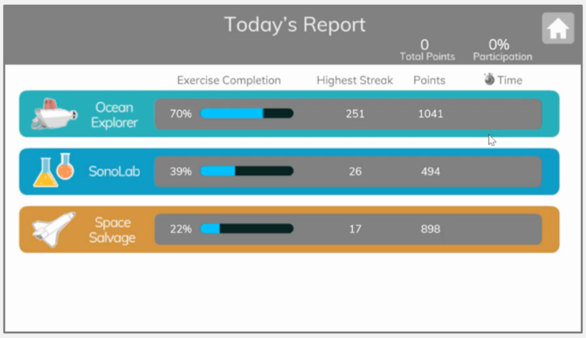
1. Each Fast ForWord session comprised three exercises that students were expected to complete within 40 minutes (maximum duration).



2. Students could complete the recommended exercises in any sequence (of their choice).

(See Figures 3-4 and 3-5 for screen captures of the exercises available to students)

3. Upon completing all three exercises, students received a progress report summarising their attainment for that session.



3.4 Data Generation

This research combined classroom lesson observations and semi-structured interviews with teachers and students to generate its data (please see Appendix C for the data generation timeline). These data were augmented with student usage data extracted from Fast ForWord, the ALS used for this research. The resulting data set thus comprised video recordings of classroom lessons, audio recordings of interviews with teachers and students and usage data on students' usage of Fast ForWord. These three types of data were intentionally selected to enable insights and triangulation of both the behavioural dimension (i.e., what people do) and the attitudinal dimension (i.e., what people say).

3.4.1 Video-Recorded Classroom Lesson Observations

Video-recorded lesson observations were employed in this study to provide a detailed and accurate account of how and to what extent ALS were integrated with classroom learning.

Video methods are particularly suitable for research in complex learning environments, as they allow researchers to capture naturally occurring interactions among teachers, students, and technological tools in real time (Derry et al., 2010). In the present study, the use of video recording enabled a close examination of if and how ALS complemented classroom instruction and influenced teaching and learning processes.

One key rationale for using video recording was its ability to capture the complexity of classroom interaction. Classroom learning often involved multiple simultaneous elements, including verbal communication, non-verbal gestures, use of digital interfaces, and teacher guidance. Video data allowed these multimodal interactions to be recorded and revisited for detailed analysis, supporting a richer understanding than field notes alone (Goldman et al., 2014). This is particularly important in EdTech research, where students' engagement with EdTech tools such as ALS could potentially occur alongside classroom discourse and teacher facilitation. Where such tools were used outside of the classroom, video data allowed for close analysis to establish any potential impact, or lack of, of EdTech use on classroom learning.

In addition, video recording supports fine-grained and systematic analysis of teaching and learning processes. Unlike 'live' observation, video enabled repeated viewing, slow-motion analysis, and the development of detailed transcripts. This allows the researcher to examine specific moments of interaction, such as how students respond to ALS feedback together with their teacher or how teachers integrate digital tasks into face-to-face learning experiences. Such detailed analysis is essential for understanding how ALS function within authentic classroom settings (Derry et al., 2010; Heath et al., 2010).

Another important strength of video-recorded observations was their contribution to methodological rigour through transparency and reliability. Video provided a permanent and reviewable record of classroom activity, which could be revisited during analysis and, where appropriate, shared with other researchers for verification. This enhanced the credibility of the findings and reduced reliance on selective recall or interpretation (Jewitt, 2012). Furthermore, video data can be triangulated with other data sources in this study, including teacher interviews, student interviews, and ALS usage data, to develop a more comprehensive understanding of the research problem.

In the context of this study, video methods were particularly valuable for analysing how ALS are integrated into ongoing classroom activities or if it was used in isolation. The use of video recording was also well aligned with the aims of this research, which sought to understand not only what happened in the classroom but also how and why the ALS was used in particular ways. Video enabled the researcher to capture both intended and emergent practices in enactment, including how teachers adapt instruction and how students interact with the technology. This supports a deeper and more contextualised understanding of ALS integration with classroom learning, and with other EdTech tools in the classroom.

In summary, video-recorded lesson observations were an appropriate and robust method for this study as they capture complex classroom interactions, support detailed and systematic analysis, enhance research rigour, and provide rich contextual data. These features made video a valuable methodological tool for investigating the integration of ALS and classroom learning.

For the purposes of this research, classroom observations were intended for examining the nature and characteristics of teacher–student academic interactions during lessons in which the ALS was integrated. The focus was on how teachers and students engage with each other in relation to learning tasks, particularly how the ALS mediated instructional practices and student participation. Attention would be given to patterns of interaction such as teacher explanations, questioning strategies, feedback, and scaffolding, as well as students' responses, including their engagement, language use, and interaction with both the teacher and the ALS (if any). The observations also aimed to capture how the ALS potentially shaped the flow of classroom activities, for example by influencing pacing, task differentiation, or opportunities for individualised support. By documenting these interactional processes in detail, the observations provided empirical evidence to address RQ2 by identifying key features of teacher–student academic interactions within the context of ALS-supported classroom learning.

Video-recorded classroom lessons included all lessons pertaining to the unit selected for integration with Fast ForWord and the respective Fast ForWord onboarding lesson conducted by both participating teachers. During planning discussions with both participating teachers, the issue of how to introduce Fast ForWord and onboard students arose. Both teachers decided to conduct an onboarding lesson for their class, and the goal of this lesson was to ensure that students knew how to log into Fast ForWord and could access the tool on their own. The teachers planned for this lesson to take place upon receiving the login credentials for the students, which was dependent on the school's choice of the start date for their Fast ForWord subscription, and the lesson schedule for that week.

In Ubin Secondary School, the onboarding lesson was conducted three weeks before the start of classroom lesson observations, and in Kusu Secondary Schools, a similar lesson was conducted two weeks before the start of classroom lesson observations. This slight variation in timing was due to the different Fast ForWord subscription period for both schools. Ubin Secondary School chose to start their Fast ForWord subscription earlier so that students had the last two weeks of Term 1 and the week of Term Break to familiarise themselves with the tool, before its integration with the lesson unit at the start of Term 2. Kusu Secondary School, whose selected lesson unit would only start in Term 2 Week 3, chose to start their Fast ForWord subscription in Term 2 Week 1.

As I was unavailable to attend these lessons in-person, the participating teachers volunteered to work with their school's technical assistant to video record their lesson. Given that this was a good-will offer on the part of the school, I did not specify the video recording setup. As such, there was some variation in the setup even though only a single phone camera mounted on tripod was used. This could also be due to the different location of the lesson, where the onboarding lesson for Ubin Secondary School was conducted in the Computer Lab while the lesson for Kusu Secondary School took place in the classroom.

Subsequent classroom lesson observations focused on the participating teachers' efforts to integrate Fast ForWord with classroom learning. This entailed the teachers teaching a lesson unit which was expressly linked to students' use of Fast ForWord. In both cases, the selected lesson unit was planned to be taught over a period of four weeks in Term 2 of the school year. The lesson unit selected by Ubin Secondary School was Reading Comprehension while that selected by Kusu Secondary School was Discursive Writing.

When planning these classroom lesson observations (Table 3-4), both the participating teacher and I took reference from the class timetable as well as the scheme of work that guided the teaching of the selected lesson unit. What we did not foresee was school closure due to public holiday and Home-Based Learning (HBL) days[14] where students did not come to school. This meant that the number of classroom lessons enacted was less than the number of planned lessons. Furthermore, Mr Tan from Ubin Secondary School had to cancel one 70-minute lesson due to sickness, and in Kusu Secondary School, a 60-minute lesson was cancelled as students were taken out of class for a mass vaccination exercise. Coupled with a delay in the completion of the previous lesson unit and the need to prepare students for the planned weighted assessment[15] at the end of the selected unit, the participating teachers in both schools had less time than planned to deliver the selected lesson unit (Appendix D). In the case of Ubin Secondary School, while teaching the selected lesson unit, Mr Tan was also using class time for editing practice, visual text comprehension and Fast ForWord. This explained why even though 12 lessons were observed, only eight lessons were related to the lesson unit.

[14] From April 2020, as part of the post-Covid 19 curriculum, all Singapore secondary schools are expected to schedule home-based learning (HBL) days twice a month on Thursdays.

[15] Weighted assessment refers to assessment that counts toward a student's overall result of the subject for the academic year. According to Ministry of Education guidelines, schools should not conduct more than one weighted assessment per subject per school term. Such assessment is typically communicated ahead of time to the students and their parents and are not rescheduled unless due to unforeseen exigencies.

Table 3-4 Classroom Lesson Observations: Planned versus Actual

Classroom Lessons	Ubin Secondary School		Kusu Secondary School	
	No. of Lessons	No. of Hours	No. of Lessons	No. of Hours
Planned	16	14 h 00 min	12	11 h 20 min
Enacted (not incl. HBL)	14	12 h 15 min	11	10 h 20 min
Observed (All)	12	10 h 30 min	9	08 h 40 min
Observed (Lesson Unit)	8	7 h 35 min	7	06 h 40 min

Each observed classroom lesson was video recorded using two mobile phones, one of which was placed on the Swivl robot and connected to five audio markers. The Swivl robot was placed at the back of the classroom to video record the teacher as it could rotate to follow the speaker with the primary marker (i.e., the teacher) automatically. The other markers were used to audio record four of the six selected students for interviews. The remaining two students were audio recorded using portable voice recorders. The other mobile phone was placed at the front of the classroom to video record the students. Overall, this setup offered a view of both the teacher and students throughout the lesson and the multiple audio sources also ensured that student talk during various learning activities such as pair work and group work were captured clearly. Data protection and ethical considerations (to be discussed at the end of this chapter) were kept in view when designing the set up.

All parents of the students involved in the classroom lesson observation in Ubin Secondary School gave consent for their child to be video recorded for the purposes of this research. However, the parents of three students in Kusu Secondary School did not consent to their child being video recorded. As a result, Ms Aliyah had to make some changes to the class seating arrangement so that these three students would not be captured by the camera, while ensuring that their learning needs and learning experience were not compromised. This also meant that the video recording setup for Kusu Secondary School (Figure 3-8 differed slightly from that of Ubin Secondary School (Figure 3-7). Logistically, where I was unable to be physically present to observe and video record any classroom lesson, the school technical assistant did the recording with a phone camera owned by the school, and the video file was subsequently handed over to me via an encrypted hard disk.

Figure 3-7 Classroom Video Recording Setup for Ubin Secondary School

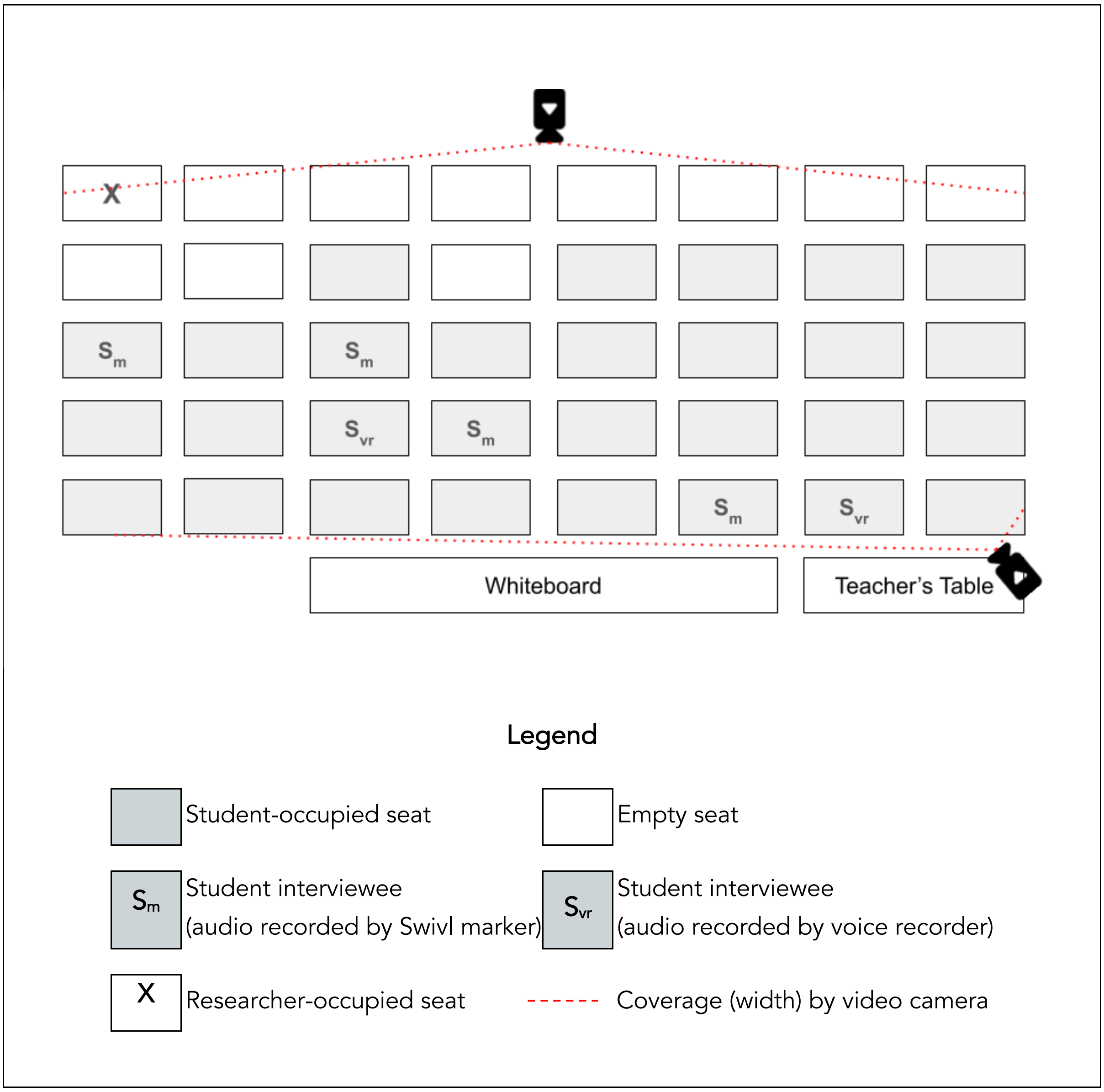
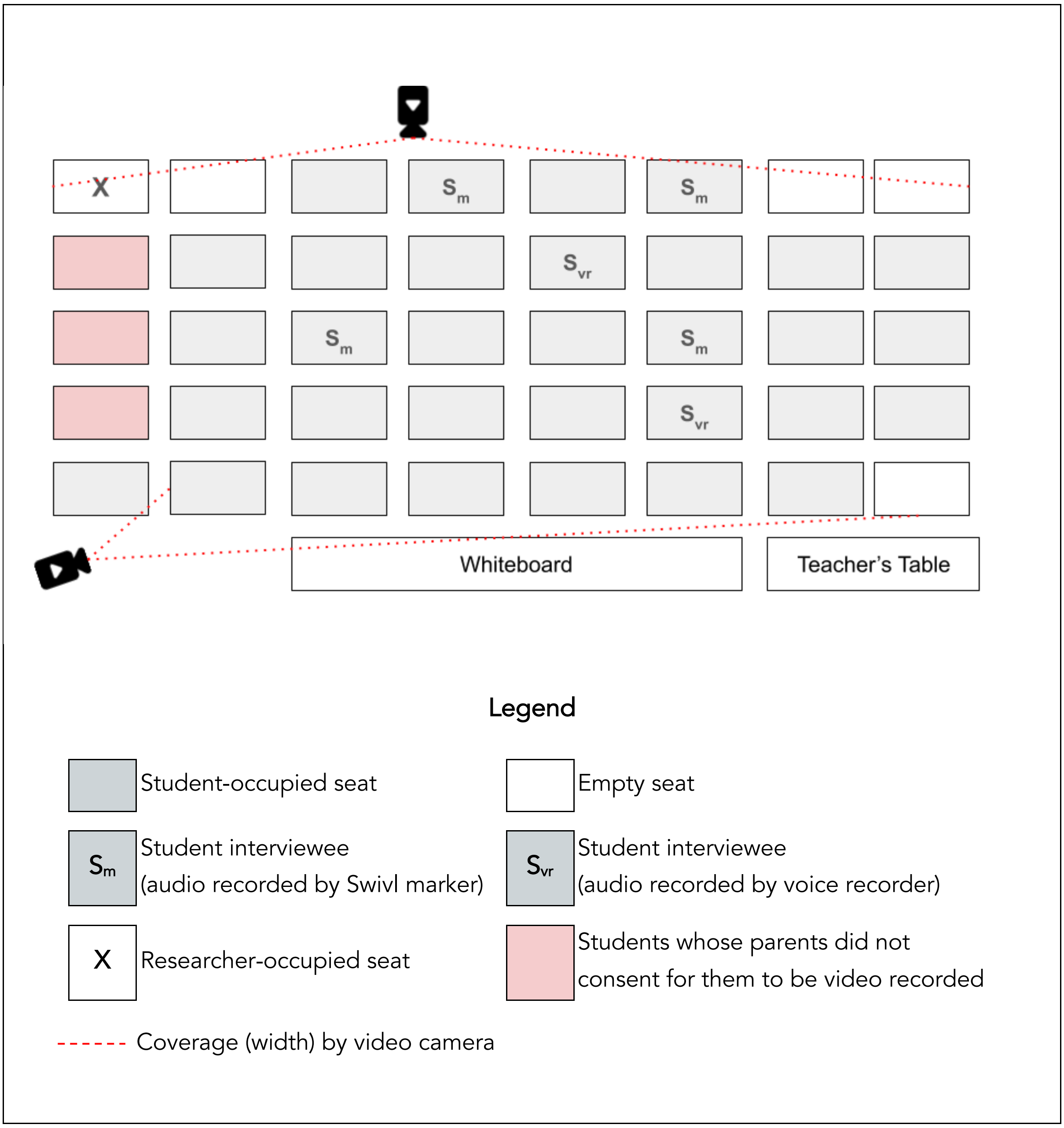


Figure 3-8 Classroom Video Recording Setup for Kusu Secondary School



3.4.2 Audio-Recorded Teacher and Student Interviews

Teacher interviews and student interviews were employed for this study to gain in-depth insights into participating teachers' and student interviewees' perceptions and interpretations of using ALS to complement classroom learning. Interviews are widely recognised as a key method in qualitative research for exploring how individuals understand and make meaning of their experiences, particularly in complex educational settings (Creswell & Poth, 2016). In the context of this study, interviews enabled access to aspects of teaching and learning that were not directly observable, such as beliefs, intentions, and perceptions of the ALS.

One key rationale for using interviews was their ability to capture the interviewees' perspectives in depth. While classroom observations documented what happens during lessons, they could not fully reveal why teachers made particular instructional decisions or how students perceived their learning experiences. Interviews allowed the researcher to explore these underlying meanings by engaging directly with the teacher and selected student participants and eliciting their viewpoints (Patton, 2015). This is particularly important in EdTech research, where the successful integration of technology is often shaped by teachers' pedagogical beliefs and students' attitudes towards digital tools (see Section 2.3.2 for factors influencing EdTech integration).

Furthermore, the use of semi-structured interviews allowed for both consistency and flexibility in data collection. A semi-structured format ensured that key topics related to ALS integration were addressed across participants, while also allowing the researcher to probe emerging issues and adapt questions based on participants' responses. This flexibility is important in exploratory research, where new insights may arise during the data collection process (Creswell & Poth, 2016). Such interviews also support the development of rich, detailed data that reflect the complexity of classroom practices.

Finally, combining teacher and student interviews enhanced the credibility of the study through data triangulation. By collecting perspectives from multiple stakeholders, the research could compare different viewpoints on the onboarding and integration of ALS with classroom learning. This would strengthen the trustworthiness of the findings and provide a more comprehensive understanding of the phenomenon (Patton, 2015). In this research, interview data were triangulated with video-recorded observations and ALS usage data to develop a holistic account of ALS onboarding and integration with classroom learning.

In summary, teacher and student interviews were an appropriate and valuable method for this research because they provided access to participants' perspectives, support in-depth exploration of both onboarding and integration experiences, and complement other data sources. These features made interviews particularly well suited for investigating the complex and context-dependent nature of ALS integration with classroom learning.

For the purposes of this research, face-to-face interviews with the participating teachers and students were conducted in the weeks of classroom lesson observation period where the researcher had access to these teachers and students. These interviews were intended to engage the teachers and students in a process of reflection and in doing so uncover their attitudes towards classroom teaching and learning as well as teaching and learning with Fast ForWord. To achieve this, semi-structured interviews were conducted with both participating teachers and six pre-selected student interviewees from each school. (Please see Section 3.2 for the selection criteria and process and Appendix E and Appendix F for the teacher interview protocols and student interview protocols respectively.)

3.4.2.1. Time and Timings of Teacher Interviews

Each participating teacher was interviewed three times, namely at the start, mid-point, and end of the observation period. Ideally, the first interview would have taken place one day prior to the start of the lesson observation, as an avenue for relationship building to put the teacher at ease ahead of the lesson observations and to gain background information such as student demographics, commonly used EdTech tools and prior exposure to ALS. However, both participating teachers were unavailable for this first interview until the middle of the first week of classroom lesson observation. By then, there had been two classroom lesson observations of each teacher.

The second interview was intended to take place at the end of the second week of lesson observation, seeking to understand the reasons behind how the participating teacher structured the lessons, managed classroom interactions, and attempted to integrate Fast ForWord. However, given that the teachers only had their interview in the middle of first week of lesson observation, it was too soon to have their second interview during the second week of lesson observation. Practically, there were also scheduling constraints as I also had to block time for student interviews. As such, this second teacher interview only took place in the third week of the classroom observation period.

The third and final interview was planned to happen at the end of classroom lesson observation period. The goal of this interview was to further clarify classroom interactions noticed during the final week of observation, surface teachers' views about the role of Fast ForWord in the series of lessons that s/he just completed and solicit any other thoughts that the teacher would like to share. However, due to the availability of the participating teachers, this interview was conducted one week after the classroom lesson observation ended. Overall, the timings of the three interviews with each participating teachers took place at similar junctures of the classroom lesson observation period and while there is some variation in the duration of each interview, the total interview duration for each participating teacher was similar (Table 3-5).

Table 3-5 Teacher Interview Timings and Duration

Teacher Interviews	Timings	Duration	
		Ubin Secondary	Kusu Secondary
Interview 1	First week of classroom lesson observation	44 min 46 sec	34 min 26 sec
Interview 2	Third week of classroom lesson observation	33 min 13 sec	37 min 41 sec
Interview 3	The week after classroom lesson observation ended	18 min 20 sec	21 min 14 sec
	Total Interview Duration	1 h 36 min 19 sec	1 h 33 min 21 sec

3.4.2.2. Time and Timings of Student Interviews

Each participating student was interviewed twice, namely at the mid-point, and end of the observation period. Students were informed ahead of time the estimated duration of the interview, which could last between 45 to 60 minutes, and then given a choice as to when they would like to be interviewed. Students' proposals and choice of interview slots were typically based on their lesson timetable and personal schedules.

The first interview was planned to take place immediately after the first week of lesson observation, to learn about students' views of Fast ForWord till date as well as their perceptions of classroom learning and their participation in class. However, as it was logistically not possible to interview every student in the same day after school, this first interview with students was conducted over the second and third weeks of lesson observation. Five students from Ubin Secondary School were interviewed over the course of the second week and one student was interviewed in the third week. Three students from Kusu Secondary School were interviewed in the second week of lesson observation while the remaining three were interviewed in the third week.

The second interview was intended to take place at the end of the lesson observation period, as a follow-up interview, to find out if students' views of Fast ForWord or their perceptions of classroom learning and their participation in class changed in any way over the observation period. Ideally, this final interview would take place at the end of or shortly after the lesson observation. However, due to scheduling constraints, including students taken out of school due to sickness or inter-school competitions, some students were interviewed prior to the end of the lesson observation, and some were interviewed two weeks after the conclusion of the lesson observation.

Overall, it is evident from Table 3-6 that there was a time gap of approximately two to three weeks between the first and the second interview for most students. This was an attempt to space out these interviews and to obtain students' perceptions after completing the lesson unit. For F08 and F27, there was a longer gap of 4 weeks due to their respective absence from school. F08 was taken out of school for close to a week to attend an overseas family event; F27 was on medical leave for two weeks. In terms of the duration of these interviews, Table 3-6 shows that across the board, the first interview was longer than the second interview, and this was likely influenced by the longer list of questions for the former, containing a set of questions designed to elicit pertinent background information including students' prior learning experiences in their respective primary schools.

On average, the duration of interviews with Secondary Two students from Kusu Secondary School was longer than that of interviews with Secondary One students from Ubin Secondary School, by approximately 11 minutes, which could be attributed to the age factor. The duration of the first interview with Secondary One students ranged from approximately 26 minutes to under 46 minutes, and that with the Secondary Two students ranged from approximately 34 minutes to almost an hour. The duration of the second interview with

Secondary One students ranged from approximately 16 minutes to under 25 minutes, and that with the Secondary Two students ranged from approximately 14 minutes to under 40 minutes. This variation corroborated with the extent to which these student interviewees elaborated on their responses to the interview questions.

Table 3-6 Overview of Timings and Duration of Student Interviews

Student Identifier	Timing		Duration	
	First Interview	Second Interview	First Interview	Second Interview
Student Interviewees from Ubin Secondary School				
F08	Week 2 (of lesson observation)	Week 6 (post lesson observation)	45 min 30 sec	24 min 46 sec
M29	Week 2 (of lesson observation)	Week 5 (post lesson observation)	39 min 46 sec	32 min 5 sec
F04	Week 2 (of lesson observation)	Week 5 (post lesson observation)	32 min 57 sec	19 min 03 sec
F01	Week 2 (of lesson observation)	Week 5 (post lesson observation)	32 min 49 sec	16 min 03 sec
M10	Week 3 (of lesson observation)	Week 5 (post lesson observation)	25 min 14 sec	18 min 47 sec
M15	Week 2 (of lesson observation)	Week 6 (post lesson observation)	26 min 17 sec	19 min 15 sec
		Average Duration	33 min 45 sec	21 min 40 sec
Student Interviewees from Kusu Secondary School				
M17	Week 3 (of lesson observation)	Week 6 (post lesson observation)	48 min 46 sec	39 min 38 sec
M32	Week 2 (of lesson observation)	Week 5 (post lesson observation)	34 min 35 sec	21 min 43 sec
F27	Week 2 (of lesson observation)	Week 6 (post lesson observation)	47 min 05 sec	14 min 33 sec
M34	Week 2 (of lesson observation)	Week 5 (post lesson observation)	34 min 03 sec	24 min 33 sec
M18	Week 3 (of lesson observation)	Week 6 (post lesson observation)	44 min 40 sec	25 min 28 sec
F26	Week 3 (of lesson observation)	Week 6 (post lesson observation)	56 min 32 sec	24 min 35 sec
		Average Duration	44 min 17 sec	25 min 05 sec

3.4.2.3. Teacher Interview Design and Format

All three interviews with the participating teachers were semi-structured interviews, with some difference in focus. The first interview centred on relationship building and obtaining background information, as mentioned earlier during this interview. It also included some questions that probed the teachers' plans to integrate the selected lesson unit with Fast

ForWord. The second and third interviews were similar, revolving around teachers' use of Fast ForWord, their observations about students' use of Fast ForWord, and the high and low points of their lessons. All teacher interviews were guided by an interview protocol (Appendix E) to ensure consistency across interviews with the two teachers as well as exercise due care in terms of word choice and question phrasing, to signal a learner mindset and not be deemed as judging the teachers.

At the initial stages of research planning, the second and third interviews were designed to comprise two segments, starting with a semi-structured interview and followed by a stimulated recall interview (SRI). The first segment was intended to clarify the teachers' instructional design, and create a shared context for the next segment, where snippets from the video recorded lessons will be used to engage teachers in a process of reflection, to uncover why they responded to students the way they did. This design stemmed from the belief that stimulated recall interview would enable a rich discussion of how the teacher interpreted students' contributions and the options they considered before choosing to respond in a particular way.

Due to a lack of video data that demonstrated a clear link between Fast ForWord and the lesson unit, SRI could not be carried out. This segment was replaced with questions that probed the teachers' perceptions of their lessons, through surfacing their high and low points during the week leading to the interview, and the reasons for these perceptions. While the absence of a visual stimulus in the form of video recording may seem like a missed opportunity to clarity specific instances of teacher-student interaction noticed by the researcher, by not providing such a stimulus, it also meant that this interview segment was guided by the teacher's choice (of instances to talk about) rather than the researcher's choice, which somewhat preserved and magnified the teacher's voice in this process.

3.4.2.4. Student Interview Design and Format

The two interviews with each participating student were semi-structured interviews, to clarify students' verbal contributions during classroom learning, their perception of the lessons and their teacher's efforts at engaging the class during lessons. Students were also asked about their use of Fast ForWord, their perception of the tool, and whether using it impacted their classroom experience in anyway. All interviews with students were guided by an interview protocol (Appendix F) to ensure consistency across interviews with all 12 students as well as exercise due care in terms of word choice and question phrasing, to signal neutrality, assure students of confidentiality and avoid coming across as favouring or judging both their teacher and Fast ForWord.

Like the initial design of teacher interviews, there were also originally two parts to student interviews, namely semi-structured interview and SRI. However, instead of reviewing video recordings of the lessons observed, the SRI segment of student interviews would make use of students' screen recordings of their ALS use, to probe how they made use of the system, as a precursor to understanding how ALS could have influenced students' contributions to class discussions. Students were asked, prior to each interview, to submit a screen recording of how they used ALS during the week. They could choose which day of the week to record themselves and the duration of the recording.

Recording and submission instructions were conveyed to the students in the presence of their teacher. Students also had hands-on practice at screen recording on their personal devices to ensure that they could do this at home on their own. However, despite this preparation and repeated reminders, most students submitted their screen recordings after the interview, which meant that the screen recordings could not be used as part of the interview. Other issues related to the screen recordings including capturing a static screen due to choice of wrong window to record and missing audio, which rendered some parts of the video incomprehensible. These challenges resulted in limited use of these screen recordings for the purposes of conducting student interviews.

In the absence of a screen recording to scaffold the interview segment on students' use of Fast ForWord, where students seemed to struggle to talk about the tool, a judgement call was made to give students the option to log into their Fast ForWord account, and share their use through a walkthrough of how they used the tool after logging in. Among the 12 students interviewed, only two students from Ubin Secondary School took up the option and logged into their Fast ForWord account. The remaining student interviewees talked about their use without additional scaffold. This improvisation stemmed from a desire to put the students at ease and served as an attempt to reduce the cognitive load of recall using a physical artefact.

3.4.3 System Generated Fast ForWord Usage Data

Fast ForWord offered progress monitoring features and could generate up to five types of reports for its student users. These reports included progress reports, growth reports, usage reports, skills reports and completion reports and were available to both the respective participating teachers and the researcher. Progress reports tracked students' completion of tasks per login while completion reports tracked overall completion of available tasks. Growth reports tracked students' weekly gains in terms of participation points while skills report reflected students' attainment of the skills that Fast ForWord sought to help students develop through its various exercises. Usage reports captured students' login frequency and duration, as well as the number of questions attempted.

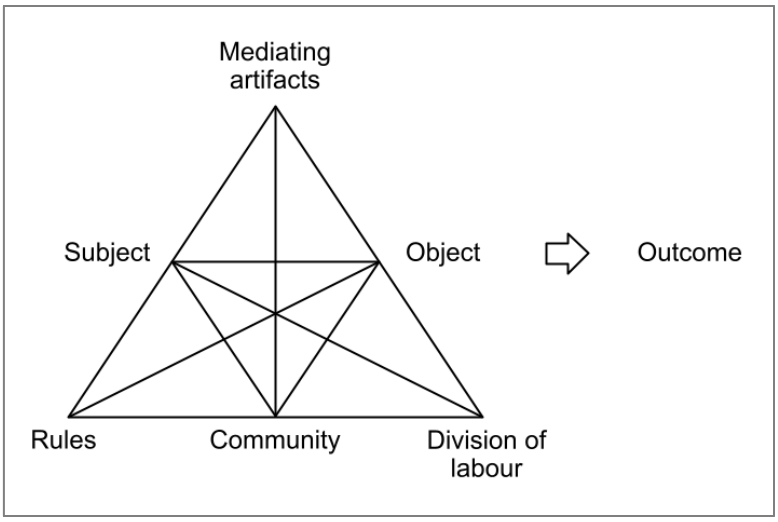
It should be noted that the purpose of these reports was to enable students to monitor their own learning and for the teachers to check if students were on track. These reports were thus learning data rather than research data, even though they could be analysed quantitatively. For this research, students' usage reports were analysed for purposes of verifying their use of Fast ForWord, and for triangulation with claims students made when interviewed. (Please see Appendix H for a sample usage report.) The remaining reports were not analysed. Parental consent was sought and given before downloading and analysing these reports from Fast ForWord.

3.5 Data Analysis through the Lens of Activity Theory

The data generated, including video recordings of classroom lessons, audio recordings of interviews with teachers and students and usage data on students' usage of Fast ForWord were analysed to address the research questions. This entailed qualitative coding of classroom lesson recordings, content analysis of the interview recordings and quantitative analysis of students' Fast ForWord usage data, to uncover participating teachers and students' views and use of Fast ForWord and classroom learning, guided by activity theory.

Activity theory enables an analysis of human agency while keeping in view the social cultural structures that influence individual actions (Engeström, 2001), acknowledging that "persons [are] continually shaping and being shaped by their social contexts" (Roth & Lee, 2007, p. 189). Activity theory allows both the influence of contextual factors such as classroom culture on teacher and student actions and the potential for teacher and student actions e.g., teacher's introduction of ALS, to change the social structure of the classroom to be examined using one framework. Taken as such, the classroom as a "collective, artifact-mediated and object-oriented activity system" becomes the prime unit of analysis (Engeström, 2001, p. 136).

Figure 3-9 The Activity System



Activity theory has been widely used in educational research, e.g., to interpret science education (Plakitsi, 2013), inform medical training (Larsen et al., 2019), unpack complexities in teacher development (McNicholl & Blake, 2013) and explain how technology influences learning experiences and outcomes (Mwalongo, 2016; Tay & Lim, 2016). An established theoretical framework, the activity system (Figure 3-9) is well suited for analysing classroom learning, providing a broad categorisation for the different elements in the classroom, which include *Artifacts*, *Community*, *Rules*, and *Divisions of Labour*. The *Subject* here refers to active participants selected as the point of view for the analysis while *Object* refers to that which "which the activity is directed and which is molded or transformed into *outcomes*" (Engeström, 1993, p. 67, italics in the original). The framework also visualises graphically how these different elements mediate the relationship between the *Subject* and the *Object*, supporting a discussion on how the different elements interact and relate with each other.

Within the context of this research, two activity systems can be found to be simultaneously operating and interacting with each other in the classroom (Engeström, 2001). These two systems are representative of the two key activities, namely teaching and learning, that are taking place in this space. It is intentional that they are represented as distinct activity systems, to highlight that both teachers and students are active agents working toward distinct but aligned goals (Figure 3-10). In this shared environment, the *Mediating Artifacts* available to the teacher and students are similar. However, while the teacher's use of *Mediating Artifacts* is dependent on what is available, students' use of these *Artifacts* is dependent on availability as well as permission from teacher.

This framework also makes visible some of the usually invisible elements such as *Rules* and *Division of labour* that could be influencing teacher-student interactions. Figure 3-10 shows that while students are to comply with *Rules* set by their teachers, which can influence how they participate in class, teachers themselves are also subject to *Rules* such as management expectations and peer pressure, which can also influence how they teach and respond to students during the lesson. Furthermore, structural decisions such as organising learning into lesson blocks that separate content learning and student development can also have a bearing on teacher-student interactions. For example, when a student exhibits disruptive behaviour during a lesson, should the teacher continue teaching as planned or grasp this teachable moment and help students learn some self-management skills? The teacher's choice in this instance will also contribute to the reinforcement or reshaping of tacit norms as to what is appropriate in this classroom.

The activity system highlights elements and relations that already exist prior to the introduction of Fast ForWord, while serving as a frame for exploring how its introduction and use interact with existing elements and relations in the classroom. This thus enables a discussion of the tensions that may arise from the introduction and integration of an ALS like Fast ForWord, which will be valuable in advancing both our understanding of the topic and classroom practice (see Section 6.4 for a discussion of the tensions observed). Figure 3-11 is a visual representation of what the proposed analytic methods of qualitative coding of lesson video recordings and content analysis of interview audio recordings are anticipated to illustrate in terms of the interactions among the different elements of the classroom activity system.

Figure 3-10 The Classroom Activity System

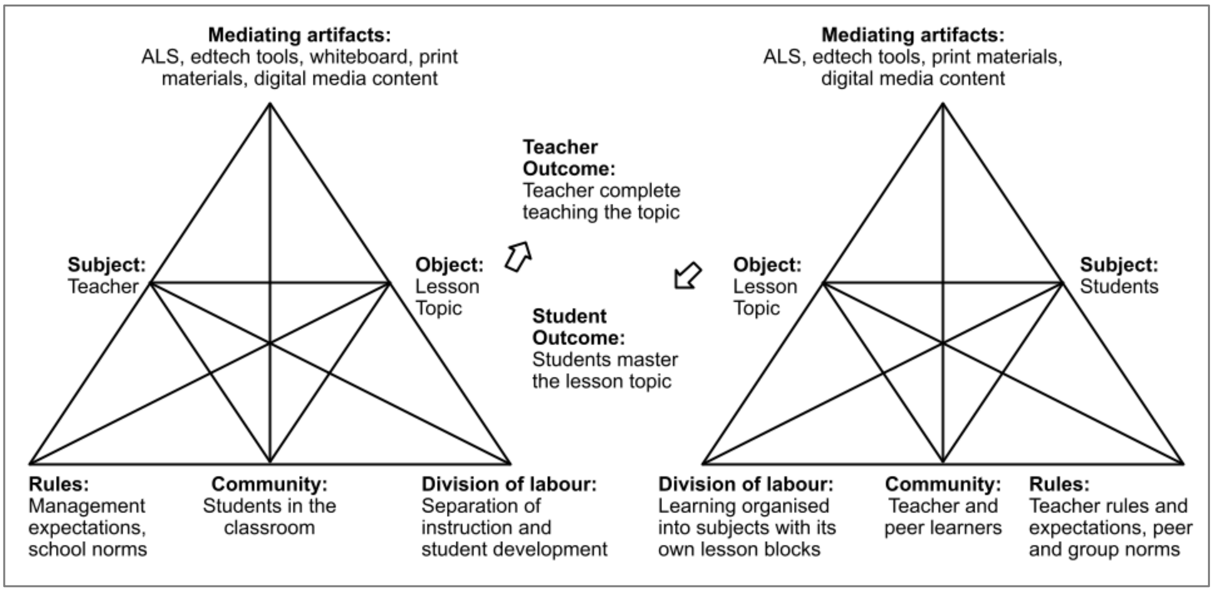
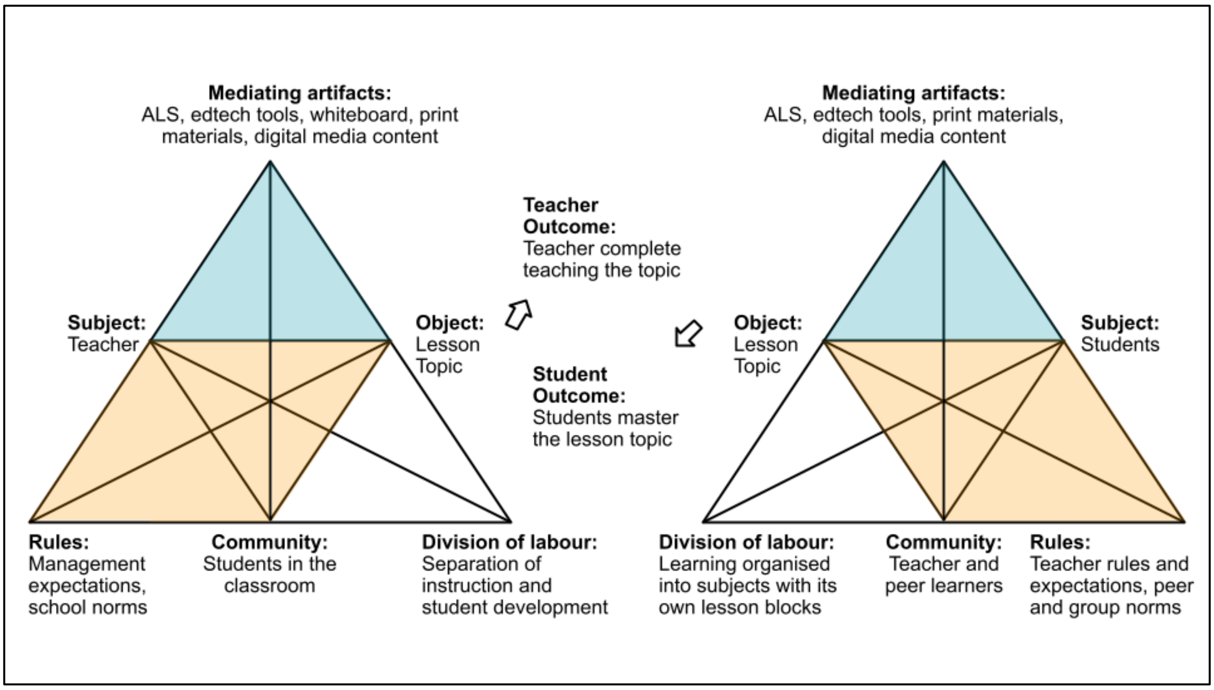


Figure 3-11 Applying Activity Theory to Data Analysis



Firstly, qualitative coding of video recordings, by focusing on how the teacher and students (*Subjects*) engage with each other (*Community*) during classroom learning (*Object*), are likely to reveal interaction patterns (*Rules*) in this context and the influence of students in the classroom as well as other teachers teaching the same grade level (*Community*) (This refers to the area in orange colour). This is intended to address RQ2 which would enable a characterisation of the teacher-student interactions observed during classroom learning. Secondly, content analysis of the teacher and student interview audio recordings would focus on uncovering these participants' perceptions of the usefulness and engagement of Fast ForWord (*Mediating Artifact*) in terms of supporting their classroom learning (*Object*) (This refers to the area in blue colour). This is intended to illuminate how Fast ForWord has been integrated with classroom learning and whether this integration was deemed to be effective or not from both the teachers' and students' perspectives.

Overall, Activity theory enables a balanced consideration of individual agency alongside influence of contextual factors, making it a valuable framework for classroom research, and more specifically for the study of teacher-student interactions and technology-enabled learning contexts such as learning with ALS.

3.5.1 Qualitative Coding of Classroom Lesson Recordings

To analyse the classroom video recordings generated, a qualitative coding approach was adopted to systematically interpret the observed interactions. Video data provide a rich and detailed record of classroom activity, but their complexity requires a structured analytic framework to identify meaningful patterns (Derry et al., 2010). Qualitative coding enables the researcher to organise and categorise segments of interaction, moving from raw video data towards theoretically informed interpretations (Miles et al., 2014). In this study, particular attention was given to the communicative processes through which teaching and learning were enacted. Given that the research focused on how ALS was integrated into classroom practice, it was important to examine not only what occurred, but how participants interacted around learning tasks. This focus led to the decision to code for dialogic moves, as these provide a fine-grained lens for analysing the nature and quality of teacher–student academic interactions within ALS-supported lessons.

This decision to examine dialogic moves in detail in this study was also grounded in the need to understand how adaptive learning systems (ALS) interact with and potentially reshape classroom discourse, even when a substantial proportion of ALS use occurred outside lesson time. While ALS often support independent, out-of-class learning, their integration into classroom practice would likely be mediated through teacher–student interactions. Analysing dialogic moves therefore provided insight into how learning from these systems was taken up, reinforced, or extended during lessons.

One key expectation underpinning this approach was that ALS use outside the classroom would influence the nature of in-class interactions. For example, students who engage with adaptive tasks independently may come to lessons with varying levels of understanding, misconceptions, or questions. As a result, classroom dialogue may shift towards more differentiated forms of questioning, targeted feedback, and responsive scaffolding. Examining dialogic moves in detail enabled the capture of how teachers responded to this variation and how they built on students' prior engagement with the ALS.

In addition, it was anticipated that the role of the teacher would evolve in ALS-supported classrooms. Rather than primarily delivering content, teachers may take on a more facilitative role, guiding discussion, interpreting system-generated data, and supporting students' meaning-making. Detailed analysis of dialogic moves—such as probing questions, uptake of student ideas, and elaborative feedback—enables the identification of these pedagogical shifts. This aligned with research on dialogic teaching, which emphasises the importance of interaction in supporting deeper learning and reasoning.

Another important consideration is that the impact of ALS on learning is not limited to individual interaction with the system but extended to how that learning is integrated into classroom discourse. Even if much of the ALS activity occurs outside lesson time, its educational value depended on how it was connected to classroom teaching. By examining dialogic moves closely, the study could investigate whether and how teachers referenced ALS activities, whether students drew on their system-based learning during discussions, and how these contributions were taken up in the classroom.

Finally, adopting a fine-grained focus on dialogic moves reflects the exploratory nature of this research. As the integration of ALS into classroom practice is still developing, it is important to remain sensitive to a wide range of possible interactional changes. Detailed coding allows the study to capture both expected and unexpected patterns, providing a richer and more nuanced account of how ALS influences teacher–student interaction.

Prior to coding and analysis, all video-recorded classroom lessons were segmented into interaction episodes. This approach is widely recommended in video-based research to manage the complexity of classroom data and to enable systematic and meaningful analysis of interactional processes. Classroom video data typically contained continuous streams of activity involving multiple participants, overlapping interactions, and shifting instructional focuses. Segmenting the data into smaller, analytically meaningful units could reduce this complexity and enabled the researcher to focus on specific instances of teacher–student interaction (Derry et al., 2010).

By identifying and isolating interaction episodes, the researcher could examine sequences of dialogue, instructional moves, and student responses in a structured way. This aligned with established approaches in video analysis, which emphasised the importance of selecting and analysing relevant segments rather than treating the entire video as a single unit of analysis (Heath et al., 2010). Furthermore, defining clear boundaries around interaction episodes ensured that coding was applied systematically across comparable units of data, ensuring consistency and transparency in the coding process.

In addition, segmenting video data afforded for the identification of meaningful patterns across lessons. Once individual episodes were coded, they could be compared within and across cases to identify recurring interactional features, such as types of questioning, feedback, or student engagement. This approach enabled both within-episode and cross-episode analysis, which would be valuable for understanding how classroom interactions evolve over time and in different instructional contexts (Goldman et al., 2014).

In view of the above considerations, all video recorded classroom lessons were segmented into interaction episodes using the two dimensions identified by Gump (1967). These dimensions were academic concern and activity type, where new episodes are marked by a change in the task or activity focus or in the participation format. All interaction episodes from the video recordings could be categorised into one of the three types of teacher-student interaction, academic, organisational and social emotional, identified by Hafen et al. (2015).

From Table 3-7, it is evident that while majority of the time for lessons was spent on academic matters, teachers spent a sizable portion of this time on organisational interactions. These interactions typically involved greetings at the start and end of the lesson, teacher efforts to get students to settle down as well as logistical instructions to students, such as asking students to move to sit with a buddy and to take out or put away specific lesson materials. In the case of Kusu Secondary School where students had their own personal learning devices, such interactions also included instructions that mediated students' use of these devices during the lesson. In both schools, social emotional interactions were relatively rare and took a negligible portion of the time for lessons. This seemed to suggest that social emotional issues, if present, were not inferring with academic learning during the duration of the classroom lesson observations and were not visible during these lessons.

Table 3-7 Overview of Teacher-Student Interactions

Interaction Episode Types	Ubin Secondary School		Kusu Secondary School	
	No. of Episodes	Duration[16]	No. of Episodes	Duration
Academic	196	7 h 31 min	120	5 h 43 min
Organisational	171	2 h 50 min	136	2 h 56 min
Social Emotional	14	0 h 09 min	3	0 h 01 min
Total	381	10 h 30 min	259	08 h 40 min

In accordance with the focus of this research to examine teacher-student interactions for academic learning, organisational and social emotional interaction episodes were excluded. Among the academic interactions, episodes that did not feature teacher-student interaction were also excluded. Excluded academic interaction episodes either comprised solely the teacher's turn or entailed student activity without teacher involvement where there was no interaction between the teacher and any student. By these criteria, student activity which saw the teacher interacting with one or some students while others were doing their work have been included for analysis (Table 3-8).

[16] The duration stated in the tables in this section refers to the duration of the episodes, which differed from the actual length of teacher-student interaction and the duration of student contributions.

Table 3-8 Included and Excluded Academic Interactions

Interaction Episodes	Ubin Secondary School		Kusu Secondary School	
	No. of Episodes	Duration	No. of Episodes	Duration
Included	91	4 h 06 min	45	2 h 52 min
Excluded	105	3 h 25 min	75	2 h 51 min
Total	196	7h 31 min	120	5h 43 min

It should be noted that not all included interaction episodes came from lessons on the selected lesson unit for integration with Fast ForWord. As mentioned earlier, this was due to a delay in the completion of the previous lesson unit which resulted in lessons on that unit continuing into the classroom lesson observation period. In the case of Ubin Secondary School, this was also due to Mr Tan using some lessons for other purposes such as editing practice. Table 3-9 shows that even though Ubin Secondary School had a higher proportion of interaction episodes from lessons unrelated to the selected unit, the amount of lesson time spent on the selected lesson unit was almost the same for both schools. Regardless, interaction episodes unrelated to the selected lesson unit were kept for analysis because they fell within the classroom lesson observation period, where the participating teachers attempted to make explicit links between what students were learning and Fast ForWord. However, these 'unrelated' episodes were mainly used for triangulation and the analysis focused on interaction episodes from lessons on the selected unit.

Table 3-9 Breakdown of Academic Interactions based on Lesson Unit

Interaction Episodes	Ubin Secondary School		Kusu Secondary School	
	No. of Episodes	Duration	No. of Episodes	Duration
Related to Lesson Unit	52 (57.1%)	2 h 32 min	32 (71.1%)	2 h 26 min
Unrelated to Lesson Unit	39 (42.9%)	1 h 34 min	13 (28.9%)	26 min
Total Included	91 (100%)	4 h 06 min	45 (100%)	2 h 52 min

After segmentation and identification of episodes for analysis, all included academic interaction episodes were then transcribed and coded using the Scheme for Educational Dialogue Analysis (SEDA). As reflected in Table 3-10, this scheme is an analytic framework comprising 33 codes for communicative acts that have been organised into eight clusters

(Hennessy et al., 2016).[17] This framework was selected as the lens for interpreting the observed academic interactions for various reasons. Firstly, it was situated within the sociocultural paradigm that acknowledges the importance of context, aligned with the theoretical underpinnings of this research, and secondly, it was developed through iterative testing using actual classroom data, which suggested some affordance as a tool for characterising academic interactions during classroom learning.

The decision to use SEDA as the coding scheme, rather than condensed versions such as Toolkit for Systematic Educational Dialogue Analysis (T-SEDA) or Cambridge Dialogue Analysis Scheme (CDAS) was based on the need for a detailed and nuanced understanding of teacher–student academic interactions during the integration of ALS with classroom learning. The full SEDA framework was designed to capture the complexity and richness of classroom dialogue by providing a comprehensive set of codes that reflect different communicative functions, including reasoning, elaboration, questioning, and building on ideas (Hennessy et al., 2016). In contrast, condensed versions such as T-SEDA and CDAS offered a reduced number of categories for greater ease of use and efficiency. While these simplified tools would be useful for large-scale or time-constrained studies, they may not capture the full range of dialogic practices present in classrooms. Given that this study sought to examine the characteristics of teacher–student academic interactions in depth, a more fine-grained analytic tool was required.

Furthermore, the use of a comprehensive coding scheme aligned with qualitative research principles that emphasise depth and richness of data analysis. Fine-grained coding enables the researcher to move beyond surface descriptions of interaction and to examine underlying patterns and processes (Miles et al., 2014). In this study, where video-recorded lesson observations were analysed, the richness of the data warranted a detailed coding approach that can fully utilise the depth of available information.

[17] Definitions for the communicative acts can be found in Appendix I.

Table 3-10 Scheme for Educational Dialogue Analysis (SEDA)[18]

	Cluster		Communicative Act
I	Invite elaboration or reasoning	I1	Ask for explanation or justification of another's contribution
		I2	Invite building on / elaboration / (dis)agreement / evaluation of another's contribution or view
		I3	Invite possibility thinking based on another's contribution
		I4	Ask for explanation or justification
		I5	Invite possibility thinking or prediction
		I6	Ask for elaboration or clarification
R	Make reasoning explicit	R1	Explain or justify another's contribution
		R2	Explain or justify own contribution
		R3	Speculate or predict based on another's contribution
		R4	Speculate or predict
B	Build on ideas	B1	Build on/clarify others' contributions
		B2	Clarify/elaborate own contribution
E	Express or invite ideas	E1	Invite opinions/beliefs/ ideas
		E2	Make other relevant contribution
P	Positioning and Coordination	P1	Synthesise ideas
		P2	Evaluate alternative views
		P3	Propose resolution
		P4	Acknowledge shift of position
		P5	Challenge viewpoint
		P6	State (dis)agreement/ position
RD	Reflect on dialogue or activity	RD1	Talk about talk
		RD2	Reflect on learning process/ purpose/ value/ outcome
		RD3	Invite reflection about process/ purpose/ value/ outcome of learning
C	Connect	C1	Refer back
		C2	Make learning trajectory explicit
		C3	Link learning to wider contexts
		C4	Invite inquiry beyond the lesson
G	Guide direction of dialogue or activity	G1	Encourage student-student dialogue
		G2	Propose action or inquiry activity
		G3	Introduce authoritative perspective
		G4	Provide informative feedback
		G5	Focusing
		G6	Allow thinking time [optional when not verbally explicit]

[18] This table is a condensed version of the framework presented in Hennessy et al. (2016)

Another consideration would be the exploratory nature of this research. As the integration of ALS in classroom learning remained an evolving area, it was important not to constrain the analysis prematurely through overly simplified coding categories. For instance, it could distinguish between different types of teacher questions (e.g. recall versus reasoning), forms of feedback (e.g. evaluative versus elaborative), and levels of student participation. Using the full SEDA framework thus allowed for greater analytic openness and sensitivity to unexpected forms of interaction that may emerge during the study. This supported the development of a more comprehensive understanding of how dialogue unfolded in technology-enhanced classrooms.

In summary, the use of the full SEDA dialogue coding scheme was justified, given the need for a detailed, rigorous, and context-sensitive analysis of classroom interactions. It enabled the study to capture the complexity of dialogic processes in during classroom learning complemented with ALS integration and supported a deeper understanding of how technology could potentially shape teacher–student academic interactions.

Turning our attention to the mechanics of coding, to ensure credibility, an experienced English language teacher was enlisted as the second coder for this research, to code five percent of the included episodes. To prepare the second coder for the exercise, I met with her to review the condensed version of SEDA and review two coded episodes that served as samples for her reference. She then coded the pre-selected episodes independently, and the resultant agreement between the two coders, the second coder and me, was approximately 45%. This led to a second meeting to review the two sets of codes and discuss our respective interpretations. After some clarifications and discussion, the final agreement between the second coder and me was approximately 73%. While the agreement rate between the two coders seemed rather low, both coders agreed that this was likely due to our consistent application of codes that were close in meaning, such as I2 and I6, and R2 and B2.

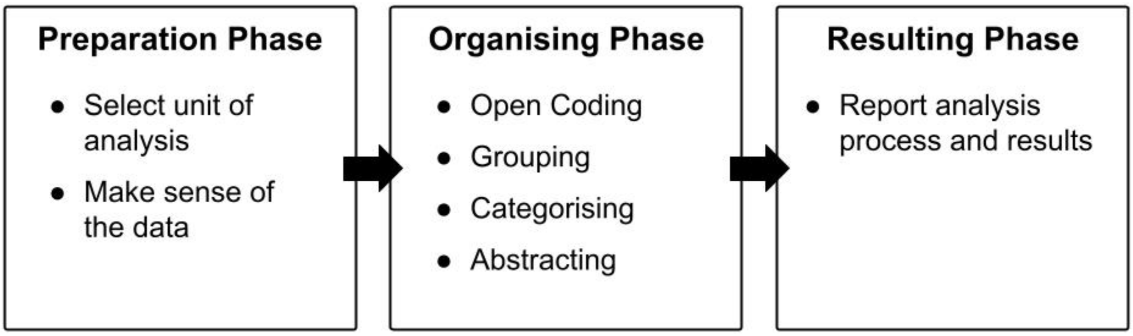
On average, there was higher agreement for data collected from Ubin Secondary School, at 49% (before discussion) and 76% respectively. Agreement for data from Kusu Secondary School was 29% (before discussion) and 64% respectively. The second coder highlighted challenges understanding the transcribed speech of Ms Aliyah as there seemed to be a lot of fragmented utterances in her speech. She also gave feedback that the transcripts did not provide adequate contextual information, and she had to make quite a few assumptions about the lesson while coding. One concrete example provided was that she did not know if the episode came from the start or the middle of the lesson and the actual activity that the class was doing. Ideally, I would like to code another 5% of the included episodes and to view the video recordings while coding. However, the second coder was unable to commit further time to this project. I thus reviewed and adjusted the codes as per our second discussion, while bearing in mind her feedback.

The final codes for each transcript were tabulated to surface the most frequently observed and rarely observed communicative acts and clusters. This ensured that what was 'not there' was kept in view while highlighting the more prevalent communicative acts, allowing for a balanced understanding of teacher-student academic interactions in each school. Coded transcripts were then reviewed qualitatively by clustering similar episodes to identify similarities and differences within these episodes. It should be noted that episodes from the two schools were coded and analysed separately.

3.5.2 Content Analysis of Teacher and Student Interview Recordings

The teacher and student interview recordings were analysed inductively, following the three phases of inductive content analysis, namely the preparation, organising and resulting phases (Figure 3-12), outlined in Elo and Kyngäs (2008). This approach was selected in view of its affordances for exploring attitudes, behaviours and experiences (Green & Thorogood, 2004), befitting the research agenda of this effort. The analysis also focused solely on manifest content and latent content such as silence and posture were not included to avoid over-reading into the participants' responses.

Figure 3-12 Content Analysis Phases[19]



To prepare the audio data for analysis, all recorded participant interviews were transcribed, and the transcripts were read several times before segmentation for analysis. The additional step of segmenting the interview responses was made in response to participant digression, particularly among the student participants, during the interviews. As part of the sense-making process, it sought to exclude personal information and views that were not relevant to this research. Examples of such information included details about participants' health condition(s) and views about local educational policies and practices that were unrelated to this research. This segmentation was as per the interview segments as presented in the interview protocol (see Appendix E and Appendix F), to minimise research bias at this early stage of data analysis.

Next, each interview transcript was coded inductively by segment, focused on surfacing repetition as well as similarities and differences, guided by the research questions presented earlier in this chapter. After this first round of coding by segment, each transcript is reviewed holistically to ensure that possible internal connections were not missed and explore if any new code needed to be added. Table 3-11 shows a short list of codes and reference samples pertaining to Fast ForWord onboarding (see Appendix G for the complete list of codes and reference samples).

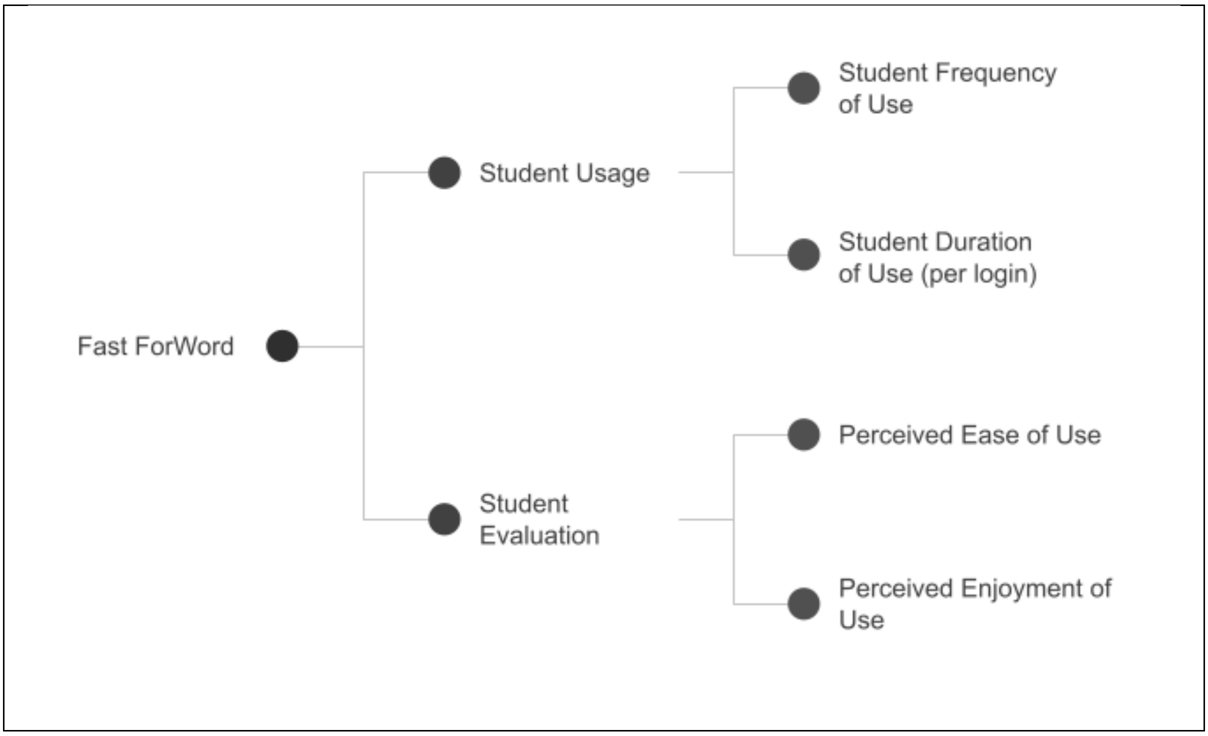
[19] Figure 3-12 is adapted from Figure 1 Preparation, organizing and resulting phases in the content analysis process published in (Elo & Kyngäs, 2008)

Table 3-11 Teacher and Student Interview Coding Scheme
(Student Use and Perception of Fast ForWord)

Category	Code	Reference Sample
Student Use of Fast ForWord	Student frequency of use	Maybe three times. I remember I didn't do it on weekends. I think around three times. – M32
	Student duration of use (per login)	On Monday I, I stayed in Fast ForWord for about, for about 15 minutes because I had homework to do and on, during the weekend which is on Saturday. I stayed on Fast ForWord for 30 minutes because I had more free time. – M15
	Description of activities attempted	On last week, there was this activity. I react to those different tones. And then if you pressed three buttons they would give you an initial tone, whether it's a high tone or low tone, and you press three buttons, whichever correctly match that tone, you would unlock a piece of a puzzle. Then after you've done all of them, you will get a picture. – M10
Student Perception of Fast ForWord	Perceived ease of using Fast ForWord	I mean, our teacher gave us a link so we just kept on learning immediately. Didn't really have a problem because I saved my password already. – M17
	Perceived enjoyment of using Fast ForWord	Yes. It's very fun. I feel like my younger self will enjoy it more. Okay, because it's very colourful. And then there's the special effects and some really cool. – F26
	Perceived usefulness of Fast ForWord	Fast ForWord really helped me like really helped me pay attention more and listen more in class. – M15

The codes presented in Table 3-11 were subsequently grouped to create broader categories, which were "conceptualized to be as close to the source material as possible" (Gläser-Zikuda et al., 2020, p. 4). This inductive derivation of categories was aimed at abstraction, to develop plausible explanations pertaining to the research focus on onboarding and integration of Fast ForWord during classroom learning (see Figure 3-13 for a sample categorisation matrix).

Figure 3-13 Sample Categorisation Matrix



3.5.3 Quantitative Analysis of Students' Fast ForWord Usage Data

Students' usage data comprised information on students' login frequency and duration, as well as the number of questions attempted. Descriptive statistics were employed to summarize and present the key characteristics of the data collected for this study. The analysis focused on the main variables, including duration of use per login, number of activities attempted, number of activities completed, and number of questions answered. Measures such as the sum, average (mean) and median were computed for each variable to identify central tendencies and overall patterns within the data. The results were tabulated to facilitate comparison across variables and to support subsequent inferential analyses, such as students' uptake of Fast ForWord. These descriptive measures provided an overview of how students were using the tool, for triangulation with claims students made when interviewed.

Analysing ALS usage data alongside classroom lesson recordings, teacher interviews, and student interviews strengthened this study by providing a more complete and triangulated understanding of how the system was used and how it related to classroom practice. While observations and interviews captured visible interactions and participant perspectives, usage data offered objective evidence of students' engagement with the system, such as frequency, duration, and progression. This allowed the researcher to connect out-of-class learning with in-class interactions, verify reported practices, and identify patterns that may not be evident from qualitative data alone. Integrating these data sources therefore enhanced the validity of the findings and supported a more holistic interpretation of ALS integration.

3.6 Positionality, Ethics & Quality

From conceptualisation to implementation, this research endeavour is inextricably related to my positionality, which is multidimensional and dynamic (Holmes, 2020; Rowe, 2014). This resulted in me treading a fine line along the insider-outsider continuum. Firstly, this research was motivated by my professional experiences as an educational technology specialist at the Ministry of Education in Singapore, which meant that I came with pre-suppositions that needed to be managed, particularly during data collection and data analysis.

During data collection, participating teachers led the decision-making process as far as possible, within the boundaries of the research design. This was to avoid undue interference from my preconceived notions or biases and entailed teachers having a free rein to determine the student interviewees, lesson unit for integration and the class seating plan. During data analysis, as mentioned earlier, a second coder was recruited to code five percent of the included video data, and the ensuing discussions between the two of us resulted in greater clarity and transparency as to how the codes in the SEDA framework were interpreted and assigned. Effort was also made to actively seek out disconfirming evidence and rival explanations during data analysis (Creswell & Miller, 2000).

Secondly, as this research was part of my doctoral studies that was fully funded by the Ministry, there was also some initial suspicion among the participating teachers as to the extent they were being evaluated by me during the research process. This was addressed through repeated assurance that my funder was not in any way involved in this research apart from the provision of financial resources and that the teachers would not be identifiable in any dissemination of the research findings. Thirdly, as a doctoral researcher enrolled in an overseas university, participating teachers were cautious to assess the extent to which they could share students' personal data with me, knowing that the data would reside in a university server that was located overseas. This resulted in conversations with the participating teachers to determine what data could be shared with me, to ensure compliance with local data protection laws and regulations.

Ethical guidelines set forth by the British Educational Research Association (BERA, 2018) also guided each step of this research. These guidelines adhered to included informed consent, avoid harm and exploitation, and maintaining confidentiality and anonymity. In particular, cognizant of teachers' heavy workload, conscious effort was made to offload participating teachers from research administrative tasks, such as preparation of information sheets and consent forms and coordinating student interviews. To minimise additional work on the teachers' part, I prepared all information sheets and consent forms needed for the teachers to disseminate to the parents. All student interviews were scheduled via email, and these emails were copied to the respective participating teacher, for purposes of transparency and accountability. This was as opposed to scheduling these student interviews through their teacher.

The next example of how I tried to avoid harm pertained to the video recording of the classroom lessons observed. The video recording setup was also carefully considered to minimise distraction and disruption to both teachers and students (Schmidt, 2019). This was particularly critical due to the use of two cameras, one placed in front and the other at the back of the classroom, to capture the students and teacher respectively. Where possible, the camera in front was placed in an unobtrusive position, to minimise students looking at the camera instead of their teacher. In the case of Ubin Secondary School, the front camera was placed on the teacher's table, beneath the projector screen, which made it somewhat camouflaged, allowing it to blend into the environment. However, in the case of Kusu Secondary School, due to space constraints and the need to avoid capturing students who opted out of this research, the camera was placed at the entrance of the classroom, which made it rather visible. To minimise distraction, it was placed as close to the door as possible so that it would hopefully not be within the students' immediate field of vision.

Another ethical consideration concerned honouring students' voice. As an adult and someone from the education sector, I could come across as authoritative or intimidating to the 13- and 14-year-old interviewees. As such, to put students at ease in the hope of retaining as much authenticity as possible in students' responses, I invested in rapport and relationship building with these student interviewees (Kuchah & Annamaria, 2012) and sought to create a safe and comfortable environment during the interviews, orienting this engagement toward "Working for them and not on them" (Balen et al., 2006, p. 43). I also intentionally gave students time to think through and elaborate on their responses. Through these mitigating gestures, I hope to preserve the authenticity of this research, ensuring that the findings would reflect the voice of these young participants.

Finally, every effort was made to ensure the quality of this research and the trustworthiness of the findings presented (Tobin & Begley, 2004). The adoption of a multi-case design, use of multiple sources and types of data as well as application of multiple analytic techniques were conscious efforts at triangulation. As part of data analysis, claims arising from the qualitative coding of lesson video data were compared with claims arising from qualitative content analysis of interview audio data and students' Fast ForWord usage data. Conflicting or incongruent findings were rationalised and presented truthfully with proposals of possible explanations. Other efforts toward trustworthiness included detailed reporting of the research methods in this chapter as well as retaining as much of the actual expressions used by the participants as possible during the coding, categorisation and reporting of this research.

That said, it remains undeniable that findings and interpretations arising from a rigorous case study would still not be generalizable. However, they remain valuable in crystalising our understanding of teachers' efforts at onboarding and integrating use of ALS, how teacher-student interactions could be influenced by such systems.

3.7 Chapter Summary

In this chapter, I presented the rationale for adopting a case study approach, and detailed specific research procedures, including data generation and data analysis, undertaken to address the stated research questions (see Table 3-12 for a summary). I also reflected on the ethical issues encountered and how I handled them, as well as the continual negotiation of my researcher positionality, particularly when engaging with the research participants. Collectively, these methodological description and considerations serve as the backdrop for interpreting the findings that would be presented in the next chapter.

Table 3-12 Summary of Research Procedures

Research Question	Data Generated	Data Analysis	Positionality, Ethical & Quality Considerations
1a. How does a teacher design and enact the ALS onboarding experience for students? 1b. How do students respond to the ALS onboarding experience and the selected ALS?	Video Recordings of Onboarding Lesson	Qualitative Coding using SEDA Framework	• Given that this lesson was recorded by the school, no prescribed video setup was given to avoid undue stress on the teachers
	Audio Recordings of Teachers' 1st Interviews	Inductive Content Analysis	• Sought to demonstrate respect and build trust during this interview
	Audio Recordings of Students' 1st Interviews		• Tried to put students at ease by allowing them to choose interview slot and location
	Fast ForWord System-Generated Usage Data	Descriptive Statistical Analysis	• Primarily used for triangulation with student interview data
2. What are the characteristics of the observed teacher-student academic interactions during classroom lessons during the period of ALS integration?	Video Recordings of English language Lessons	Qualitative Coding using SEDA Framework	• Tried to make the video cameras as inconspicuous as possible • Ensured that students who were not part of the research were not recorded • Worked with a second coder to minimise bias and ensure credibility
	Audio Recordings of Teachers' 2nd & 3rd Interviews	Inductive Content Analysis	

Research Question	Data Generated	Data Analysis	Positionality, Ethical & Quality Considerations
	Audio Recordings of Students' 2nd Interviews		• Kept closely to the interview protocol to avoid leading the interviewees and to ensure consistency • Giving wait time, particularly for student interviewees

4

Findings on ALS Onboarding, Initial Use and Perceptions

Chapter Four describes Ubin Secondary and Kusu Secondary teachers' efforts to onboard students, their students' perception of the onboarding process as well as students' initial use and perceptions of Fast ForWord. The teachers' efforts were unpacked focusing on key teacher activities prior, during and after the onboarding lesson, while students' perception of the onboarding processes was derived through student recounts during their first interview respectively. Students' initial use of Fast ForWord was gleaned through Fast ForWord usage data, focusing on frequency of login, duration of use and number of activities completed, while their perception of the tool was unpacked in terms of perceived ease of use, perceived fun to use and perceived usefulness.

4.1 Teacher Efforts to Onboard Students

This section zooms into how teachers introduced students to Fast ForWord and how they attempted to encourage students to make use of this tool during these early days of use. Each of the case studies presented will contain a rich description of the teachers' actions to onboard students, followed by interpretations of these observed actions with reference to teachers' articulations during interviews and further unpacking guided by activity theory.

4.1.1 Case Study 1: Ubin Secondary

Mr Tan's efforts to onboard his class of Secondary One students could be said to have begun with efforts to first onboard himself. This is derived from his request at the planning meeting in Jan 2023, for early access to Fast ForWord, the selected ALS. He explained that he would like to familiarise himself with the platform so that he would know better how to introduce it to his students and obtain their buy-in. After negotiating with BrainFit, the local distributor of Fast ForWord, Mr Tan was given access to the platform one week prior to the commencement of the 3-month subscription period at no additional charge. (For more details on planning meetings, see Chapter 3.2.2.1 on pre-intervention engagement.)

Mr Tan updated via email the day after receiving his login credentials about his explorations of the platform's offerings and shared that he had "completed instructor role certification" on Fast ForWord. In this email, he also enquired if students would be given access to learning activities in Reading Assistant Plus (RAP) in addition to those in Fast ForWord. Upon checking with BrainFit, the company's representative clarified that as part of the adaptive learning experience, students will need to complete all learning activities in Fast ForWord before progressing to RAP learning activities.

Other than taking an interest in the type of activities accessible by students, Mr Tan seemed also to be thinking about how he would onboard students to the platform. In the same email mentioned above, Mr Tan shared more concretely, compared to the early planning meeting in Jan 2023, how he would like to introduce Fast ForWord to students. He wrote that, "Looking at the details, I'm thinking of priming my students before next Friday's onboarding session by introducing them to the system's features. Maybe a quick 5 min every lesson before next Friday to play one of the training videos that showcase a feature."

During the week of the Fast ForWord onboarding lesson, Mr Tan had lessons with the class on all days except Tuesday. During the two 35-minute lessons on Monday and Thursday, he carried out the 5-minute priming activity at the start of each lesson, where he introduced the concept of adaptive learning and the Fast ForWord platform respectively. He explained during the first interview that this was his way to "get them [the students] interested… to sell the product."

> "So, what I did was essentially, you know, I introduced them the concept of adaptive learning itself. So I asked them, I posed them a question. Okay, what if you know you could have personalized attention, you know, about, when you are reading, right, and the difficulty is scaled to you itself, so it cannot be too difficult or too easy, but it's just right for you? How would you like that."

> "Then another time, I shared with them the video that was on the Fast ForWord website, about what Fast ForWord was... And I said then, okay, this what you'll be doing in, soon."

On the day of the onboarding lesson, Mr Tan spent the first 20 minutes settling students into the computer lab, before starting the lesson proper where he shared an anecdote from his past reading challenges and asked if students had similar experiences. Quite a number of students were observed to be nodding and raising their hands to indicate they have had similar experiences. Mr Tan then introduced Fast ForWord as a "reading skills programme" to help them read better, before playing a video featuring the founder of Carnegie Learning who talked about how their programme will help students become better readers and learners. At the end of the video, Mr Tan drew connections between the founder's message and what he shared earlier before distributing to students their respective Fast ForWord login credentials.

> "So it's just not the producer of Fast ForWord who had this before. As I shared with you just now, I also had this uh issue as well, so when he spoke, when I watched the video for first time, it resonated with me, yah, because I have experienced it before, as some of you also shown, yes or no. okay?"

Mr Tan then asked students who have received their Fast ForWord login credentials and who have successfully logged into the school laptop to try logging into Fast ForWord. While the students were doing so, Mr Tan went around the computer lab to help those who were unable to log in; quite a number of students encountered problems as they selected the wrong login domain. A few minutes later, Mr Tan called students to attention "laptop covers 45 degrees down, eyes on me," asking them to stop what they were doing for a moment. He explained that he saw that "majority of you have logged in and I am not going to make you wait, okay; the two or three that have issues, we'll help them, is that clear."

After getting the students' attention, Mr Tan proceeded to introduce the Reading Progress Indicator (RPI) and then asked them to complete it as their first Fast ForWord task upon successful login. RPI is an assessment tool that measured phonological awareness, decoding, vocabulary and comprehension (see Chapter 3.3 and Appendix B for more information on RPI). At this very first instance, RPI sought to diagnose students' respective reading levels for personalising their subsequent learning experience on the platform. After setting the students on their first Fast ForWord task, Mr Tan walked around the computer lab to help students who were still struggling with login issues, whether it was logging into the school laptop or logging into Fast ForWord.

Approximately five minutes before the end of the onboarding lesson, Mr Tan asked students to "pause what you are doing," put their "laptop covers 45 degrees downwards," and "turn your chairs to face the screen." After ensuring that all students complied with his instructions, Mr Tan went on to explain to students what they could expect after completing the RPI. He projected the daily task interface on the screen and informed students that "every one of you will have a different activity to do, based on how you have been assessed itself, yes or no."

Mr Tan then made explicit the expected minimum frequency of use of Fast ForWord by students, "three times a week for 30 minutes each." He added that students should try and go beyond this stipulated minimum, "when you have time, just go for it; the more you do the better, is that clear." Mr Tan reiterated this expectation before reminding students to update their vocabulary books (before the next lesson; this announcement is not related to Fast ForWord onboarding). He then asked students to log out of the school laptops before he dismissed the students and sent them back to the classroom.

Table 4-1 presents an overview of how Mr Tan staged his efforts to introduce Fast ForWord to his students, culminating in the onboarding lesson on Friday. In total, Mr Tan spent 80 minutes out of the 210 minutes of the lesson time he had for the week on Fast ForWord onboarding, accounting for 38% of the time he had with the class that week. This is a rather substantial amount of time spent on onboarding students to Fast ForWord, given that this time could have been used instead to advance curriculum goals. Furthermore, given that the onboarding lesson itself took an entire 70-minute lesson and there were only two 70-minute lessons each week with the class, it could be inferred that Mr Tan did buy into this project and he was committed to ensuring that students started well with Fast ForWord.

Table 4-1 Mr Tan's Efforts to Onboard Students

Week of Onboarding Lesson		Teacher Actions
Mon	9:00 - 9:35 AM (35 min)	[5 min] Introduced the concept of adaptive learning to students
Tue	(No English lesson)	-
Wed	8:25 - 9:35 AM (70 min)	-
Thu	2:15 - 2:50 PM (35 min)	[5 min] Introduced Fast ForWord to students by playing a video from its website
Fri	7:50 - 9:00 AM (70 min)	[70 min] Conducted onboarding lesson in the Computer Lab

During the 70-minute onboarding lesson that was presented at length in the preceding paragraphs, two out of the three types of teacher-student interaction identified by Hafen et al. (2015) were observed. They were academic interactions and organisational interactions; social emotional interactions were not observed. This absence of social emotional interactions seems to suggest that these students do not 'act out' very much in class and can be considered to be compliant or cooperative learners. Overall, academic interactions occupied close to 45 minutes (approximately 65%) of the total lesson duration while organisational interactions took close to 25 minutes (approximately 35%) of the total lesson duration (see Table 4-2).

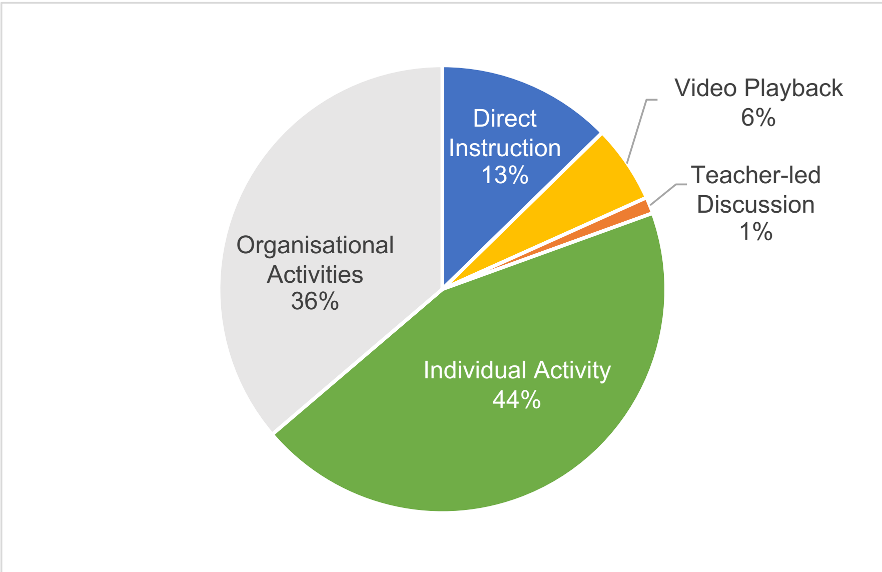
Table 4-2 Teacher-Student Interactions Observed during Mr Tan's Onboarding Lesson

Type of Teacher Student Interaction	Duration	Percentage of Lesson
Academic	44 min 38 sec	63.8%
Organisational	25 min 22 sec	36.2%
Social Emotional	0 min 0 sec	0.0%

Teacher-student organisational interactions observed included bringing students from the classroom to the computer lab, getting students to log into the school laptop, troubleshooting computer password and login issues, distributing Fast ForWord login credentials to students, and helping students log into Fast ForWord. For example, students took about 11 minutes to move from the classroom to the computer lab and they took another 8 minutes to turn on and log into the school laptop.

Had Mr Tan chose to conduct the onboarding lesson during a 35-minute lesson, it is likely that he would at best only been able to distribute Fast ForWord login credentials before the lesson ended, given that organising the students took close to 25 minutes. However, because Mr Tan chose to use a 70-minute lesson for onboarding, he could engage students with an array of academic activities that formed the kernel of this onboarding lesson. Types of activities observed during the onboarding lesson included direct instruction, video playback, teacher-led discussion and individual activity (see Figure 4-1).

Figure 4-1 Distribution of Mr Tan's Onboarding Lesson Time by Observed Activity Types



Notably, individual activity accounted for 44% of the entire lesson (close to 30 minutes) and this time was mostly taken up by the lesson segment where students worked individually on the RPI. At the start of this individual activity segment, one student was still unable to log in. Mr Tan then enlisted the help of the Technical Assistant (TA) who was present in the computer lab to support the student with troubleshooting. Mr Tan then walked around the class to monitor students' progress with RPI. There was at least one occasion where he was stopped by students with their questions, and he was able to render help immediately.

Compared to having students log into Fast ForWord for the first time on their own at home, having them do so in the computer lab during the lesson gave Mr Tan the opportunity to resolve any teething issues that students may encounter. This was evident from the login issues students experienced and the questions they had when doing the RPI, e.g., questions arising from unfamiliarity with the Fast ForWord user interface. By the end of the onboarding lesson, while not all issues were resolved and all questions answered, at the very least, all students would have logged into Fast ForWord and started on RPI, if not completing it.

From the observer's perspective, Mr Tan's onboarding efforts appeared to be rather successful. He explained clearly why the class was doing this and his expectations of students in terms of their use of Fast ForWord. He also gave students time to engage with Fast ForWord, ensuring that they knew how to go about using the tool when they were back at home. However, Mr Tan's self-assessment of his onboarding efforts seemed rather critical. During his first interview, he shared that upon reflecting on the lesson, he felt that much of the lesson was on diagnosing technical issues and did not seem to adequately prepare students for using Fast ForWord for independent learning at home.

> "Well, what happened was after the lesson itself, I was looking and reflecting upon it, and I realized actually that what we had done is actually to get them to log into the system and to do the diagnostics, but that was using the school laptop. … This was also compounded by the issue that I think two students actually gave feedback, that they had problems logging into Fast ForWord in using their own devices."

> "I don't want a situation where suddenly near the end of the holidays, or at the start of this term, you know, students come to me and say, Oh, I didn't do it, because I couldn't log into my system. And that would be very, very sad."

Mr Tan also shared that, because of this reflection, he conducted a second onboarding lesson the following week for students to use Fast ForWord. However, he did not share much detail of this lesson other than the fact that it was a 35-minute lesson.

4.1.2 Case Study 2: Kusu Secondary

Ms Aliyah's efforts to onboard her class of Secondary Two students could be said to be concentrated on the 40-minute onboarding lesson that she conducted at the start of the subscription period. She started the lesson by asking students to put away their books and notes and take out their Chromebook and an earpiece if they had brought one. Ms Aliyah also gave students who did not bring an earpiece the option to loan a headset from her later. She waited a few minutes for students to settle down before introducing Fast ForWord as "a new online programme or tool."

Ms Aliyah proceeded to show the first screen students would see when they logged into Fast ForWord, before playing a video explaining what RPI was. The video featured the tool's creator who spoke briefly about the test before sharing tips on how to approach the RPI. At the end of the video, Ms Aliyah reiterated the video's key message to "just try your very best" though she referred to the RPI as "a quiz." She also reminded students that they "should not be discussing with each other… and should be done on your own." Following this, Ms Aliyah moved on to tell students how to access the link to Fast ForWord and distributed the login credentials to the class. It was also at this juncture that she instructed students who needed headsets to collect one from her desk at the front of the classroom.

After the last student received their login credentials, Ms Aliyah stopped the video recording at 10 minutes and two seconds. When queried on the reason for not recording the full lesson, she shared that students were doing the RPI till the end of the lesson and there was "nothing to see." This comment corroborated with Ms Aliyah's representation of how she onboarded students during her first interview, "I gave out all the passwords and the user names and then I just got them to do the RPI. So that was our onboarding."

Unlike Mr Tan, who chose to onboard students during a 70-minute lesson, one of the two longest lesson durations of the week, Ms Aliyah chose to do so during a 40-minute lesson, which in contrast, was the lesson of the shortest duration (Table 4-3). She also did not plan for any priming activity prior to the onboarding lesson, which meant that the onboarding lesson was Ms Aliyah's sole attempt at acquainting students with Fast ForWord; and that accounted for 25% of the time she had with the class that week. However, based on what Ms

Aliyah said at the start of the onboarding lesson, “I think I mentioned before we are going to use a new online programme or tool for the class,” it could be deduced that she did inform students that they would be starting on Fast ForWord prior to the onboarding lesson, though it was not clear the context in which the tool was first mentioned.

Table 4-3 Ms Aliyah’s Efforts to Onboard Students

Week of Onboarding Lesson		Teacher Actions
Mon	10:20 -11:20 AM (60 min)	-
Tue	11:40 - 12:40 PM (60 min)	-
Wed	10:00 - 10:40 AM (40 min)	[40 min] Conducted onboarding lesson in class
Thu	(No EL lesson)	-
Fri	(No EL lesson)	-

For this onboarding lesson, two out of the three types of teacher-student interaction identified by Hafen et al. (2015) were observed. They were academic interactions and organisational interactions; social emotional interactions were not observed. Organisational interactions observed typically entailed Ms Aliyah giving instructions to students, such as asking them to keep away their books and take out their PLDs, and distribution of Fast ForWord login credentials. Academic interactions observed included Ms Aliyah introducing the tool and students doing the RPI. Overall, academic interactions occupied close to 35 minutes (approximately 87%) of the total lesson duration, while organisational interactions took close to 5 minutes (approximately 13%) of the total lesson duration (see Table 4-4).

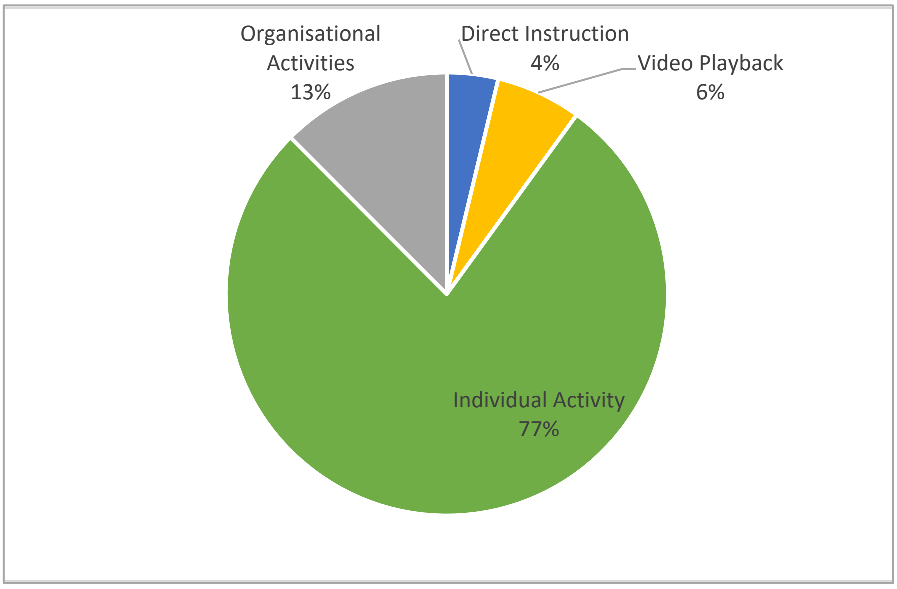
Table 4-4 Teacher-Student Interactions Observed during Ms Aliyah’s Onboarding Lesson

Type of Teacher Student Interaction	Duration	Percentage of Lesson
Academic	34 min 40 sec	86.7%
Organisational	5 min 20 sec	13.3%
Social Emotional	0 min 0 sec	0.0%

Notably, individual activity accounted for 77% of the entire lesson (approximately 30 minutes) and this time was mostly taken up by the lesson segment where students worked individually on the RPI (Figure 4-2). With reference to the amount of time for individual activity during the onboarding lesson conducted by Mr Tan, it should be noted that despite the difference in the overall lesson duration, the amount of time given by both teachers for students to explore Fast ForWord was approximately the same, around 30 minutes.

This is possibly because Ms Aliyah's students were using their personal learning devices (PLDs) to log into Fast ForWord and thus experienced significantly less log in issues, compared to Mr Tan's students who were logging in using school laptops (that they were unfamiliar with) (see Chapter 4.1.2.1 for further discussion). Ms Aliyah also expressed that she found Fast ForWord "quite straightforward," which seemed to suggest that she was confident that her students would be able to log into and use the tool independently.

Figure 4-2 Distribution of Ms Aliyah's Onboarding Lesson Time by Observed Activity Types



Following the onboarding lesson, Ms Aliyah did not plan to conduct another lesson on Fast ForWord or ask students to work on Fast ForWord in class. However, on the day of the first lesson observation (i.e., approximately 1.5 weeks after the onboarding lesson), Ms Aliyah's lesson was disrupted due to close to half the class being taken out of class for Covid-19 vaccination, she decided to let those remaining in class to work on Fast ForWord instead of carrying out the planned lesson. She shared that students appeared to be "more open to using the programme (Fast ForWord) now compared to the onboarding lesson, where "from the RPI I think they probably thought it was very tedious. She noticed "some intense concentration" among students when doing the Fast ForWord activities, which she hoped would "spur them to carry on."

While Ms Aliyah, did not seem to have much to say about her onboarding lesson, she did express some views of this tool (that she had earlier selected) during her first interview. She shared that not having any sight of the students' activities on Fast ForWord was "difficult." This not only hampered her ability to nudge students to use the tool more often, but also made it difficult for her to link what students were learning with Fast ForWord and what students were learning in class.

> "if I am able to go in and see where the challenges are for them… it's probably something that I can bring to class and talk about it and then and create that relation for them to see how what they're doing can be related to what we're doing in class"

While she conceded that she had access to student activity reports which could provide some insight on students' progress, she shared that she was unable to commit time to analysing these individual reports for in-class remediation. Fast ForWord did not provide any aggregated analysis or reports for the entire class.

She also expressed a desire to be able to "choose the type of activity that I want to assign to the students, because then it will be more relevant to what I'm doing at the moment" even though she also noted that the Fast ForWord learning experience was meant to be adaptive, "follow the students' ability." She explained that "But that also means that the students all might be at different levels. So, in terms of teaching in class, it's a little bit more difficult in that sense." This and the preceding request were strikingly aligned to what has come to be known as teacher-in-the-loop, where, based on what Ms Aliyah has articulated, it would seem that she felt taken out of the Fast ForWord learning loop even though the tool offered teachers a monitoring dashboard.

When asked if there were any aspects of Fast ForWord that appealed to her, she responded with "I think it's just, okay" before highlighting that the tool was "very user friendly." It was not clear if Ms Aliyah herself did not buy into the tool or that she was still unfamiliar with the tool at the point of the interview. She had shared that she only logged into Fast ForWord this week (two days ago) after conducting the onboarding lesson (1.5 weeks ago); this was in part because Ms Aliyah was on medical leave for most of the previous week. At the end of this interview segment, Ms Aliyah shared candidly that she was "still grappling with it" where "it" here referred to both Fast ForWord and integrating the tool with the selected lesson unit.

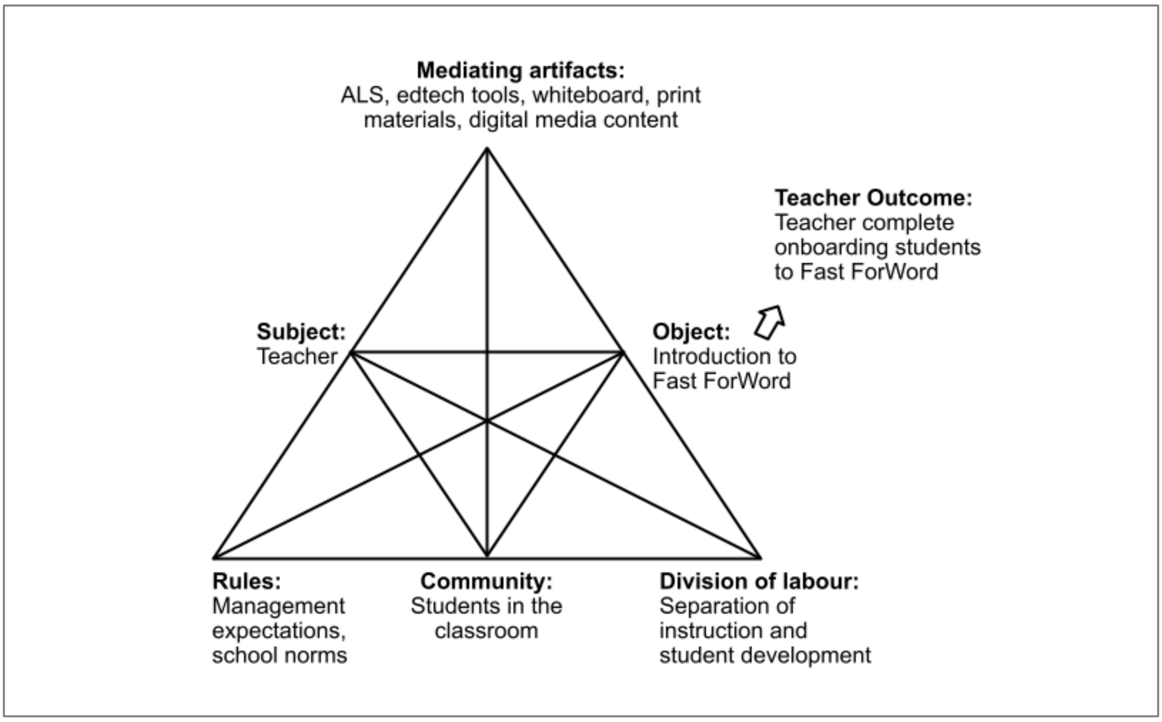
4.1.3 Using Activity Theory to Unpack Teachers' Efforts to Onboard Students

Following the rich description and interpretation of Mr Tan and Ms Aliyah's actions to onboard students (in Chapter 4.1.1 and 4.1.2 respectively), we will now further unpack both onboarding lessons using activity theory, starting with Mr Tan's lesson and followed by Ms Aliyah's lesson. Due to the relatively shorter lesson duration of the latter, its unpacking will focus largely on contrasting Ms Aliyah's actions with those of Mr Tan's.

Regarding the onboarding lesson conducted by Mr Tan, i.e., the *Activity*, the *Subject* in this instance would be the teacher, Mr Tan, who was the active participant whose point of view has been selected for analysis. The *Object*, which was introducing students to Fast ForWord, refers to that which "gains motivating force that gives shape and direction to activity… [and] determines the horizon of possible actions" (Engeström et al., 1999, p. 381). This *Object* in turn, sought to contribute to bringing about the broader teacher-desired outcome of onboarding students to Fast ForWord (see Figure 4-3).

The onboarding lesson was mediated by various *Artefacts*, such as Fast ForWord and the school laptop, functioning as tools expressing anticipated and actual cognition. Mr Tan also made use of digital media content such as Fast ForWord screen captures and a video clip featuring the tool's creator. In particular, the use of the school laptop appeared to be particularly problematic as many students did not remember their school laptop login credentials. This could have been avoided if students were using their personal learning device (PLD). Unfortunately, at that point in time, students had yet to receive their PLD due to operational delays. In this instance, the school laptop appeared more to be a source of distraction rather than a cognitive tool, taking students' attention away from Fast ForWord and what they were supposed to be doing.

Figure 4-3 Teaching Activity System of the Onboarding Lesson Conducted by Mr Tan



Fast ForWord during this onboarding lesson was imbued with multiple meanings. Firstly, it embodied Mr Tan's aspirations of the change that would occur in students' reading proficiency, arising from their engagement with the tool. He anticipated that Fast ForWord would teach students "the individual skills that will help you to decipher what a text is, to help you to understand a text better". Secondly, students' actual first encounter with Fast ForWord entailed them completing the RPI before they were assigned any tasks to work on. As Mr Tan explained, "it will consist of 60 questions and the whole reason why you are doing this is for the system to assess your current reading levels." This meant that students first experienced Fast ForWord as an assessment tool rather than a learning tool or learning aid, which may have foreshadowed students' perception of Fast ForWord.

Turning our attention to the *Division of labour* during this lesson, the presence of the TA was incidental rather than intentional and was not the norm. The TA was in the computer lab to video record the onboarding lesson for the purposes of this research. This could be why Mr Tan did not immediately enlist the TA's help with troubleshooting when students first reported their login issues. It was only when more and more students struggled to login that Mr Tan asked the TA for help. What then transpired was the TA going on to resolve most of the students' login issues and seeking external support from the service provider to address the remaining issues. The presence of the TA not only freed Mr Tan to progress with the onboarding lesson as he took over troubleshooting with students but also reduced the amount of time taken to resolve the various student login issues. This would suggest that on-site technical support during the onboarding lesson, though not the norm, could be useful.

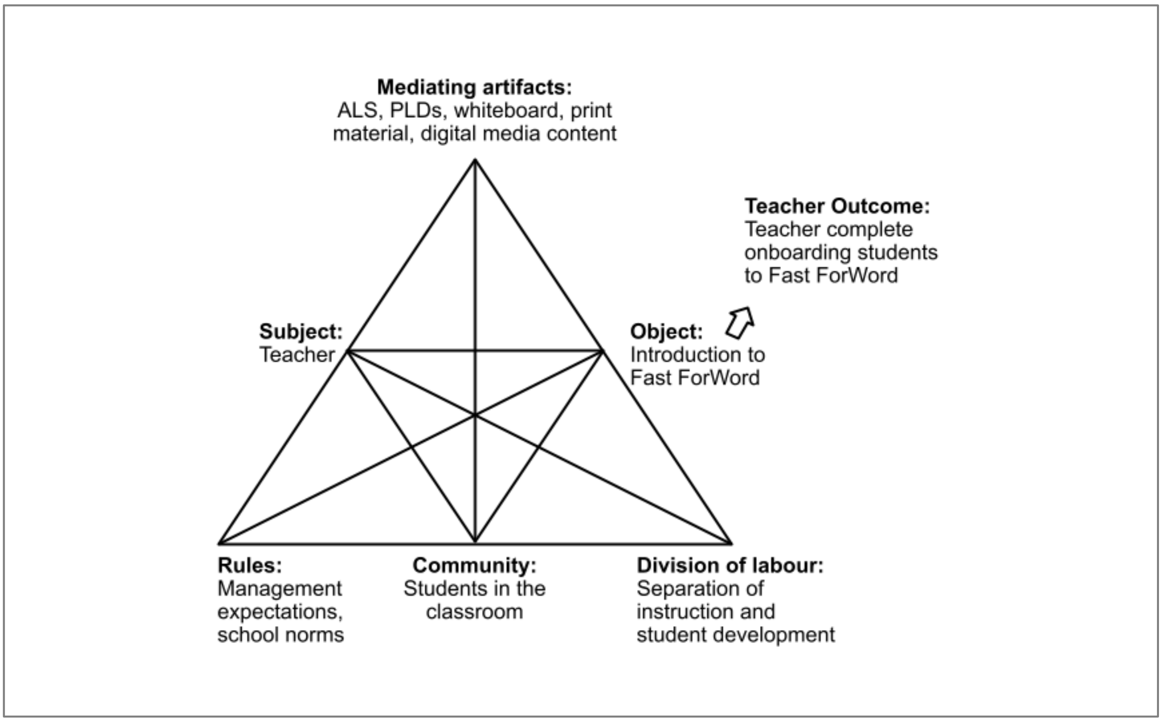
Finally, the students were observed to be rather compliant and collegial with one another during the onboarding lesson. This can be seen with how promptly they complied with Mr Tan's instructions, where he rarely had to repeat his instructions to the class. For example, when he asked students who have logged into their school laptop to help those who could not log in. The students immediately sprang into action after hearing his instruction. This corroborated with Mr Tan's description of the class to be "very well behaved," where even though they needed occasional reminders on how to behave in class, they were quick to respond, "And a reminder to them, you know, okay, let's focus your eyes on me and so on, will actually cause them to stop being distracted already."

Overall, from the video recorded onboarding lesson, it can be observed that classroom norms and climate, as well as the *Community* of students in the classroom were generally positive and can be said to contribute positively to the onboarding lesson. Even though Mr Tan did not consider this onboarding lesson to be a success and said so during his first interview, him giving clear instructions to students, making explicit expectations of students' use of Fast ForWord and creating time and space for students to engage with the tool in class were evidence of a coherent and carefully designed onboarding experience for students.

Regarding the onboarding lesson conducted by Ms Aliyah (Figure 4-4), the *Subject* and *Object* of this onboarding lesson would be the same as that by Mr Tan, where the teacher, Ms Aliyah in this instance, was the *Subject* and introducing students to Fast ForWord was the *Object*. The latter in turn sought to contribute to the broader teacher-desired outcome of onboarding students to Fast ForWord, which was also the desired outcome for Mr Tan. However, despite both teachers sharing the same desired outcome, they remained some differences in how they conducted the lesson, such as their choice of lesson duration, lesson venue and choice of device for students to access Fast ForWord.

Comparing the two activity systems (i.e., Figure 4-3 and Figure 4-4), it may appear that the differences between these lessons were rather minor. However, the implications of these differences are not necessarily insignificant, and they will be highlighted below.

Figure 4-4 Teaching Activity System of the Onboarding Lesson Conducted by Ms Aliyah



First, both onboarding lessons were mediated by various *Artefacts* such as Fast ForWord, video(s) and printouts of students' login credentials. However, unlike students in Mr Tan's class who were using school laptops, students in Ms Aliyah's class were using their personal learning devices (PLDs), which were Google Chromebooks. These students had been using their PLD for at least a year and did not encounter the same device login issues that were observed during the onboarding lesson by Mr Tan. Instead, students were able to log into Fast ForWord more quickly and could start working on the Reading Progress Indicator (RPI) almost immediately after receiving their login credentials.

In this instance, the onboarding lesson took place in the classroom, which saved time from having students move to the computer lab, and without TA support. These seemed to suggest that for older students, Ms Aliyah's students were one grade level higher than Mr

Tan's students, and/or for students who have been using PLDs for a while, the presence of a TA may not be critical to the onboarding process. This is deduced based on what the video captured of students' screens, up till the end of the 10-minute recording, students have already logged into Fast ForWord and doing the RPI. This would mean that while the lesson duration of the two onboarding lessons by Ms Aliyah and Mr Tan varied quite greatly in terms of their duration, 40 minutes and 70 minutes respectively, this decision would appear to be right for their respective context, as both led to similar outcomes of students given time to do the RPI.

Second, while both Ms Aliyah and Mr Tan played videos from the Fast ForWord website as part of their preamble during the onboarding lesson, their choices of videos and what they emphasised on were rather different. The video selected by Mr Tan focused on what Fast ForWord was trying to achieve, which was to help students become better readers, while the video selected by Ms Aliyah focused on explaining what RPI was about, emphasising the initial diagnostic assessment. These choices reflected the different approach adopted by the two teachers, with Mr Tan seemingly trying to get students' buy-in by demonstrating the value proposition of Fast ForWord, while Ms Aliayah seemed to focus on ensuring that students did things right.

Third, Ms Aliyah did not stipulate any expectations or communicate the expected minimum frequency of use of Fast ForWord during the onboarding lesson, "I didn't actually… I think I forgot." While she did remind students subsequently to use the tool, she did not give explicit instructions like, "must do [Fast ForWord activities] three [times] every week." However, she conceded that not making her expectations clear to her students might have contributed to some of them not completing their RPI during the week of onboarding. She noted that, as of "yesterday" (the day before the interview), more than two weeks after Fast ForWord was made accessible to students, less than 10 students "have started and have done at least a few activities;" in fact, most students "did not touch it at all."

This absence of explicit communications on expectations of students' use of Fast ForWord after the onboarding lesson, coupled with what seemed like an emphasis on RPI rather than Fast ForWord during the onboarding lesson, might result in students not realising that they should be using the tool in their own time as part of their learning following this lesson (see Section 4.3.2 for further discussion). Furthermore, Ms Aliyah shared during her first interview that, "from the RPI I think they probably thought it was very tedious" which seemed to suggest a lack of uptake, though Ms Aliyah did not seem to have a plan or have taken steps to remedy that.

Overall, from the partial video recording of the onboarding lesson, it can be observed that the lesson progressed rather smoothly even though little can be said about the classroom norms and climate. This is because the video camera was placed at the back of the classroom, and students' expressions could not be observed. It was thus not clear what their initial reactions were to Fast ForWord. Furthermore, given the slightly skewed emphasis on RPI and no clear instructions to students on the expectations of their use of Fast ForWord, it is unlikely that the goals of onboarding were achieved through this onboarding lesson.

4.2 Student Perception of the ALS Onboarding Experience

This section turns the focus to students, exploring their impressions of their onboarding experience. Findings reported here are largely drawn from the first semi-structured interview with six students from each school, through which solicited these participants' views on their ALS onboarding experience were solicited (see Chapter 3.2.1 for how these students were selected). Each case study will present how students represented the onboarding lesson, their re-articulation of their teachers' expectations (or lack of) of Fast ForWord usage and how they felt about the onboarding experience.

4.2.1 Case Study 1: Ubin Secondary

Mr Tan's efforts to onboard students entailed a brief introduction of the concept of adaptive learning and sneak preview of Fast ForWord prior to the onboarding lesson, as well as two onboarding lessons that spanned 70 minutes and 35 minutes[20] respectively. During the first onboarding lesson, Mr Tan shared his personal struggles with reading and attempted to

[20] As mentioned earlier in Chapter 4.1.1, the second onboarding lesson (unplanned) was conducted due to Mr Tan's dissatisfaction with the first onboarding lesson (planned).

demonstrate how Fast ForWord can help students in developing their reading skills. In the second onboarding lesson, he attempted to resolve all known technical and login issues so that students would have no reason not to use Fast ForWord when they were at home (see Section 4.1.1).

Interestingly, despite Mr Tan's rather elaborate efforts to engage his students, the student interviewees' representation of the entire onboarding experience was rather brief and tended to focus only on the 70-minute onboarding lesson. None of them mentioned the second onboarding lesson. Only one student interviewee remembered Mr Tan introducing the concept of adaptive learning at the start of their lesson in the library, which was the first of his two lead-ups to the onboarding lesson. However, his articulation differed somewhat from what was shared by Mr Tan.

> "He brought us to the library. Then he was telling us all about the benefits of Fast ForWord and how is it going to impact us on the learning" – M10

> "So, what I did was essentially, you know, I introduced them the concept of adaptive learning itself. So I asked them, I posed them a question. Okay, what if you know you could have personalized attention, you know, about, when you are reading, right, and the difficulty is scaled to you itself, so it cannot be too difficult or too easy, but it's just right for you? How would you like that." – Mr Tan

Comparing the two recounts by Mr Tan and his student M10, it is evident that M10's recount not only contained less detail than that of Mr Tan but also presented quite different versions of what transpired. M10 remembered Mr Tan talking about Fast ForWord, i.e., the tool, and not "the concept of adaptive learning." And while Mr Tan was trying to make connections to reading, M10 remembered it more generically as learning. This could have been possibly a signal that Mr Tan's messages during onboarding were not received and/or retained by students. In fact, the first thing the student mentioned was, "He brought us to the library." It was almost as if the venue was the most memorable aspect of the experience.

Unlike those 5-minute lead-ups that did not seem to leave much of an impression among the students, all student interviewees at the very least were able to say something about the onboarding lesson. However, their recounts tended to be brief and were incomplete representation of the lesson. In other words, none of the student interviewees were able to fully recount what transpired during the lesson. What appeared to stand out for students was the lesson venue, i.e., the Computer Lab, which was mentioned by five out of the six student interviewees. This reinforced the earlier conjecture that going to a different venue for lesson was among the most memorable aspects of the experience. Student F8 offered a reason for this, "[on] very hot day … I prefer the air-con."

Overall, students' recount of the onboarding lesson can be categorised into "doing the Fast ForWord things" (F01) and teacher "demonstration on how to use Fast ForWord" (M10). The student interviewees who talked about the former used verbs like "doing", "try" and "explore" to represent their first encounter with the tool. Students who talked about the latter used phrases like "gave us a demonstration", "told us" and "gave us a brief look" which highlighted their teacher's actions instead. Interestingly, when talking about the onboarding lesson, all female student interviewees tended to focus on what they did, i.e. student activity, while all male student interviews were predominantly talking about what Mr Tan did, i.e. teacher activity (see Table 4-5).

From Table 4-5, it would appear that Mr Tan's efforts at context setting, which included his attempts to clarify the rationale for using Fast ForWord and his introduction of the RPI, did not leave much of an impression on students. This was in spite of students appearing to be rather responsive (e.g., nodding) during the lesson. In a similar vein, none of the student interviewees mentioned the RPI specifically even though three of them did talk about "doing" Fast ForWord. This seemed to suggest that students were not paying attention when Mr Tan was explaining what the RPI was and students may also have not realised that what they were doing then on Fast ForWord was the RPI and not the daily assignments (that they were expected to do upon completion of RPI).

Table 4-5 Ubin Secondary Students' Representation of the Onboarding Lesson

Duration	Key Academic Activities	F01	F04	F08	M10	M15	M29
8 min 27 sec	Teacher shared his personal reading challenges, engaged students on their reading challenges and showed a video explaining how Fast ForWord is designed to help with these challenges.						
1 min 20 sec	Teacher explained what the Reading Progress Indicator (RPI) and the reasons for it is being students' first task in Fast ForWord						
27 min 41 sec	Students started doing the RPI in Fast ForWord while Teacher went around to help those who needed help.	✓	✓	✓			
3 min 22 sec	Teacher guided students through the Fast ForWord Assignments interface.				✓	✓	✓
	Teacher set expectations on frequency of use and reminded students to complete RPI at home if they have not already done so.						✓

✓ *indicated that the student mentioned this activity during their interview.*

Another pertinent observation is that only one student interviewee remembered Mr Tan's instructions on the expected frequency and duration of use of Fast ForWord, "do three times during the March holidays, three times for at least 20 minutes each day" (M29). However, based on his (quoted above) verbalisation, it would appear he interpreted Mr Tan's instructions to apply only "during the March holidays" even though Mr Tan did not stipulate a time frame. This misinterpretation coupled with the rest of the student interviewees seemingly not registering Mr Tan's expectations on the frequency and duration of use might have been an early weak signal that the actual utilisation of Fast ForWord would unlikely be high.

In terms of how students felt about the onboarding lesson, four of the six student interviewees remained silent and chose not to respond. One of them (F04) shrugged at the question, which could suggest ambivalence or an unwillingness to comment. The two students (F01 and F08) who shared how they felt about the lesson presented rather opposing reactions. F01 considered the onboarding lesson to be one of the "more painful lessons" she had to endure because the lesson involved her working alone and she "couldn't talk to anyone." F08 however, shared that she "like the Comp Lab experience," not only because of the air con but also because it was a departure from the usual "paper and pen" learning experience and "it's like more fun."

In summary, recounts of the onboarding experience by all six student interviewees from Ubin Secondary were partial, primarily focused on the onboarding lesson, though even that was incomplete. Only one (M29) among them remembered that Mr Tan's expectations of their Fast ForWord usage but his memory of this expectation was also inaccurate. Most were quiet on how they felt about the onboarding experience and the two (F01 and F08) who expressed how they felt articulated some pretty polar sentiments. These observations, which were captured during the first interview which took place approximately 3 weeks after the onboarding lesson, seemed to be pointing at an ambivalent attitude toward the Fast ForWord onboarding experience. This in turn raises questions about students' attitudes towards Fast ForWord itself (which will be addressed in Chapter 4.3).

4.2.2 Case Study 2: Kusu Secondary

Ms Aliyah's efforts to onboard her class of Secondary Two students were concentrated on the 40-minute onboarding lesson that she conducted at the start of the subscription period. During this lesson, she distributed login credentials to her class after a short preamble on the RPI. Thereafter, students were given the rest of the lesson to explore Fast ForWord, which largely entailed completing the RPI.

When asked about their onboarding experience, all student interviewees were able to say something about the onboarding lesson. However, even though students working independently on the RPI took more than 70% of the lesson duration (see Table 4-6), the first thing that came to students' minds when asked about the onboarding lesson were Ms Aliyah's gesture to loan students headsets, which were needed for the RPI, and the video that she played. That said, half of the six student interviewees volunteered some form of a rationale as to why they were introduced Fast ForWord, when describing the onboarding lesson, though the rationale given varied somewhat. Students' articulated rationales were "to improve our hearing" (M32), "learn English more effectively" (F27) and "upgrade your English level" (M18). This was despite Ms Aliyah was talking mostly about RPI and its importance during the onboarding lesson.

> "[T]o make full use of this tool, it [RPI] has to have an accurate assessment of your abilities… so when you do the quiz [RPI] later, you should try your very best. You should not discuss with each other." – Ms Aliyah

Table 4-6 Kusu Secondary Students' Representation of the Onboarding Lesson

Duration	Key Academic Activities	F26	F27	M17	M18	M32	M34
3 min 43 sec	Teacher introduced the Reading Progress Indicator (RPI) and reiterated the importance of taking the RPI seriously.						
28 min 50 sec	Students started doing the RPI in Fast ForWord while Teacher went around to help those who needed help.		✓	✓	✓		✓

✓ *indicated that the student mentioned this activity during their interview.*

Interestingly, while Ms Aliyah shared during her interview that she did not stipulate any expectations or communicate the expected minimum frequency of use of Fast ForWord during the onboarding lesson, more than half of the student interviewees recounted some form of an expected frequency of use. They ranged from "whenever we can" (F27) to "twice a week (M17), "at least three times a week" (M34) and "daily" (M32). The remaining two student interviewees (namely F26 and M18) did not recall such instructions, which was in agreement with what Ms Aliyah had shared.

These differing responses from the six student interviewees and Ms Aliyah seemed to suggest two possibilities. First, Ms Aliyah indeed did not mention any expectations on minimum frequency of use of Fast ForWord during the onboarding lesson. However she may have mentioned something to that effect on another occasion, before or after the onboarding lesson. This would potentially explain why three students recalled some expectations in terms of how often they should log into Fast ForWord. Secondly, the difference among these three student interviewees may have been the result imperfect memories, with different students remembering what was said differently. It would be plausible that Ms Aliyah may have referred to specific frequencies, including three times a week which would be the ideal case and at least twice a week being the next best alternative.

In terms of how students felt about the onboarding lesson, four of the six student interviewees remained silent and chose not to respond, which could suggest they did not have an opinion or they did not want to comment about their teacher. Among the two students who responded, M17 said he was "neutral about this thing," while F26 shared that, she "don't think it was necessary." It was not clear whether "it" referred to the entire onboarding lesson or Ms Aliyah's attempt to introduce Fast ForWord before allowing students to explore the tool on their own as F26 followed her comment that "it" was not necessary with "I feel like it's better to let the student explore on the website itself." For M17, he also shared that he had to leave the onboarding lesson early to attend to something else. This could potentially contribute to explaining his response, given that he "didn't even manage to finish up" the RPI, which he called "the quiz."

Overall, even though all six student interviewees from Kusu Secondary attended the same onboarding lesson, their recounts of the experience were varied and partial, whether it be the rationale for introducing Fast ForWord or the expectations of use. In both instances, students' articulations contained content that were not found in both the onboarding lesson video and Ms Aliyah's interview transcripts. How students formed these impressions were not evident, which made it quite impossible to be certain what transpired, in the absence of supporting data. This may mean that Ms Aliyah's messages were not received and/or retained by students. Furthermore, students' recounts of the onboarding experience tended to be brief and lacking in detail, which further supported the possibility that that it did not leave much of an impression on the student interviewees. This in turn raises questions if students truly understood the rationale for Fast ForWord and if they were 'onboarded' at all.

4.2.3 Using Activity Theory to Unpack Students' Perceptions of the Onboarding Experience

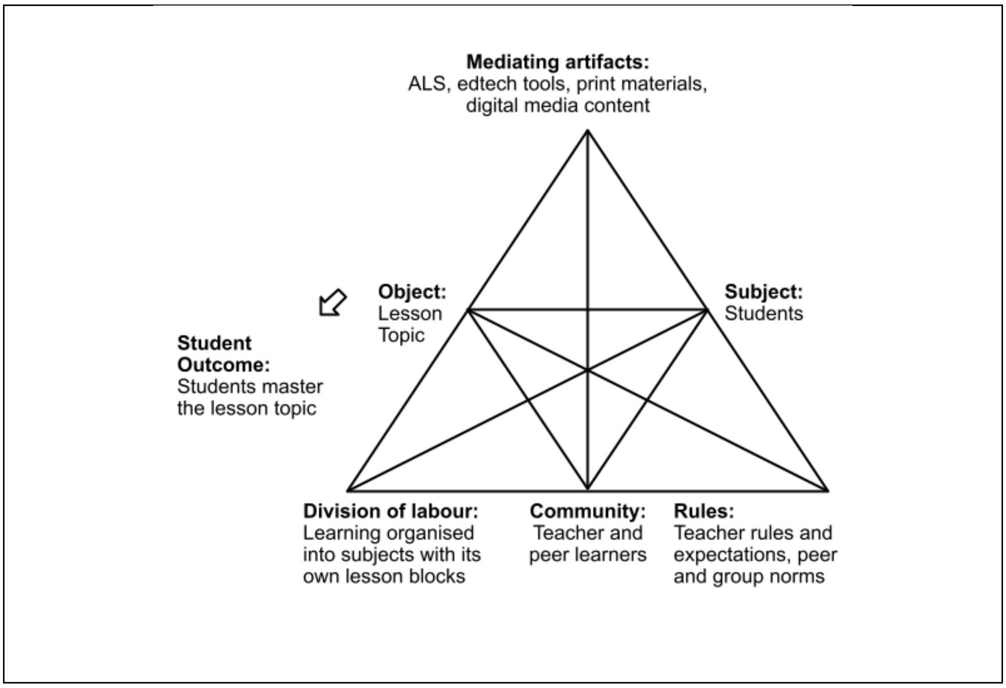
Following the reconstruction of the onboarding experience as perceived and represented by students during their respective interviews (in Section 4.2.1 and 4.2.2 respectively), we will now further unpack these student perceptions using activity theory. This unpacking will focus on covering as many components of the learning activity system.

Starting with *Object* and *Outcome*, it should be noted that the students in both cases may or may not be aware of what the Object of the lesson was and may or may not have attended the lesson with clear outcomes in mind. This is unlike the teachers, Mr Tan and Ms Aliyah who were clear about these aspects of the teaching activity. The primary reason for this being the learning agenda for each lesson, including this onboarding lesson, was typically set by the teacher and not always communicated to the students, even though students were the ones who were doing the learning. This could be why students gave differing accounts, as they were making sense of their lesson experience from their varied vantage points and guided by their respective schemata (Webb & Dennis, 2020).

While there was no specific measure to ascertain the extent to which students had been onboarded, their low utility and vague articulations of Fast ForWord would suggest that they might not have been successfully onboarded (see Section 4.3 for further elaboration of these findings). Furthermore, students' recollection of the onboarding lesson (to be presented in the following paragraphs) would also suggest that a standalone onboarding lesson would likely be inadequate, and the need for prolonged and potentially integrated approach to onboarding. It might also bear reconsidering the inter-relatedness between onboarding and integration (see Section 6.4 for a discussion on the reconceptualization of EdTech onboarding and integration as a mutually reinforcing loop).

Looking across what was shared by the 12 student interviewees from both schools, it would seem the onboarding experience for them was primarily the onboarding lesson, and that the most concrete aspects of their experience, such as the physical environment and *Mediating Artifacts*, were the first things that students shared when asked about how Fast ForWord was introduced. As mentioned in the previous sub-sections, having the lesson in the Computer Lab instead of the classroom was the first and most frequently recalled aspect of their experience about among student interviewees from Ubin Secondary; and for student interviewees from Kusu Secondary, headsets and the RPI video were the first and more frequently recalled aspects of their experience.

Figure 4-5 Learning Activity System of the Onboarding Lesson from Students' Perspective



Examining how students articulated the more concrete aspects of their experience, it would appear that operational issues featured more than cognitive ones. For example, operational problems such as login issues appeared to be more prominently remembered by students rather than other lesson segments. Furthermore, even though students in both cases had close to 30 minutes to engage with the RPI, there was hardly any mention of the RPI experience, whether it was easy or difficult, or if the types of questions were familiar or foreign. Furthermore, the student interviewees did not seem to see their school laptops or PLDs as cognitive tools, and only made passing reference to these devices that was central to the onboarding process. Collectively, these observations suggest that, if we accept that what students recalled were what they retained, Mr Tan and Ms Aliyah's efforts to contextualise and rationalise Fast ForWord to their students may not have been successful.

Another aspect of the onboarding experience that bears further unpacking pertains to *Rules*, specifically, how students perceived to be their teacher's expectations of their use of Fast ForWord. In both cases, students gave differing recounts of what their teacher's expectations were. In the case of Ubin Secondary, Mr Tan clearly articulated his expectations of students' use of Fast ForWord, in terms of frequency of use and duration of each session, during the onboarding lesson, but none of the students interviewed recalled his expectations accurately.

In the case of Kusu Secondary, while Ms Aliyah shared that she forgot to articulate any expectations, four out of the six student interviewees recalled some form of expectation being articulated by Ms Aliyah.

From these student responses, it would appear that Mr Tan, who appeared more intentional in communicating his expectations, did not leave much of an impression of his expectations on his students. This could also be due to the students being distracted by the numerous login issues encountered during the lesson. Conversely, Ms Aliyah, who appeared to be more laissez faire in terms of communicating her expectations, seemed to have made a relatively stronger impression given that most of the student interviewees from Kusu Secondary could recall some form of an expectation being communicated. These differences do raise the question on the setting of *Rules* like teacher expectations in the context of technology onboarding, as to what would be a more effective approach and to what extent this is likely to be context dependent.

A final point to note regarding students' perception of the onboarding experience pertains to *Community*, specifically peer learners around the student interviewees. This is noteworthy as there was no question asking students about their peers (see Appendix F for student interview protocol), yet one student interviewee from Kusu Secondary shared views related this. F27 shared that, "everyone's really focused and attentive to the activity and I was really shocked because even though my class doesn't focus a lot, people seemed really interested in Fast ForWord." From what the student expressed, it was clear that she was watching her classmates, and interested in gauging their response to Fast ForWord. This contextual awareness of peers in the classroom was not observed in any of the student interviewees from Ubin Secondary, which could be due to the latter being Secondary One students and the former were Secondary Two students.

In summary, this unpacking of students' perception of their onboarding experience, surfaces some interesting insights. First, evident from students' recounts of their teacher's expectations, teacher articulations often did not translate into an equivalent student reaction or retention. Second, students seemed to retain more of the physical and concrete aspects of their learning experience (e.g., device and media used, and lesson venue) than the abstract aspects (e.g., rationale for Fast ForWord or goal of the onboarding lesson). Third, while the Secondary One students from Ubin Secondary tended to focus more on themselves when responding to the interview questions, the Secondary Two students from Kusu Secondary showed more inclination to refer to their peers in their response.

4.3 Students' Initial Use and Perception of the ALS

This section moves from exploring students' perceptions of their onboarding experience to examining their use and perception of Fast ForWord, focusing on the period between the onboarding lesson and the start of the lesson unit. Findings reported here are largely drawn from students' Fast ForWord usage data as well as the first semi-structured interview with six students from each school. Each case study will present students' duration of use, activity completion and frequency of use at a class level, before zooming into the six student interviewees' perceptions of Fast ForWord. The latter would focus on the extent to which Fast ForWord was deemed to be easy to use, fun to use and useful from the students' perspectives, while the former examines students' actual engagement and use of Fast ForWord.

4.3.1 Case Study 1: Ubin Secondary

Ubin Secondary students had three weeks to familiarise themselves with Fast ForWord, until Mr Tan started on the lesson unit that he had selected for integration with the tool. In these weeks, which were the last two weeks of the first school term and the week of term break, Ubin Secondary students' Fast ForWord usage data revealed students' average login duration to be increasing at a decreasing rate, while their total login duration dipped from the second to the third week.

Table 4-7 shows that these 29 students from Ubin Secondary used Fast ForWord for a total of 58 minutes in the first week, clocking an average of six minutes 27 seconds per login. This duration may appear low at first glance but it should be noted that these minutes did not include time spent by students completing the Reading Progress Indicator (RPI), their very first task upon first login. Given that the actual duration spent by students to do the RPI was not captured by the system, it was as such not possible to include the time spent by students completing the RPI in this tabulation. This meant that the 58 minutes captured here reflected only students' self-initiated use of Fast ForWord, and teacher-initiated use, e.g., students doing the RPI during onboarding lesson, were excluded from tabulation.

Table 4-7 Total Duration of Fast Word Use by Ubin Secondary Students During the First Three Weeks of Subscription

Week	Total login duration	% increase in total duration from previous week	Average duration per login	% increase in average duration from previous week	Median duration per login	% increase in median duration from previous week
1	0 hours 58 minutes	-	6 minutes 27 seconds	-	3 minutes	
2	14 hours 06 minutes	1358.6%	17 minutes 37 seconds	173.5%	19 minutes	533.3%
3	12 hours 9 minutes	- 13.8%	22 minutes 05 seconds	25.3%	21 minutes	10.5%

The second week saw a 1,358.6% increase in the total login duration from 58 minutes to 14 hours and 6 minutes, with an average login duration of 17 minutes and 37 seconds. This steep increase could be partially explained by the second onboarding lesson which accounted for nine hours and 27 minutes of Fast ForWord use by the students. This meant that Fast ForWord usage by students in the second week comprised both teacher-initiated (i.e., second onboarding lesson[21]) and student-initiated (i.e., self-initiated learning at home).

For a more accurate comparison of the duration of student-initiated Fast ForWord usage, the 9 hours and 27 minutes of teacher-initiated use was removed from tabulation (see Table 4-8). With this adjustment, an increase in total login duration was observed. This seemed to suggest that the dip reflected in Table 4-7 could be due to the nine hours and 27 minutes of teacher-initiated use during the second onboarding lesson, and may not be an accurate

[21] This contrasted with the first onboarding lesson which focused on troubleshooting login issues and helping students get started on their RPI. As mentioned in the earlier paragraph, these time spent in Fast ForWord was not captured by the system and thus not reflected in the tabulation of total and average duration, unlike the second onboarding lesson.

reflection of students' self-initiated Fast ForWord usage. By focusing solely on student-initiated Fast ForWord use, Table 4-8 shows that the total login duration increased by 381.0% from the first to the second week and by 161.3% from second to third week.

Table 4-8 Total Duration of Student-Initiated Fast Word Use by Ubin Secondary Students During the First Three Weeks of Subscription

Week	Total login duration	% increase in total duration from previous week	Average duration per login	% increase in average duration from previous week	Median duration per login	% increase in median duration from previous week
1	0 hours 58 minutes[22]	-	6 minutes 27 seconds	-	3 minutes	-
2	4 hours 39 minutes	381.0%	14 minutes 23 seconds	127.9%	18 minutes	500.0%
3	12 hours 9 minutes	161.3%	41 minutes 05 seconds	50.4%	21 minutes	16.7%

While the percentage increase in both total duration and average duration of Fast ForWord seemed to be decreasing over the weeks, it should be noted that both the total duration and average duration of students' self-initiated use of Fast ForWord in the third week was three times that in the second week. This could be interpreted as an indication that students were becoming more engaged with Fast ForWord. Furthermore the average duration of 41 minutes and 5 seconds in the third week also exceeded Mr Tan's requirements of at least 30 minutes of use per login.

Turning our attention to the number of activities attempted and completed, it may appear that students' engagement with Fast ForWord during these initial weeks was quite modest. In fact, the pattern observed in terms of total number of activities attempted was similar to that of the total login duration, reflecting a dip from the second to the third week. Table 4-9 shows that the total number of activities attempted by the 29 Ubin Secondary students fell from 90 in the second week to 67 in the third week. However, despite the drop in absolute

[22] While there were six students who started on Fast ForWord activities during the onboarding lesson, they did so out of their own initiative and as such, the time spent on these activities was included in the total login duration.

numbers, the percentage of activities attempted, with reference to the total number of activities assigned, increased from 62.5% in the second week to 67.6% in the second week.

Table 4-9 Total Number of Fast Word Activities Attempted and Completed by Ubin Secondary Students During the First Three Weeks of Subscription

Week	Total number of activities assigned[23]	Total number (%) of activities attempted		Total number (%) of activities completed*	
1	24	11	(45.8%)	2	(18.2%)
2	144	90	(62.5%)	37	(41.1%)
3	99	67	(67.6%)	46	(68.7%)

**This percentage is based on the total number of activities attempted.*

Furthermore, if the activities completed during teacher-initiated use of Fast ForWord were excluded from tabulation, an increase in the total number of activities attempted could be consistently observed over the period of three weeks, from 45.8% in the first week to 59.3% in the second week and to 67.6% in the third week. It is also interesting to note that, by focusing on students' self-initiated usage of Fast ForWord during this initial three-week-period, the total number of activities assigned, attempted and completed were consistently increasing. However, it should still be noted that by the third week, slightly less than half of the activities assigned were completed, which seemed to be a signal that students may not be fully onboarded or yet to be making full use of Fast ForWord.

Table 4-10 Total Number of Fast Word Activities Attempted and Completed by the Entire Class of Ubin Secondary Students During Self-Initiated Use in the First Three Weeks of Subscription

Week	Total number of activities assigned	Total number (%) of activities attempted		Total number (%) of activities completed*	
1	24	11	(45.8%)	2	(18.2%)
2	54	32	(59.3%)	12	(37.5%)
3	99	67	(67.6%)	46	(68.7%)

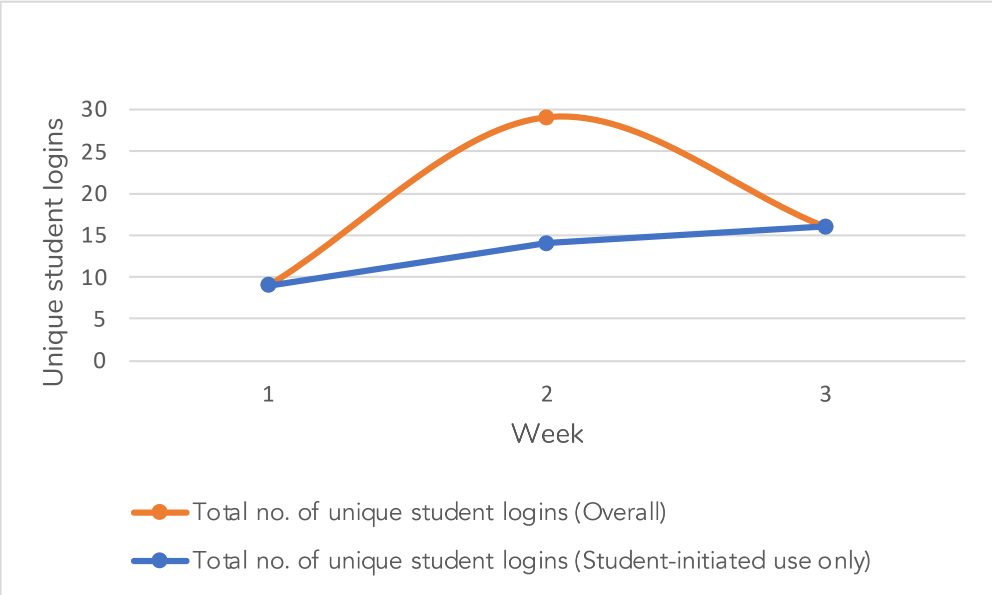
**This percentage is based on the total number of activities attempted.*

The final dimension of students' Fast ForWord usage to be examined pertains to their frequency of use during these first three weeks of subscription. Firstly, with reference to the

[23] This is tabulated based on the number of login, where three activities were assigned to each user per login.

number of unique logins to Fast ForWord each week, the pattern observed is similar to that of duration of use and activity completion (see Figure 4-6). After excluding teacher-initiated logins to Fast ForWord, it is clear that the number of student users of Fast ForWord is increasing, from 9 in the first week, 14 in the second week, to 16 in the third week. However, it should be noted that by the end of the third week, there remained six students who never used Fast ForWord outside of EL lessons, and one student who logged into Fast ForWord for less than one minute.

Figure 4-6 Number of Unique Student Logins by Week for Ubin Secondary



Secondly, in terms of how frequently students logged into Fast ForWord each week, focusing solely on student-initiated use (see Table 4-11), it can be observed that only nine students used the tool in the first week of subscription and all of them only logged into Fast ForWord once. In the second week, the number of student users increased to 14, where 11 students logged into the tool once, two students using it twice and one student logging it more than three times that week. By the third week, which was also the week of term break where students had no school, 16 students were using the tool, where nine students logged in three times that week and seven students used Fast ForWord once.

Table 4-11 Frequency of Self-Initiated Fast ForWord Use by Ubin Secondary Students

Week	No. of students who logged in…				No. of students who did not login in at all
	once	twice	three times	more than three times	
1	9	0	0	0	20
2	11	2	0	1	15
3	7	0	9	0	13

While the number of students using Fast ForWord was increasing and more students were logging into the tool more frequently, there remained a substantial portion of students who did not log into Fast ForWord each week. In the first week, 20 students did not use Fast ForWord at all. In the second week, this number dipped slightly to 15 students and in the third week, 13 students did not use the tool. These indicate that each week, at least close to half of the students were not using Fast ForWord. This was also the case during term break, where students had no school and technically should have more time.

Furthermore, with reference to the usage requirement set by Mr Tan, to use Fast ForWord at least three times a week for 30 minutes each login, only one student (F03) completely met this usage requirement and only once in the three-week period. Table 4-11 shows that while one student and nine students used Fast ForWord three times or more in the second and third week, they fell short in terms of the duration of use. For example, the one student (M17) who logged in more than three times in the second week clocked at least 30 minutes for 2 sessions of use that week. Overall, students' frequency of use seemed to suggest that students were not incorporating Fast ForWord into their learning routine.

In summary, with reference to students' duration of use, activity completion and frequency of use as indicators of students' overall use of Fast ForWord, a dip in both students' duration of use, activity completion and frequency of use was observed from the second to the third week. Excluding students' Fast ForWord use during the second onboarding lesson, and focusing solely on students' self-initiated use of the tool, both the total duration and average duration of self-initiated use and the number of activity attempted and activity completed by the 29 Ubin Secondary students were increasing over the three weeks, though both were increasing at a decreasing rate. Furthermore, while the number of students who did not log into Fast ForWord each week was decreasing, majority of the students never met the usage requirement set by Mr Tan. Not only that, there was also no sign that students' login frequency was increasing. If these were taken as a proxy for the extent to which students were onboarded to Fast ForWord, it is likely that students were not onboarded to Fast ForWord.

Zooming into the six student interviewees and their perception of Fast ForWord, we will now focus on the extent to which Fast ForWord was deemed to be easy to use, fun to use and useful from the students' perspectives. Firstly, two of the six student interviewees (F01 and F08) reported access issues during the first week of Fast ForWord subscription. Specifically, F01 experienced issues logging in due to device compatibility, and this was eventually resolved by asking the student to use another device that she had access at home. F08 reported struggling to remember her login credentials, which she resolved on her own by setting the device she was using, i.e., an iPad that she shared with her sisters, to remember her credentials.

Apart from access issues, F01 and M10 also reported some initial struggle with the Fast ForWord user interface. In particular, M10 and F01 expressed confusion over "how you do the question" and "was just like, clicking everywhere" respectively. It would seem that these students were expecting some kind of instruction to help them navigate the task. However, despite the absence of navigation instructions, both F01 and M10 went on to overcome these initial confusion without additional help. Separately, M15 also stated during the first interview that "It's very easy to know which is the website." All these seemed to suggest that Fast ForWord was quite easy to use, despite initial hiccups that required some troubleshooting on students' part.

Another aspect of Fast ForWord that students expressed difficulty with pertained to the tasks assigned. For example, M29 reported struggling with Sono Lab as he could not "stay focused." He shared that, "You must listen attentively… I kept struggling because I couldn't differentiate the sound. So I keep on getting wrong at that time. And that was the hardest." M10 shared a similar sentiment, though his articulation was directed at the questions' "difficulty level." He shared that, "some of the questions were a bit hard then, I couldn't understand them. Then sometimes I couldn't understand what the question mean."

On the flip side, F01 found Fast ForWord activities to be "pretty okay, because the activities were fun." She added that, "if I were to do the Fast ForWord every single day, I will eventually get bored of it because… it's like just [doing] the same thing… every day." These opposing accounts collectively point toward a few possibilities. Firstly, these reported difficulties could be due to Fast ForWord activities being very unlike the activities students were used to doing in school for language learning. Secondly, there could be a mismatch between students' abilities and the activities assigned, potentially signalling that the diagnostic assessment might not have been effective.

Overall, Fast ForWord seemed easy to use, presenting little to no navigational challenges. Where navigation challenges were encountered, students could resolve them without external help. In terms of the activity difficulty level, responses from the student interviewees were mixed. While M10 and M29 reported some challenges with the activities assigned, F01 found them boring over time. From these seemingly conflicting perceptions, it may be that students did not find Fast ForWord engaging.

Student interviewees' reactions on whether Fast ForWord was fun to use were also mixed (see Table 4-12). Here, it should be noted that F04 refused to rate the tool or provide an explanation for refusing to do so. She merely shrugged her shoulders when pressed. The remaining five students gave a rating between six and 10, with two students (M10 and M15) giving Fast ForWord a perfect score. M10 explained that the tool's interactive quizzes, colourful interface and competitive elements were reasons for the high score. M15 however, did not seem to be able to elaborate much on his score, other than it was "fun" and "helped me test my skills."

Table 4-12 Ubin Secondary Students' Fun-to-Use Rating of Fast ForWord

Student ID	Rating (/10)	Reason Given
F01	6.0	Because it "improve[s] my memory in my memorization skills and my concentration. And because I have like issues with the two of those things." While the activities were "interesting" when doing it for the "first time", it became "repetitive… then it's not very fun anymore."
F04	(*Did not rate and did not explain why*)	
F08	8.0	"I really don't like the part where I get it wrong because I know the correct answer but I still interpret wrong, so that makes me so frustrated." "Because … I want to quickly like level up especially as fast as possible. But then sometimes I just tell myself to slow down because if I go too fast so I will like keep on tapping the wrong answer, then it's like so frustrating."
M10	10.0	"Like there's a lot of interactive quizzes and … that's why it's very fun. And it's very colourful." "I would compete with some of my friends like who can complete more questions in some time. So I think it's very fun."
M15	10.0	"[I]t's actually quite fun, … it helped me test my skills."
M29	6.5	"[I]f you get a very high streak, very high points you also feel satisfied."

It is interesting that while M10 saw the competitive elements as a boon, they appeared to be the bane of F08. She shared that, because she wanted to "quickly like level up" she would often get the answer wrong in haste, and this was "frustrating" to her. Even so, she rated Fast ForWord eight out of 10, which seemed pretty high, though her explanation of her rating appeared to focus on the negative aspects of the tool which made her "frustrated." The lowest rating came from F01 who reported access and navigation issues during the initial subscription period. She also shared separately that she found Fast ForWord activities boring after a while, which corroborated with her rating and explanation of her rating here.

In terms of how useful student interviewees found Fast ForWord, compared to fun-to-use ratings, a wider range of ratings was given, with 4.5 (by M29) being the lowest rating and 9.0 (by F08 and M10) the highest. M15 did not give a usefulness rating though he did explain what he found to be useful about Fast ForWord, that it helped him with pronunciation. Comparing both fun-to-use and usefulness ratings, three student interviewees (F01, M10 and

M29) found Fast ForWord to be more fun than useful. Only one student (F08) found Fast ForWord to be more useful than fun. No comparison could be made for F04 and M15 as they only offered ratings for one aspect of the tool, i.e. usefulness and fun-to-use respectively.

Reasons given for Fast ForWord's usefulness pertained to improving concentration, listening, pronunciation and vocabulary. In particular, some of these sentiments, e.g., improving concentration, echoed the benefits of Fast ForWord presented in the video Mr Tan played during the first onboarding lesson. It is also noteworthy that none of the student interviewees mentioned how Fast ForWord improved their reading skills, given that it was a reading programme and Mr Tan had intended for it to supplement his lesson unit on Reading Comprehension. This seemed to suggest students' experience of Fast ForWord in these first three weeks might not have achieved the desired effect that Mr Tan has intended.

Another interesting observation pertained to the dissonance articulated by F01, between the espoused outcomes of using Fast ForWord and her learning goals. When asked about the usefulness of the tool, she made a distinction between improving language skills and improving her grades, and asserted that the latter was more important to her. She also expressed that, based on her experience of Fast ForWord thus far, the tool could contribute to the former, but unlikely to help with the latter. This in particular was why she did not find Fast ForWord to be useful. However, her rating of five was not the lowest. M29 rated the usefulness of Fast ForWord to be 4.5, slightly lower than that of F01, who expressed a similar concern, that Fast ForWord was not helping them in what they felt they needed help with. These sentiments again pointed to a potential failure in the adaptivity feature of Fast ForWord to personalise students' learning experience and thus leading to "frustration" and potentially also some dissonance.

Table 4-13 Ubin Secondary Students' Usefulness Rating of Fast ForWord

Student ID	Rating (/10)	Reason Given
F01	5.0	"Fast ForWord can train our concentration to be improved. And then we can like concentrate more." "When I'm talking about improving my academics. I don't mean like, improving my memorization, improving my hearing, I mean like, improve like, my marks, my grades and everything."
F04	8.0	"Because I need to concentrate and then in class I also need [to] focus in class. It's a practice for you to learn how to focus."
F08	9.0	"I feel my English has improved like my focus on English improved." "I don't get why Fast ForWord will say different sounds and I must like click, I don't get how it helps our reading."
M10	9.0	"it's helpful because from that, I learned a lot of new words and phrases. So sometimes in my composition, I can use new words to make it more better." "Some of the questions are too advanced which I don't learn now, but they might help me later, but you might not also be used in school."
M15	-	"It helped me to easier pronounce words and helped me to know the difference between each syllable in one of the reading tests; it will help you to know how to know the difference in the pronunciation of each word."
M29	4.5	"I learned more on differentiating between higher pitch sounds and lower pitch sounds." "I felt like they keep on repeating the sound which are, very slow… I feel like that the repetitive part wasn't really useful because I wanted to work more like the part where they sounded it more faster than for you to press which part."

Putting together these student interviewees' fun-to-use and usefulness ratings with their actual usage of Fast ForWord (see Table 4-14), it emerges that even though M10 rated Fast ForWord 10 in terms of fun-to-use, he only logged into the tool once throughout the first three weeks of subscription, and completed none of the activities assigned. M15 which gave the highest rating for both fun-to-use and usefulness was also not the student with the highest login frequency or activity completion, even though, among the six interviewees, he clocked the second highest total duration of use.

Across the six student interviewees, the activity completion rate ranged from 33.3% to 90.0%, though no discernible pattern was observed between students' fun-to-use and usefulness ratings and their total number of activities completed. For example, on the one hand, F08 rated Fast ForWord highly and also had the highest number of activities completed. On the other hand, F04 only completed one activity despite a high usefulness rating of eight. Furthermore, she only clocked a total duration of 20 minutes over three weeks, which was the lowest among the six interviewees.

Finally, it should be noted that all six student interviewees knew they were pre-selected for interview and this usage though low might already contain some positive skew in anticipation of the upcoming interviewees. Even so, F08 who had the highest total duration of use clocked less than half the required duration of three logins of 30-minute sessions per week. In light of these observations, it is likely that students' initial perception of Fast ForWord might not be as positive as they expressed during their respective interviews.

Table 4-14 Ubin Secondary Students' Ratings of Fast ForWord and their Actual Engagement with the Tool

Student ID	Fun-to-Use Rating	Usefulness Rating	No. of Logins	No. of activities attempted	No. of activities completed	Total duration	Average duration per login
F01	6.0	5.0	2	5	4	47:00	23:30
F04	-	8.0	2	3	1	20:00	10:00
F08	8.0	9.0	5	10	9	2:04:00	24:48
M10	10.0	9.0	1	2	0	20:00	20:00
M15	10.0	-	3	5	4	1:05:00	21:40
M29	6.5	4.5	4	7	3	1:00:00	15:00

In summary, initial use by Ubin Secondary students and perceptions reported by the six student interviewees seemed to suggest a lukewarm response to Fast ForWord. While students tended to be generous when rating the tools, the reasons provided and their actual usage of Fast ForWord signalled that they might not have as positive an impression of Fast ForWord as their ratings might have suggested. Overall, student buy-in, whether it was based on students' interview accounts or usage data, seemed to be low. The fact that only one student met Mr Tan's usage requirements and close to half of the students not using Fast

ForWord each week, there is no indication that Fast ForWord was becoming part of students' learning routine and foreshadowed the poor integration of Fast ForWord with the lesson unit.

4.3.2 Case Study 2: Kusu Secondary

Kusu Secondary students had two weeks to familiarise themselves with Fast ForWord, before Ms Aliyah planned to start on the lesson unit that she had selected for integration with the tool. In these weeks, which were the first two weeks of the second school term, Kusu Secondary students' Fast ForWord usage data revealed that only a total of eight students logged into the tool (see Table 4-15). This meant that, by the end of the onboarding period, 24 students (approximately 75% of the entire class) had never logged into Fast ForWord and thus were not onboarded to the tool. This was in spite of a large proportion of time spent during the onboarding lesson[24] for students to complete the Reading Progress Indicator (RPI) and explore the tool.

Table 4-15 Total number of unique student logins and login sessions
by week for Kusu Secondary

Week	No. of unique student logins	No. of login sessions*
1	4	5
2	7	11
1 & 2	8	16

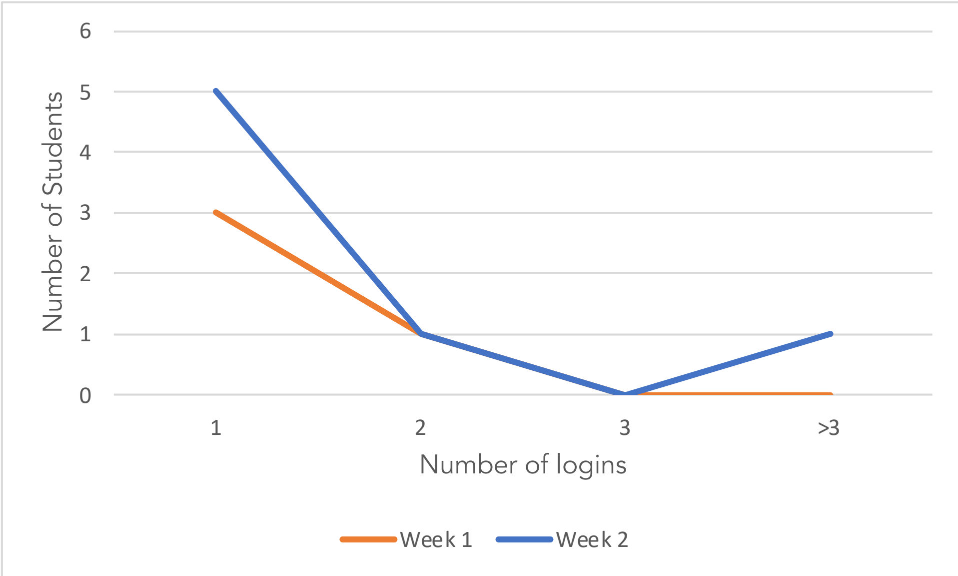
**Some students logged in more than once each week.*

A deeper dive into the data also revealed that none of the students started on Fast ForWord activities during the onboarding lesson. In fact, during this first week of Fast ForWord subscription, only four students logged into the tool after the onboarding lesson. Among these four students, three logged in once and one logged in twice (see Figure 4-7). In particular, F08, who logged in twice during the first week, spent 100 minutes and 40 minutes respectively on the activities assigned. (The remaining students logged in for a duration between two and 40 minutes.) F08 then went on to log into Fast ForWord four times the

[24] This onboarding lesson took place during the first week of Fast ForWord subscription and was video recorded by the school. The recording given to the researcher only contained the first 10 minutes of the lesson where Ms Aliyah was instructing the class. The rest of this lesson, where students did the RPI was not recorded as Ms Aliyah shared that there was "nothing to see."

following week, with an average login duration of 37 minutes and 30 seconds, and was the only student to meet Ms Aliyah's expectations of using Fast ForWord three times a week and for 30 minutes each time during these two weeks.

Figure 4-7 Frequency of Kusu Secondary Students' Login During the First and Second Weeks of Fast ForWord Subscription



While F08 seemed to be highly engaged with Fast ForWord, M31, who logged in once in the first week for two minutes, seemed to be highly disengaged with the tool. M31 did not log in again on his own initiative after this first encounter. His subsequent logins were teacher-prompted, i.e., in-class use of Fast ForWord, or to access the new module, Reading Comprehension (made available in the fourth week of subscription), also prompted by Ms Aliyah. These seemed to suggest that Fast ForWord might not be engaging M31, for after the one login to explore the Reading Comprehension activities, M31 never logged into Fast ForWord again.

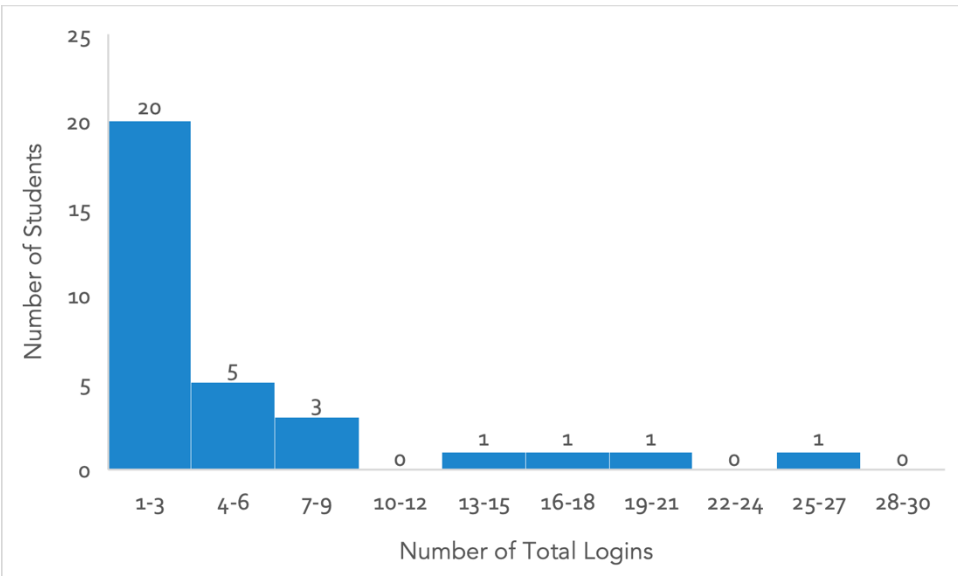
Table 4-16 Number of Fast ForWord Logins by F08 and M31 During the 3-Month Subscription Period

Student ID	No. of Fast ForWord Logins during Week…												Total No of Logins
	1	2	3	4	5	6	7	8	9	10	11	12	
F08	2	4	2	4	2	1	1	0	1	0	2	2	21
M31	1	0	1	2	0	0	0	0	0	0	0	0	4

On the one end was M31, who did not seem to buy into Fast ForWord, on the other end was F08, who seemed to be regularly engaging with the tool, making fairly consistent use of Fast ForWord over the 3-month subscription period (see Table 4-16). However, even so, F08 only met Ms Aliyah's usage requirements once, i.e., in Week 2 where she logged in more than three times and for a duration of at least 30 minutes each login. Though F08 had on other weeks used Fast ForWord for 30 minutes or more, she only used the tool twice or less in those weeks. F08's average duration of use over the 3-month subscription period was 38 minutes 34 seconds.

Both F08 and M31 represented two spectrums of students in terms of their Fast ForWord usage patterns, where four students (including F08) used the tool fairly regularly throughout the subscription period while the rest logged in less than 10 times overall. This pattern mirrors student usage observed during the onboarding period, i.e., the first two weeks of Fast ForWord subscription, which seemed to suggest that students might not be receptive to the tool, whether it be during the initial onboarding phase or the subsequent lesson unit integration phase. Overall, close to 88% of the students used Fast ForWord less than 12 times throughout the 3-month subscription period. This meant that their usage of the tool was less than once a week.

Figure 4-8 Kusu Secondary Students' Login Frequency to Fast ForWord
During the 3-Month Subscription Period



Turning our attention back to students who logged into Fast ForWord during the first two weeks of subscription, the number of activities assigned and completed by these students, alongside their total, average and median duration of use collectively offered insights on the extent to which students were using Fast ForWord. Firstly, Table 4-17 revealed similar patterns over the two weeks, where the total number of activities attempted was close to 100% and the total number of activities completed was around 70%. While these high percentages could potentially signal a high level of use among these students, the fact that most students stopped using Fast ForWord after the sixth week of the subscription period, i.e., the midpoint, seemed to suggest that these students did not seem engaged by Fast ForWord.

Table 4-17 Total Number of Fast Word Activities Attempted and Completed by Kusu Secondary Students During the First Two Weeks of Subscription

Week	Total number of activities assigned[25]	Total number (%) of activities attempted		Total number (%) of activities completed*	
1	15	15	(100.0%)	11	(73.3%)
2	33	31	(93.9%)	21	(67.7%)

**This percentage is based on the total number of activities attempted.*

Table 4-18 Total Duration of Fast Word Use by Kusu Secondary Students During the First Two Weeks of Subscription

Week	Total login duration	% increase in total duration from previous week	Average duration per login	% increase in average duration from previous week	Median duration per login	% increase in median duration from previous week
1	3 hours 7 minutes	-	37 minutes 24 seconds	-	25 minutes	
2	5 hours 28 minutes	75.4%	29 minutes 49 seconds	-20.3%	25 minutes	-

Examining students' total, average and median duration of Fast ForWord use over the first two weeks of subscription, Table 4-18 showed that, while the total login duration increased from three hours and seven minutes in the first week to five hours and 28 minutes in the

[25] This is tabulated based on the number of login, where three activities were assigned to each user per login.

second week, a dip in the average login duration was observed. The average login duration for the first week was 37 minutes 24 seconds, while that for the second week was 29 minutes and 49 seconds. Even so, the average login duration was close to (for the second week) and exceeded (for the first week) Ms Aliyah's requirement of 30 minutes per login. The median duration however, remained the same over the two weeks, which seemed to signal some consistency in how students were using Fast ForWord.

In summary, only eight out of 32 students in Kusu Secondary started using Fast ForWord during the onboarding period, i.e., the first two weeks of subscription. This meant that at least three quarters of the students never logged into Fast ForWord prior to the start of the planned lesson integration phase. Among the eight students that started using Fast ForWord during the onboarding phase, less than half of these students were still using the tool by the end of the subscription period. Many students stopped using Fast ForWord by the end of the sixth week of the 3-month subscription period. While students' total and average duration of use (see Table 4-18) and number of activities attempted and completed (see Table 4-17) seemed to suggest students were engaged in learning with the tool, it should be noted that this data represented only the eight students who were using Fast ForWord during the onboarding phase. In fact, the lack of sustained use by many students would more likely suggest a lack of engagement. In particular, the low number of students is likely to be an indication that only a handful of students were successfully onboarded.

Zooming into the six student interviewees and their perception of Fast ForWord, we will now focus on the extent to which Fast ForWord was deemed to be easy to use, fun to use and useful from these students' perspectives. But before that, to better contextualise these student interviewees' perceptions of the tool, it would be necessary to interpret these perceptions in light of their actual Fast ForWord usage. Firstly, it should be noted that only one of these student interviewees (M32) started using the tool during the onboarding period. He logged in for the first time in the second week for a duration of 40 minutes, and this was also the only time he used Fast ForWord during the onboarding period,. Most of remaining student interviewees (M17, F26, F27 and M34) started using Fast ForWord in the third week while M18 started doing so in the fourth week.

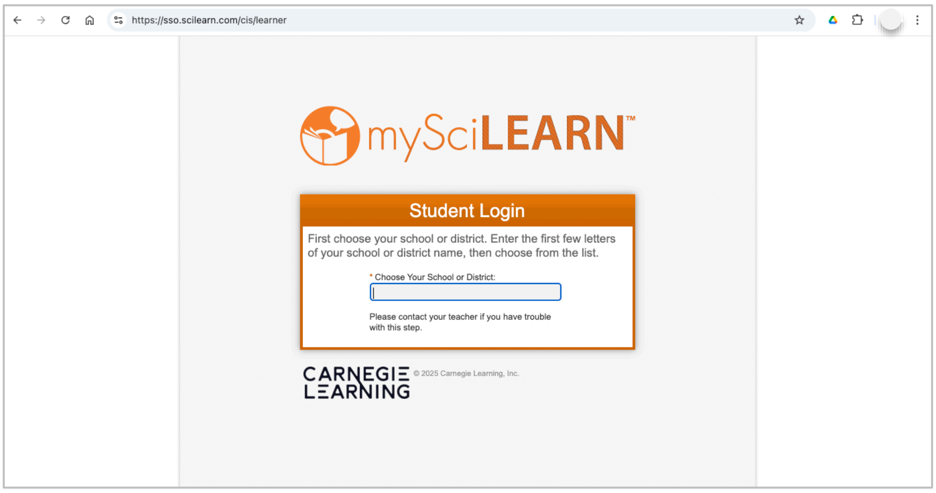
By the time of these students' first interview, where they were asked to talk about their initial impression of Fast ForWord, i.e., whether they found Fast ForWord easy to use, fun to use and/or useful in helping them learn the English language, all students had logged into the tool at least once, with M17 and M34 logging in twice and M32 logging in six times (see Table 4-19). In fact, F26 was upfront to say that she logged into Fast ForWord only to prep for the first interview. M16, M17, F27 and M34 also offered reasons for their infrequent use, which were related to prioritising homework and co-curricular activity commitments. Regardless, these data indicated that all student interviewees, having used the tool at least once, would have some basis for their perceptions though most of them, with the exception of M32 might not be very familiar with Fast ForWord given their limited use.

Table 4-19 Relating Kusu Secondary Students' Use of Fast ForWord and their Interviews

Student ID	Number of logins…			Total number of logins
	prior to first interview	between first and second interview	after second interview	
M17	2	0	0	2
M18	1	0	1	2
F26	1	2	2	5
F27	1	0	0	1
M32	6	12	0	18
M34	2	3	1	6

In terms of ease of use, all student interviewees reported no issue with accessing Fast ForWord, though M17 did share an episode where he was unable to find the login link. He explained that the URL, which was "https://sso.scilearn.com" did not contain the name of the tool and he did not immediately connect it to Fast ForWord when he was trying to search for the login link to access the tool (see Figure 4-9). These student interviewees also found the Fast ForWord interface "quite easy to navigate" though M18 did comment that he "didn't really like the main page" but did not explain why.

Figure 4-9 Fast ForWord Login Page and URL



When asked if they experienced initial struggles with Fast ForWord, two student interviewees (F27 and M34) shared that they found RPI to be challenging, not so much because of its difficulty but more so in terms of the volume of questions they had to answer in this diagnostic assessment. F27 shared that "when I saw the amount of questions… I was really shocked." This corroborated with M34's response where he shared that his "only challenge would be… the diagnostic test. It was a bit long to do, longer than usual." These student interviewee responses seemed to suggest that while the students did not experience much friction with using Fast ForWord, they seemed somewhat impatient to complete the activity before them and may not be as engaged as they should be with an adaptive learning system.

This seeming impatience was also observed in F26's articulations of her Fast ForWord experience, where she shared that she was "distracted" and "discouraged" by the amount of time she took to complete the activities. In her words, "You have like one hour and then how many minutes have passed… you keep wanting the time to end earlier." M34 also shared similar sentiments, where he expressed that, "I'd rather do it a bit quicker," and "I kind of got tired of reading each and every paragraph just to answer one question. It kind of made me… put off." The above articulations seemed to suggest that these student interviewees might not be enjoying Fast ForWord as one would expect of a personalized learning experience.

When asked to rate how fun it was for them using Fast ForWord, only four out of the six students offered a rating (see Table 4-20). Among the remaining two students who did not rate the tool, M32 did share what he enjoyed about the tool, that it was "fun" though he did not elaborate further. M17, on the other hand, did not rate how fun he found the tool, and did not comment on what he liked or disliked about Fast ForWord activities. Among the four students who rated Fast ForWord, all gave a positive rating of between seven and eight out of 10. Their reasons for these ratings ranged from how Fast ForWord was different from the other assignments, its colourful interface and special effects, as well as the activities did not "involve much… and I could do it at the pacing I want."

Table 4-20 Kusu Secondary Students' Fun-to-Use Rating of Fast ForWord

Student ID	Rating (/10)	Reason Given
M17	(*Did not rate and did not explain why*)	
M18	7.0	"because some of the things are interesting, not like the kind of assignments you usually get. You also get to broaden your experience and helped you learn English in different ways."
F26	7.0	"Yes, It's very fun. I feel like my younger self will enjoy it more. Because it is very colourful and then there's the special effects and some are really cool."
F27	7.5	(*Did not explain why*)
M32	(*Did not rate*)	"..the activities. I feel that it can help me, like in the long run. And I feel that if it can help me and it's fun, I might as well do it."
M34	8.0	"… Ocean Explorer would be my favourite because it doesn't really involve much, just your hearing, and I could do it at the pacing I want and it was a bit fun to press the buttons here and listen to the sounds and trying to keep the score."

Triangulating the student interviewees' ratings with the number of times they logged into Fast ForWord (see Table 4-20), it would appear that the basis for these seemingly high ratings is weak, based largely on one or two encounters with Fast ForWord. This may also possibly explain why the reasons given by these students for their rating tended to be vague and contained little reference to specific features of the tool. As such, it is likely that the student interviewees did not find Fast ForWord as fun as they claimed.

Table 4-21 Kusu Secondary Students' Fast ForWord Logins and Fun-to-Use Rating

Student ID	Rating (/10)	Number of Fast ForWord login(s) prior to first interview
M17	(*Did not rate*)	2
M18	7.0	1
F26	7.0	1
F27	7.5	1
M32	(*Did not rate*)	6
M34	8.0	2

Turning our attention now to the student interviewees' perceptions on the usefulness of Fast ForWord, only half of these students offered a rating (see Table 4-22). Of these three students, only F27 found the tool to be slightly more useful than fun, while M18 and M34 found Fast ForWord to be slightly more fun than useful to their learning. Furthermore, even though M17 and M32 did not offer a usefulness rating for Fast ForWord, both did have an opinion on the usefulness of the tool, sharing respectively that it was "not as bad as homework" and "I think it can if I consistently do it."

It is noteworthy that even though F27 only used Fast ForWord once prior to the interview for a total of 36 minutes, she offered a rather detailed description of what she felt were benefits of learning with Fast ForWord, which included improved listening skills, greater attentiveness and better vocabulary (see Table 4-22). That said, she never logged into Fast ForWord again after this one and only engagement with the tool. Conversely, M32, who logged into Fast ForWord six times prior to the first interview and spent two hours 17 minutes using the tool, was not able to elaborate on why he thought the tool was useful. He then went on to log into Fast ForWord 12 more times and was among those students who used Fast ForWord most frequently.

Based on some of these student interviewees' articulations, it would seem like they were trying to portray Fast ForWord positively. However, whether this was due to a halo effect or a social desirability bias is not clear. For example, M17 associated his improved listening comprehension practice scores with his usage Fast ForWord, but he only logged in twice before this interview. Even more pronounced for M18, who stated that, "I don't really know if it actually helped me or not. But I definitely learnt something from Fast ForWord," but he was unable to explicate that "something." Collectively, a triangulation of students' articulations and their usage of Fast ForWord revealed that students might not have found Fast ForWord useful in helping them improve their language skills.

Table 4-22 Kusu Secondary Students' Usefulness Rating of Fast ForWord

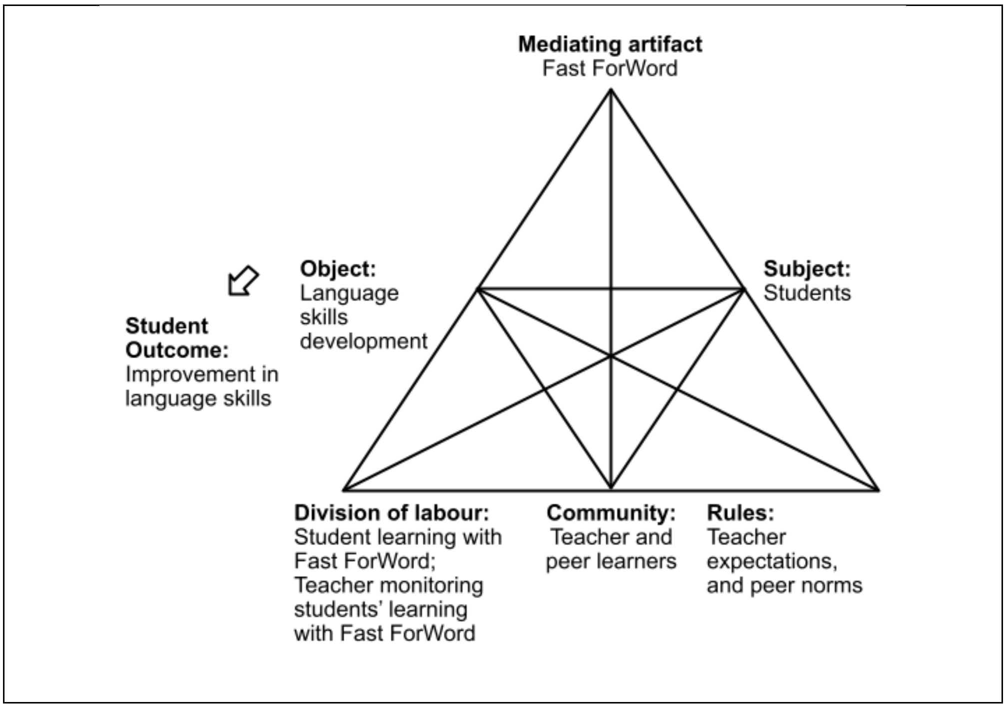
Student ID	Rating (/10)	Reason Given
M17	(*Did not rate*)	"I procrastinate Fast ForWord a lot… The oral [activities are] … pretty useful in my personal opinion… I actually failed listening when I was in Secondary One… After using [Fast ForWord]… I got like 21 [marks]." "… not as bad as homework"
M18	6.5	"I haven't seen my improvement level yet. I don't really know if it actually helped me or not. But I definitely learnt something from Fast ForWord."
F26	(*Did not rate*)	"I don't know."
F27	8.5	"I think that it really helped me listen much more better and teach me how to be more attentive. It also taught me how to talk more articulately and more expressively and it gave me a view of better vocabulary."
M32	(*Did not rate*)	"I think it can if I consistently do it."
M34	7	"Because of AI Assistant and Sono Lab…. I started to get used to it and I got more correct."

In summary, initial use by Kusu Secondary students and perceptions reported by the six student interviewees seemed to suggest a lack of buy-in among students of Fast ForWord. This is evident from the fact that a large proportion of the students had yet to log into the tool at all by the end of the two-week onboarding period, and further corroborated by the lack of elaboration observed in student interviewees' articulations on whether Fast ForWord was fun or useful. That said, among students who were using the tool, there were some who engaged fairly consistently over the 3-month subscription period, even though these students were a minority. Overall, it would appear that Kusu Secondary students did not find Fast ForWord meaningful or fun, which could potentially account for the low usage by the majority of these students.

4.3.3 Cross-Case Comparison of Students' Initial Use and Perception of Fast ForWord Using Activity Theory

Building upon the earlier sections that presented students' initial use and perceptions of Fast ForWord during the first weeks of subscription, i.e., during the onboarding phase (in Chapter 4.3.1 and 4.3.2 respectively), we will now unpack and contrast how this initial use and perception vary across Ubin Secondary and Kusu Secondary. Using activity theory, this unpacking will focus on contrasting the extent to which students met their respective teacher's usage requirements, i.e., *Rules*, as well as students' perceptions and interactions with Fast ForWord, the *Mediating Artifact* (see Figure 4-10).

Figure 4-10 Activity System of Students' Learning with Fast ForWord



Firstly, a comparison of Ubin Secondary and Kusu Secondary students' usage of Fast ForWord revealed that only one student in each school met the stipulated requirement of using Fast ForWord at least three times a week and for at least 30 minutes per login (see Table 4-23). It should also be noted that both these students only met this requirement once during this onboarding period of three weeks for Ubin Secondary and two weeks for Kusu Secondary. This seemed to suggest a disregard for the *Rules* set by their respective teacher on the frequency and duration of Fast ForWord use.

In fact, none of the student interviewees expressed any concern or fear of not meeting the usage requirement. One possible reason for this attitude, as alluded by quite a number of student interviewees in both schools, was their choice to prioritise 'school work' with consequences, e.g., graded assignments, homework that will be checked and co-curricular activity. In contrast, there appeared to be no consequence for not using Fast ForWord, which meant that it would likely be deprioritised by these busy students. This lack of consequence for not using Fast ForWord could be explained by the lack of *Division of labour* between the teachers and Fast ForWord, where the teacher did not seem to have an active role when students were learning with Fast ForWord.

As mentioned earlier (in Section 4.1.2), Ms Aliyah specifically had expressed a desire to be able to "choose the type of activity that I want to assign to the students, because then it will be more relevant to what I'm doing at the moment." She appeared to be mildly frustrated that she could not influence the activities students were doing in Fast ForWord. Even when she had directed students to work on a specific activity, e.g., Data Stream, there were still some students who were not assigned the activity by Fast ForWord and there was no means for these students to circumvent the algorithm and access the activity. Furthermore, while the teachers could view individual students' learning progress with Fast ForWord, there was no avenue for the teacher to influence its recommendations nor were there any recommended next steps for the teachers to act in class.

Table 4-23 Ubin Secondary and Kusu Secondary Students' Self-Initiated Use of Fast ForWord with Reference to the Prescribed Usage Requirements

School	Total no.(%) of students who used Fast ForWord during the onboarding phase	No. of students who used Fast ForWord…		
		at least three times a week*	at least 30 minutes continuously	at least three times a week and at least 30 minutes continuously
Ubin Secondary	23 (79.3%)	8	5	1
Kusu Secondary	8 (25.0%)	1	4	1

**Includes students who used the tool at least three times a week* <u>and</u> *at least 30 minutes each login*

In terms of the differences between the two schools, Table 4-23 reveals some interesting contrasts. For example, 23 students from Ubin Secondary, close to 80%, used Fast ForWord at least once during the onboarding period, while only 8 students from Kusu Secondary, 25% of the class, used Fast ForWord at least once during the onboarding period. This could suggest that more Ubin Secondary students have been onboarded to Fast ForWord given that majority of these students starting using the tool after the onboarding lesson. This may also suggest that Ubin Secondary students were engaging more with the tool than Kusu Secondary students.

However, in terms of sustained interaction with Fast ForWord, it would appear that a higher percentage of Kusu Secondary students, i.e., 50%, were using Fast ForWord for at least 30 minutes continuously, compared to the approximately 22% of Ubin Secondary students. This in turn suggests that, while less Kusu Secondary students have been onboarded, the buy-in from these onboarded Kusu Secondary students might potentially be higher (than that of Ubin Secondary students), given the more sustained use by the former. Collectively, it would appear that while ALS use was previously found to be a significant predictor of academic persistence (Ahmed & Abdullah, 2025), this was not the case for both Ubin Secondary and Kusu Secondary students.

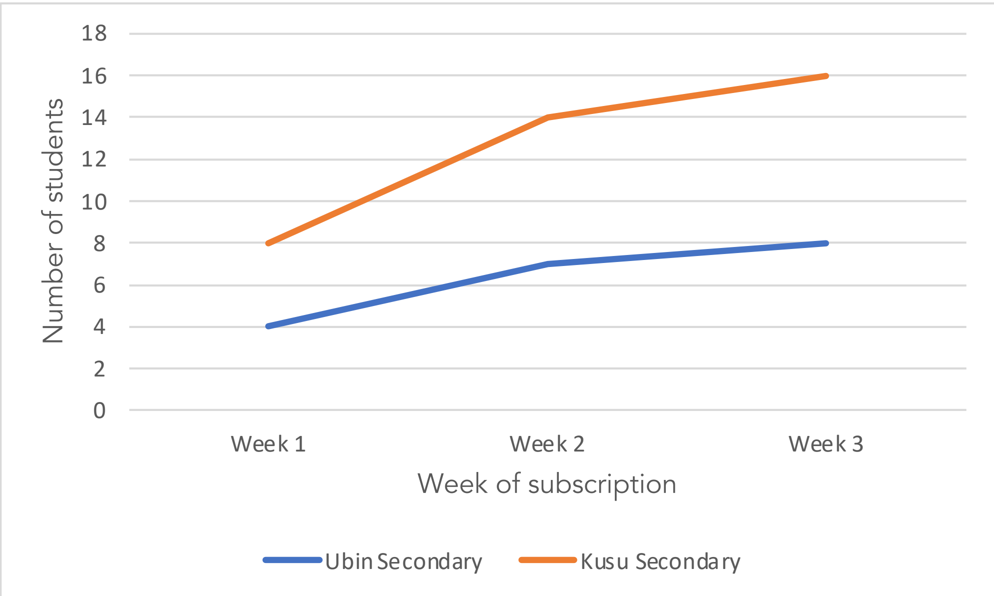
These differences corroborated with the differences observed in terms of the students' duration of use (see Table 4-24). The average login duration for Ubin Secondary students was 11 minutes and 51 seconds, less than half of that of Kusu Secondary students, which was 32 minutes and 11 seconds. This meant that on average, Kusu Secondary students were using Fast ForWord for longer durations than Ubin Secondary students. As such, it would appear that while more Ubin Secondary students were using Fast ForWord during the onboarding phase, Kusu Secondary students were on average using it for longer duration per login.

Table 4-24 Number of Unique Student-Initiated Logins and Duration of Use by Ubin Secondary and Kusu Secondary Students During the Onboarding Period

School	Onboarding Duration	No. of unique student logins	Duration of Use		
			Total	Average	Median
Ubin Secondary	3 weeks	30	17 hours 46 minutes	11 minutes 51 seconds	18 minutes 30 seconds
Kusu Secondary	2 weeks	8	8 hours 35 minutes	32 minutes 11 seconds	25 minutes

Further comparison of students' frequency of using Fast ForWord revealed some interesting patterns. Firstly, Figure 4-11 revealed similar patterns of overall use by Ubin Secondary and Kusu Secondary students over the first three weeks of Fast ForWord subscription. Table 4-25 further revealed that, while both schools started with fairly low use of the tool, where only nine and four students from Ubin Secondary and Kusu Secondary respectively were using Fast ForWord, by the third week of subscription, 16 students from Ubin Secondary, more than half of the class, logged into Fast ForWord that week, while only seven students from Kusu Secondary used the tool in the same week.

Figure 4-11 Number of Unique Self-Initiated Ubin Secondary and Kusu Secondary Student Logins During the First Three Weeks of Fast ForWord Subscription



However, a tally of the total number of students from each school who had logged into Fast ForWord at least once during the first three weeks of subscription revealed that 30 Kusu Secondary students, close to 94%, had logged into the tool at least once, while only 23 Ubin

Secondary, close to 80%, had logged into Fast ForWord at least once. The reason behind this sudden spike in number of Kusu Secondary students logging into Fast ForWord was not known, though some possible explanations included Ms Aliyah giving students time to explore Fast ForWord during the first English language lesson of the third week due to many students taken out of class for mass vaccination exercise and the presence of the researcher who started observing Ms Aliyah's lessons during this same week.

Table 4-25 Frequency of Self-Initiated Fast ForWord Use by Ubin Secondary and Kusu Secondary Students

Frequency of Student Logins	Ubin Secondary	Kusu Secondary*
Week 1		
No. of unique student logins	9 (31.0%)	4 (12.5%)
No. of students logged in once	9	3
No. of students logged in twice	0	1
No. of students logged in three times or more	0	0
No. of students who did not login	20	28
Week 2		
No. of unique student logins	14 (48.3%)	7 (21.8%)
No. of students logged in once	11	5
No. of students logged in twice	2	1
No. of students logged in three times or more	1	1
No. of students who did not login	15	25
Week 3		
No. of unique student logins	16 (55.2%)	7 (21.8%)
No. of students logged in once	7	4
No. of students logged in twice	0	2
No. of students logged in three times or more	9	1
No. of students who did not login	13	25
No. of unique student logins over the onboarding period	23	8
No. of unique student logins over the first three weeks of subscription	23	30

**Kusu Secondary's onboarding period was two weeks, one week less than that of Ubin Secondary.*

Secondly, Table 4-25 also revealed that both Ubin Secondary and Kusu Secondary students showed similar login frequencies for the first two weeks of the subscription. In the third week of subscription, Ubin Secondary students seemed to be logging in more frequently, with nine students logging into Fast ForWord three times that week, while the login frequency for Kusu Secondary reflected a pattern that was similar to the first two weeks of subscription. This different pattern observed among Ubin Secondary students could be traced back to *Division of labour*, where students had school during the first two weeks of subscription and could only use Fast ForWord after school. In contrast, during the third week of subscription, which was term break for Ubin Secondary schools, students had no school and there was thus less competing activities for their time and attention. This could potentially explain why Ubin Secondary students were logging in more frequently that week.

Overall, it would appear that despite differences between how Mr Tan and Ms Aliyah onboarded their students, Ubin Secondary and Kusu Secondary students exhibited similar patterns of use in terms of number of unique logins per week and students' frequency of use. While some variation in the average and median duration of use was observed between the two schools, no clear reason emerged for these differences. However, Kusu Secondary students were spending more time on average per Fast ForWord login even though Mr Tan planned and conducted more onboarding activities than Ms Aliyah. Finally, while student interviewees from both schools seemed in general to be positively predisposed toward Fast ForWord and had a relatively positive onboarding experience, few students from both schools showed sustained use of Fast ForWord over the 3-month subscription period.

4.4 Chapter Summary

In this chapter, I first described both teachers' efforts at onboarding students to Fast ForWord before contrasting them using activity theory. In doing so, I surfaced key differences between the two onboarding lessons, namely choice of lesson duration, lesson venue and device for students to access Fast ForWord and highlighted their implications. However, despite these differences, students' perceptions of the onboarding experience were quite similar, which I elaborated next, presenting how students recalled and represented their onboarding experience. Here, I also noted that student interviewees in both schools exhibited some reluctance to comment on the onboarding experience and suggested possible reasons for this. Further unpacking of these students' perceptions using activity theory also surfaced *contradictions* between what students recalled and represented and those by their teachers.

Finally, I expounded on Ubin Secondary and Kusu Secondary students' duration and frequency of Fast ForWord use during the onboarding period as well as their initial perceptions of the tool, based on their articulations during their first interview. Triangulating students' actual usage and their articulations (of their perceptions) revealed that students in both schools might not have found Fast ForWord to be fun or useful to their learning, which could potentially explain the low usage among these students. Through the lens of activity theory, I also contrasted the two cases while highlighting pertinent differences including number of unique student logins, students' login duration and frequency and postulated possible reasons for these differences.

Overall, based on students' actual use and articulations of their perception during this onboarding phase, it can be said that students' low usage and generally vague articulations about Fast ForWord were both indication that they were not quite onboarded to the tool. This was despite efforts by both teachers to onboard their students. While it was not possible to ascertain the reasons for this, some conjectures will be discussed in Chapter 6.

5

Findings on Observed Teacher-Student Academic Interactions during the ALS Integration Phase

Chapter Five presents the types of academic activities and teacher-student academic interactions observed during classroom learning, highlighting both frequently and rarely observed interactions during Mr Tan and Ms Aliyah's lessons. These observed lessons were conducted during the Fast ForWord integration phase, featuring the teaching of an instructional unit that was pre-selected for integration with Fast ForWord. An examination of the types of academic activities provides the context through which teacher-student academic interactions can be interpreted, and highlighting frequently and rarely observed teacher-student academic interactions offer snapshots of the classroom learning experiences during the period of integrating classroom learning and Fast ForWord.

5.1 Types of Academic Activities Observed

The academic activities observed during Mr Tan and Ms Aliyah's lessons in Ubin Secondary and Kusu Secondary respectively could be broadly classified into six activity types. They included teacher direct instruction, teacher-led discussion, student-initiated discussion, group activity, pair activity and individual activity, manifesting varying degrees of teacher control and student autonomy. For example, teacher direct instruction and teacher-led discussion could be considered to be activity types where the teacher exerted relatively more control of the interaction (Denessen et al., 2020), while group, pair and individual activity represent moments where students would have relatively more autonomy in their learning (Frambach et al., 2013; Kaur, 2009b). Of these six activity types, all except for student-initiated discussion and pair activity were observed in both classrooms. The latter two activity types were only observed during Mr Tan's lessons (see Table 5-1 for an overview of the activity types observed.).

Table 5-1 Types of Academic Activities Observed During Mr Tan and Ms Aliyah's Lessons

Activity Type	Brief Description	Examples from Mr Tan's Lessons	Examples from Ms Aliyah's Lessons
Teacher Direct Instruction	Typically a single extended turn by the teacher who either did not solicit any verbal response from students or asked only binary questions.	• Mr Tan explained how to approach a global question.	• Ms Aliyah explained the different types of writing hooks.
Teacher-Led Discussion	Characterised by the teacher trying to engage the entire class in one conversation by soliciting and responding to students' contributions.	• Mr Tan worked with the class to answer a factual question.	• Ms Aliyah reviewed students' posts on Padlet with the class.
Student-Initiated Discussion	Involved as least one student proposing an alternative that resulted in a discussion that was not part of the teacher's initial lesson plan.	• Students proposed alternative answers for discussion.	
Group Activity	Entailed four to five students working together on a single task. Such activity often entail movement and change in seating arrangement.	• Students worked together to complete a recall task.	• Students worked together to create an infographic.
Pair Activity	Where students worked with a peer to complete a task. This does not often requirement movement or change of seats though it can.	• Students worked with a peer to generate inferences.	

Activity Type	Brief Description	Examples from Mr Tan's Lessons	Examples from Ms Aliyah's Lessons
Individual Activity	Students worked at their tables on a single task which they were expected to complete without needing any help.	• Students worked independently to answer a global question.	• Students worked independently to write thesis statements.

5.1.1 Case Study 1: Ubin Secondary

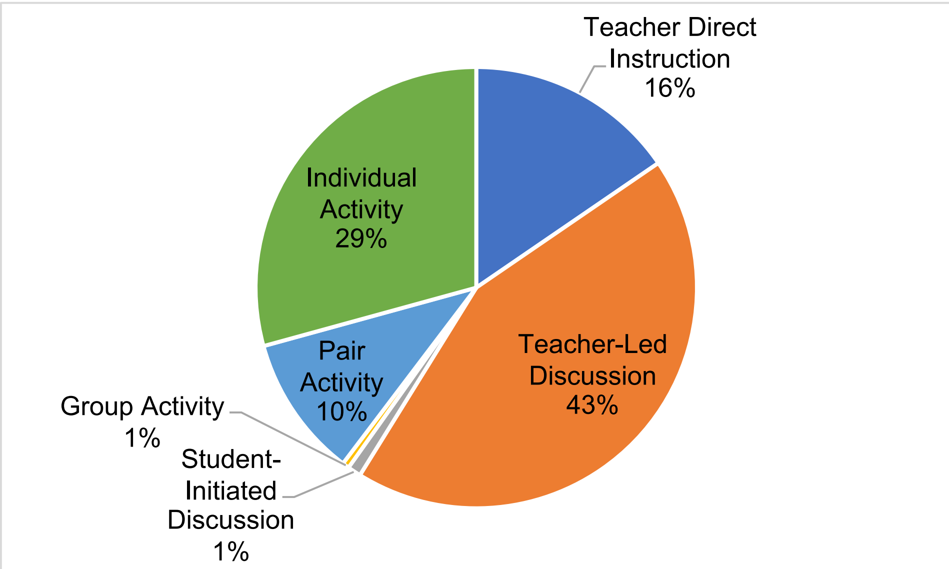
Mr Tan selected the unit on Reading Comprehension to be taught in tandem with the use of Fast ForWord, which students were expected to access at home for self-directed learning, complementary to classroom learning. The main objective of the Reading Comprehension unit was to equip students with the skills to answer different types of questions including factual, quotation, in-your-own-words, inferential, and global questions. To achieve this learning objective over the four weeks that he had to complete the unit, Mr Tan employed a combination of all six observed activity types to engage his students. They included teacher direct instruction, teacher-led discussion, student-initiated discussion, group activity, pair activity and individual activity (Figure 5-1).

Tabulation of the time spent by Mr Tan on each academic activity type revealed that Mr Tan spent almost half of his lessons engaging students through teacher-led discussion. In fact, teacher-led discussion was observed in almost every lesson on the unit except for the lesson where students worked on a Reading Comprehension task simulating examination conditions.

The discussions led by Mr Tan were varied, ranged from tapping students' real-world experiences and prior knowledge, expanding students' vocabulary, building upon students' task responses, and working through different types of reading comprehension questions with students. Variation in the duration of these teacher-led discussion episodes was also observed, ranging from approximately half a minute to just under nine minutes.

From Figure 5-1, it may appear that Mr Tan relied little on teacher direct instruction to deliver the unit, given that such episodes only accounted for 16% of his lessons. However, teacher direct instruction was observed in all Mr Tan's lessons on the unit, and the total number of teacher direct instruction episodes (38) was also comparable to that of teacher-led discussion episodes (45). These suggested that teacher direct instruction, like teacher-led discussion, was an academic activity type frequently used by Mr Tan to engage his students even though he tended to keep these episodes brief. Mr Tan was observed to be using teacher direct instruction for a range of purposes, including setting learning goals for the lesson, giving instructions for the next activity, explaining assessment or task requirements, deconstructing different types of reading comprehension questions, demonstrating an approach to answering reading comprehension questions and addressing student errors. The duration of these episodes was also quite varied, ranging from less than half a minute to just under seven minutes.

Figure 5-1 Distribution of Mr Tan's Lesson Time by the Observed Activity Types



Mr Tan was observed to have spent 40% of his lessons on student activity, where students engaged in individual, pair or group activity. While Figure 5-1 seemed to suggest that individual activity (29%) was occurring much more often than pair activity (10%), however this was the result of what could be termed as an outlier lesson where Mr Tan guided students to complete a reading comprehension task simulating examination conditions. This meant that students spent the entire lesson of approximately 70 minutes working independently on the task, which skewed thus the amount of time on average spent on individual activity. If this lesson were not included in the tabulation, it became evident Mr Tan's use of pair activities (10%) and individual activities (11%) was comparable, whether this was in terms of the number of episodes or the actual duration of such activity types. Pair and individual activities could be in the range of seconds, where students seated next to each other shared briefly their answers to a reading comprehension question. The longest pair activity lasted five minutes, where students collaborated on two reading comprehension exercises, while the longest individual activity was close to three minutes where students completed a worksheet.

Group activity and student-initiated discussion were rather rare occurrences in Mr Tan's lessons. Throughout the four weeks of lesson observation, there was only one episode of group activity where students had slightly less than two minutes to work together on a recall task. Eight episodes of student-initiated discussion were observed during four lessons. These episodes typically entailed students proposing alternative responses to answers provided by Mr Tan for his input, though there were some which saw students clarifying task requirements. In general, these episodes ranged from half a minute to slightly more than a minute. These student-initiated discussion shared a common characteristic, in that students were often wanting to know what was correct, whether it were the correct thing to do or the correct answer.

Table 5-2 Teacher-Student Academic Interactions Observed Across All Mr Tan's Lessons

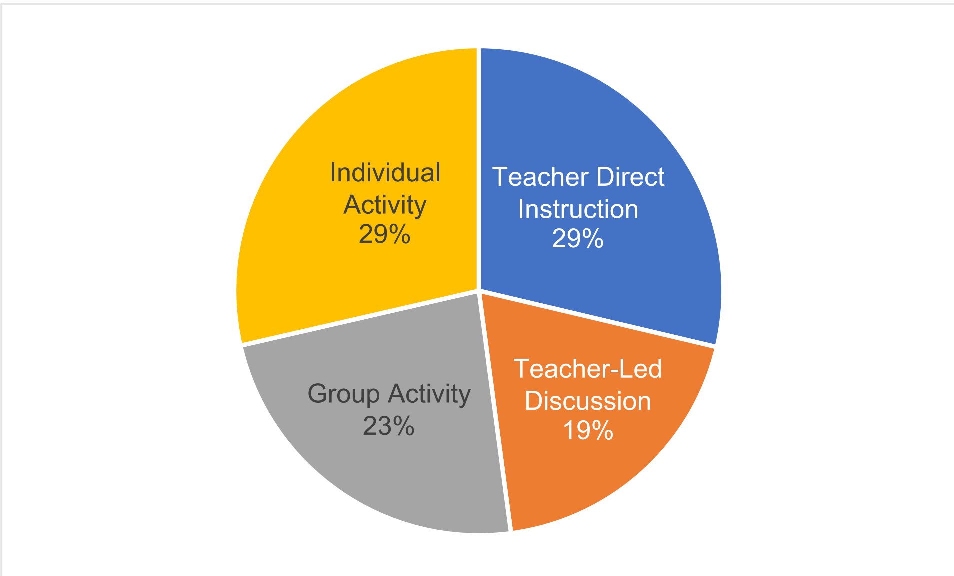
Type of Academic Activities	No. of Unit-Related Academic Interaction Episodes	No. of Episodes with Teacher-Student Interactions	Total Duration of Episodes with Teacher-Student Interactions
Teacher Direct Instruction	35	1	1 min 56 sec
Teacher-Led Discussion	38	38	2 h 3 min 29 sec
Student-Initiated Discussion	4	4	2 min 56 sec
Group Activity	1	0	0 sec
Pair Activity	19	4	14 min 11 sec
Individual Activity	21	0	0 sec
Total	118	47	2 h 22 min 32 sec

While Mr Tan employed a range of academic activity types to engage his students, academic teacher-student interactions were not always observed. Mr Tan tended to leave the students to work by themselves during group and individual activity, though he would occasionally offer help to students during pair activities. Evident from Table 5-2, most of Mr Tan's academic interactions with his students took place during teacher-led discussion. It should be noted here that none of these interactions were directly related to Fast ForWord.

5.1.2 Case Study 2: Kusu Secondary

Ms Aliyah selected the unit on Discursive Writing to be taught in tandem with the use of Fast ForWord, where students were expected to use Fast ForWord for self-directed, home-based learning and apply what they have learnt from it to their classroom tasks. The objectives of the Discursive Writing unit were twofold; students were expected to explore the topic of teenage brain and body and learn how to explain cause and effect when writing discursive essays. To achieve these learning objectives over the three weeks that she had to complete the unit, Ms Aliyah made use of a combination of teacher direct instruction, teacher-led discussion, group activity and individual activity during her lessons to engage her students. Figure 5-2 shows that, in Ms Aliyah's classroom, the amount of curriculum time used for teacher direct instruction and teacher-led discussion was slightly less than that for group and individual activity, suggesting that some balance between teacher control and student autonomy.

Figure 5-2 Distribution of Ms Aliyah's Lesson Time by the Observed Activity Types



Ms Aliyah typically employed teacher direct instruction episodes for one of the four following purposes, namely explaining formal assessment and learning task requirements, teaching explicitly specific knowledge and skills, demonstrating worked examples from learning packages, and giving generic feedback on students' work. These episodes ranged from under a minute to slightly more than 13 minutes, with most of them between two to three minutes in duration.

Teacher-led discussion episodes are the least frequently observed activity type in Ms Aliyah's classroom. This could be due to students' reticence about speaking up in class, and Ms Aliyah has described this class as "quiet" and not "very engaging." Perceived lack of curriculum time resulting in the need to move forward with the lesson could be another possible reason; Ms Aliyah also shared that she felt she was "trying to chase time, just trying right to finish (the unit)" when interviewed. These teacher-led discussion episodes ranged from close to a minute to just under 12 minutes and were quite varied in length and content, which included soliciting students' views on a topic and guiding students through a task. The start and end of these episodes were typically determined by Ms Aliyah. In terms of students' participation, only a few students would volunteer their responses in class. Most students had to be repeatedly called upon before they would speak.

Group activity episodes were observed in only two of Ms Aliyah's lessons. In contrast, almost all lessons observed, except for one, had at least one episode of individual activity. Like that for teacher-led discussion, the duration of group activity and individual activity episodes were quite varied. Group activity episodes ranged from slightly over a minute to close to 16 minutes, while individual activity episodes ranged from a few seconds to close to 17 minutes. While these episodes were intended for students to be engaged in activity independent of the teacher, a fair amount of teacher-student academic interactions were observed during these episodes. This type of interaction is sometimes described as between-desk instruction (Amri & Sert, 2022; Kaur, 2009a).

The group activity episodes observed were centred on a creative task following students' use of Fast ForWord. The task entailed students working collaboratively to produce a graphic organiser before selecting a representative to present the completed output to their peers and was completed over two lessons. During both the creation and presentation process, Ms Aliyah sat with the different groups to listen to their discussions and offer her suggestions and feedback. The individual activity episodes observed typically entailed students doing some form of a written work using either pen and paper or on their Chromebooks. Task examples observed included making posts on Padlet, copying down writing samples projected on the screen and engaging in short writing assignments. Ms Aliyah would occasionally use this time to check on students' work progress and offer individualized feedback. Some students were also observed to ask Ms Aliyah questions when she walked past their seat.

Table 5-3 Teacher-Student Academic Interactions Observed Across All Ms Aliyah's Lessons

Type of Academic Activities	No. of Unit-Related Academic Interaction Episodes	No. of Episodes with Teacher-Student Interactions	Total Duration of Episodes with Teacher-Student Interactions
Teacher Direct Instruction	26	3	9 min 3 sec
Teacher-Led Discussion	12	12	46 min 34 sec
Student-Initiated Discussion	0	0	0 min 0 sec
Group Activity	14	8	42 min 20 sec
Pair Activity	0	0	0 min 0 sec
Individual Activity	25	6	39 min 42 sec
Total	77	29	2 h 17 min 39 sec

Academic interactions between Ms Aliyah and her students were observed across all types of academic activities, though such interaction appeared to take place more frequently during teacher-led discussion, group activity and individual activity episodes (Table 5-3). It is interesting Ms Aliyah had the most academic interaction with her students during teacher-led discussion, despite her students' reluctance to speak up in class.

Based on the findings presented, both Mr Tan and Ms Aliyah engaged students in teacher-led discussion and that such discussions could be considered a key means through which teacher-student academic interactions took place. However, in Mr Tan's class, teacher-led discussion was the primary means through which he interacted with students; while in Ms Aliyah's class, such interactions accounted for approximately one third of the teacher-student academic interactions observed. The remaining two thirds of such academic interactions were observed to take place during group and individual activity. In the next section, we will take a closer look at some specific teacher-student academic interactions, to concretise our understanding of such interactions during Mr Tan and Ms Aliyah's lessons.

5.1.3 Cross Case Comparison of the Types of Academic Activities Observed Using Activity Theory

Both Mr Tan from Ubin Secondary and Ms Aliyah from Kusu Secondary, the teacher Subject of the classroom activity system (see Figure 3-10), had pre-selected, as part of their participation in this research, their respective lesson topic, Reading Comprehension and Discursive Writing respectively, for integration with Fast ForWord, which were thus the respective *Object* for each case. By design, Mr Tan had intended for Fast ForWord to be used by students for self-directed learning, to complement what students were learning in class. As such, there were no specific references to or use of Fast ForWord when Mr Tan was teaching Reading Comprehension in class. In contrast, while Ms Aliyah also asked students to use Fast ForWord at home for self-directed learning, she made explicit reference to the tool in one of the lessons and assigned Data Stream, an activity in Fast ForWord, as a pre-learning task. Regardless, both Ubin Secondary and Kusu Secondary students rarely mentioned Fast ForWord during classroom learning.

To achieve the desired teaching and learning outcomes, both teachers employed a combination of activity types to engage their students across their sequence of lessons. While Mr Tan employed all six observed activity types to engage his students (see Figure 5-1), Ms Aliyah used only four of the six observed activity types, namely teacher direct instruction, teacher-led discussion, group activity and individual activity during her lessons to engage her students (see Figure 5-2). The two activity types that were employed by Mr Tan but not observed in Ms Aliyah's lessons were pair activity and student-initiated discussion. Through the lens of activity theory, these teachers' choices and enactment of the various activity types revealed both the teacher-student dynamics and the learning norms, i.e., the *Rules* in each case, which will now be unpacked below.

One obvious difference observed pertains to the enactment of teacher-led discussion. On the one hand, teacher-led discussion was an academic activity type frequently used by Mr Tan to engage his students. In fact, teacher-led discussion could be observed in almost all of Mr Tan's lessons on the unit, except for that one lesson where simulating examination conditions students worked on a Reading Comprehension task . On the other hand, teacher-led discussion was the least frequently observed activity type in Ms Aliyah's classroom. This could be due to the lack of student response to such discussions, and Ms Aliyah had to prompt students repeatedly before they would speak. Even though Mr Tan also had to prompt his students to speak up, his students were in general more responsive than those of Ms Aliyah.

This difference in students' response to teacher-led discussion is revealing of the teacher-student dynamics, i.e., *Community*, and classroom norms, i.e., *Rules*, in the two contexts. Firstly, it could serve as an indication of teacher-student relationship, where Mr Tan's students seemed to respond more favourably and with less prompting to his invitations to speak, compared to those of Ms Aliyah. Even though student interviewees from both schools spoke positively of their teachers' efforts to engage them in class, Mr Tan's students were observed to show less reticence in speaking up compared to Ms Aliyah's students. Second, this difference could also be due to students' interpretation of the questions, whether they perceived these questions to be rhetorical in nature or the teacher was seeking an answer from them.

That said, there could also be other possible reasons for the observed differences beyond teacher-student dynamics and classroom norms, such as student dynamics. This difference may also suggest the extent to which students felt safe to speak in class, which by extension could be an indication of student-student relationship and the overall class climate. While student interviewees from both schools raised the fear of being judged by their peers as a reason for keeping silent during teacher-led discussion, student interviewees from Ubin Secondary were observed to still be speaking up and volunteering their answers to Mr Tan's questions, more so than Kusu Secondary student interviewees. It was not clear, however, whether this was due to Kusu Secondary students feeling more self-conscious as slightly older teens (one year older than Ubin Secondary students) or the class climate in Kusu Secondary was less supportive than that of Kusu Secondary.

Students' reticence may also explain why both Mr Tan and Ms Aliyah seemed to prefer individual activity over the other types of student activity, e.g., group or pair activity, though in the case of Ubin Secondary, Mr Tan was observed to alternate between individual activity and pair activity. And while Ms Aliyah never assigned the Kusu Secondary students to work in pairs, she had her students engaged in group activity for two of her lessons where Fast ForWord was set as a pre-learning task. That said, regardless of the type of student activity, both teachers were observed to use the time where students were working at their seat, in pairs or in groups to provide closer support to specific students. Some students were also observed to be seeking out their teacher's attention with their questions during such moments.

Putting together Ubin Secondary and Kusu Secondary students' behaviours during teacher-led discussion and during individual, pair or group activity, it is possible to deduce the following *Rules*, that these students seemed to feel comfortable enough to engage their teachers in small group settings, e.g., during pair or group activity but less so in a large group setting, e.g., teacher-led discussion. This could indicate that while there may be a positive teacher-student relationship between Mr Tan and Ms Aliyah and their respective students, the student-student relationship or the overall class climate might not be sufficiently positive to encourage students to speak up in class, and this will be further discussed when diving into the communicative acts observed in the next section.

5.2 Frequently Observed Communicative Acts

All unit-related episodes with teacher-student academic interaction were examined on the eight clusters and 33 communicative acts from the Scheme for Educational Dialogue Analysis (SEDA). The eight clusters were invitation to elaboration or reasoning, make reasoning explicit, build on ideas, positioning and coordinating, connect, guide direction of dialogue or activity, reflect on dialogue or activity, and express or invite ideas (Hennessy et al., 2016). This analysis revealed that both Mr Tan and Ms Aliyah used communicative acts from all eight clusters though they did seem to use communicative acts from some clusters more frequently than others (Table 5-4). These findings will be elaborated in the following sections.

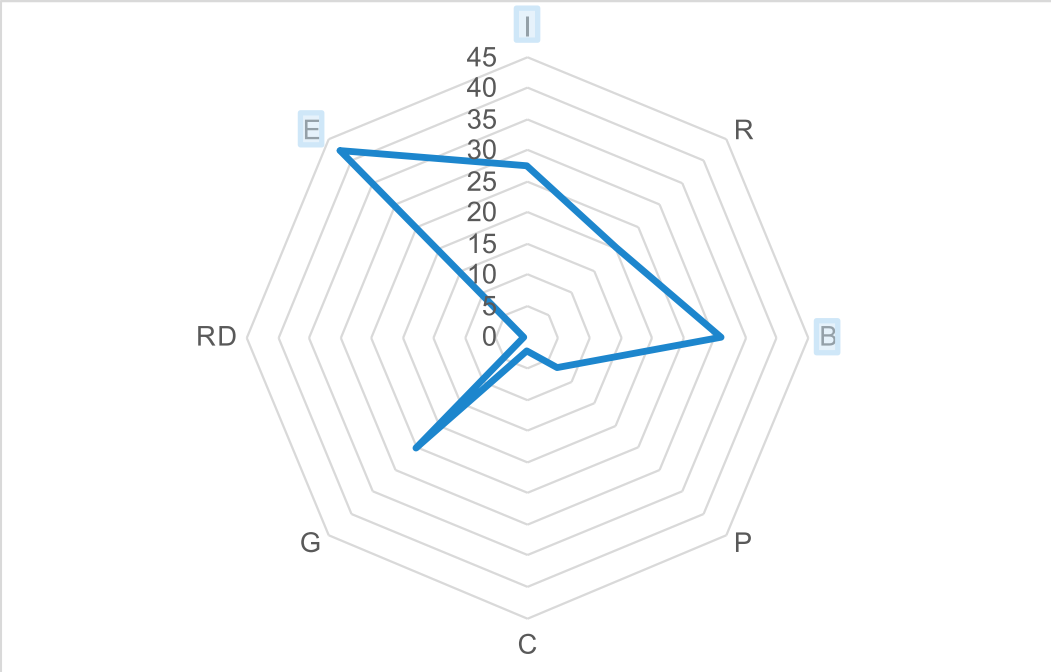
Table 5-4 Observed Communicative Acts by Clusters During Mr Tan and Ms Aliyah's Lessons

	Mr Tan's Lessons (Number of Acts Observed)		Ms Aliyah's Lessons (Number of Acts Observed)	
Frequently Observed Communicative Acts	1. Express or invite ideas	(297)	1. Invite elaboration or reasoning	(192)
	2. Build on ideas	(218)	2. Express or invite ideas	(212)
	3. Invite elaboration or reasoning	(192)	3. Build on ideas	(119)
	4. Guide direction of dialogue or activity	(176)	4. Make reasoning explicit	(115)
Rarely Observed Communicative Acts	5. Make reasoning explicit	(142)	5. Guide direction of dialogue or activity	(85)
	6. Positioning and coordination	(48)	6. Positioning and coordination	(33)
	7. Connect	(16)	7. Connect	(30)
	8. Reflect on dialogue or activity	(5)	8. Reflect on dialogue or activity	(2)

5.2.1 Case Study 1: Ubin Secondary

The most frequently observed communicative acts in Mr Tan's classrooms came from the following clusters: express or invite ideas, build on ideas and invite elaboration or reasoning (Figure 5-3). Most of these acts, which often took the form of questions, were performed by Mr Tan during teacher-led discussion, with the dual intentions of encouraging verbal participation among his students whilst advancing his instructional goals. Mr Tan made frequent use of questioning to engage students cognitively, and questions posed by Mr Tan ranged from open invitations for students to share their ideas to specific requests for explanation or elaboration. This varied use of questioning will be illustrated through the three excerpts presented below.

Figure 5-3 Communicative Acts (by Averages) Observed in Mr Tan's Classroom[26]



First is an excerpt from Mr Tan's introductory lesson on two reading comprehension question types, factual and quotation questions (Excerpt 5-1). In this teacher-led discussion, Mr Tan issued an open invitation to students to share what they have learnt about these question types from their primary school schools. The excerpt illustrated how Mr Tan drew students into conversation through questioning and building upon students' contributions. He opened the space for discussion by asking for "responses on what we know about our factual and quotation questions." He later repeated this invitation twice, with phrases such as "Anything, anything. Everything and anything under the sun about it" and "what else do we have?" He also did not immediately jump in when a student (F24) was stuck; instead, he tried to help her by prompting her with a more focused question, "Or what must you ensure when you're writing the quotation question?" When that was also met with silence, another student (F2) was nominated to help and to share her response instead.

Mr Tan seemed intentional in acknowledging each student's contribution and building upon them. For example, Mr Tan repeated F8's response "underline the keywords in the question"

[26] Please refer to Appendix J for the distribution of communicative acts (by clusters) observed in each of Mr Tan's lesson.

before adding that this would ensure "your answer will be relevant." He also clarified F2's response, "Do you find clues in the passage for the factual question?" Even though Mr Tan sounded hesitant and did not seem to totally agree with what F2 said, evident from the utterance "Well, that is true. Right? Alright," he considered and eventually accepted her contribution. In the case of M17's contribution, he not only repeated what was said, he also reiterated it, "If they tell you that is one word, you must give one word and everything itself" before endorsing M17's contribution with "that is absolutely true. That's correct." This episode not only captured the various communicative acts performed by Mr Tan through his use of questioning to engage students cognitively; students were also observed to be generally cooperative. Specifically, non-verbal observations recorded F8 and M17 raising their hands to signal their willingness to share, before Mr Tan called upon them.

Excerpt 5-1 Teacher-Led Discussion on Students' Prior Knowledge

Speaker	Utterance
Mr Tan	Let's have some responses on what we know about our factual and quotation questions. Anybody, come, share? (.) Come on, let's go.
Mr Tan	Okay, **F8** again, let's go. One thing. Just one thing is that clear?
F8	The quotation, for the quotation one (I learn to read)
Mr Tan	(Louder please)
F8	For the quotation questions, I learnt to always read the question, and underline the important key words first, like example, like they will always tell you from which paragraph then I always underline that.
Mr Tan	Ah, so underline the keywords in the question, right? So you ensure that you, your answer will be relevant, yes or no. Very good. **F8**. Okay. **F8**, please choose someone else to answer.
F8	**F24**.
Mr Tan	Hey, **F24**, your, all yours. Let's go.
Mr Tan	Anything, anything. Everything and anything under the sun about it. Let's go.
F24	For quotation (questions)
Mr Tan	(Pull down) your mask and talk.
F24	For quotation questions, like, if you read the instructions wrong, you will lose marks, (so that's)
Mr Tan	(I think) that is for every single kind of question, right?
Mr Tan	Okay. Any other things about the quotation question? Or what must you ensure when you're writing the quotation question?
Mr Tan	Maybe someone can help you? Call someone to assist you?
F24	**F2**.
Mr Tan	Oh, **F2**, save the day. Let's go.
F2	But. Can I say about factual questions?

Speaker	Utterance
Mr Tan	Sure, go ahead. Anything under the sun. Factual questions go.
F2	Factual question is like you find clues in the passage like a,
Mr Tan	You find what?
F2	Clues, clues
Mr Tan	Do you find clues in the passage for the factual question?
F2	Yes.
Mr Tan	Well, that is true. Right? Alright. I mean, yes, there are cues in the question that help you to identify the factual question there is that as well.
Mr Tan	Okay, what else do we have, **M17**, go.
M17	For the quotation question, sometimes they say the answer is in two words, so you have to answer in two words.
Mr Tan	Right. So if they tell you, it's two words, you must use two words. If they tell you that is one word, you must give one word and everything itself. Okay, that is, that is absolutely true. That's correct.

Second is an excerpt from the lesson on inferential questions which took place during the second week of the lesson observations. This excerpt (Excerpt 5-2) brings us to the middle of a teacher-led discussion where Mr Tan was asking students to share what they considered to be good and bad inferences, with reference to a paragraph they have read earlier. It illustrates Mr Tan's efforts at inviting elaboration or reasoning, and how he attempted to connect and build upon contributions by different students. Unlike Excerpt 5-1 where Mr Tan employed primarily open-ended questions to advance the discussion, questions posed by Mr Tan in Excerpt 5-2 were primarily 'why' questions, such as "Why would Sue be blowing out the candles?" and "Why is this a very bad inference?".

Just prior to this excerpt, M15 shared a bad inference "We then eat the cake and had a fun day" and attempted to explain why he thought this was a bad inference. It was at this point that F9 raised her hand signalling she would like to share. Here we thus see Mr Tan acknowledging F9's raised hand and gave her permission to speak, "Okay, you have to say something." However, as she was sharing, M10 was observed to be talking at the same time to the person seated next to him. Mr Tan then took M10 to task for being disruptive before asking F9 to repeat her contribution. He then prompted F9 to link this to M15's contribution and she proceeded to explain why she thought M15's earlier contribution was a bad inference, which Mr Tan tried to build upon and probed further. This brief exchange showed how Mr Tan tried to get students to engage with each other's contributions as well as further develop their responses through probing questions. At the end of the brief exchange with F9, M10 raised his hand to signal that he would like to share, and while Mr Tan acknowledged his action, he declined to call upon him with the reason that "But we don't have much time. Alright. I'll call upon you another time." Instead, he called upon F2 to share a bad inference that he has helped F2 and her buddy (F22) generate during the pair activity prior to this teacher-led discussion. It is evident here that even though F2 and F22 have already discussed the inference with Mr Tan, F2 still had to be prompted to explain the inference after sharing their inference.

This excerpt not only makes evident Mr Tan's efforts at inviting elaboration or reasoning; it also reveals some challenges faced when attempted to engage students in discussion, which included having to manage students' disruptive behaviours and repeatedly prompting students to elaborate on their contributions. All these take up lesson time and could potentially affect the extent to which he could complete the prescribed syllabus. It should thus be unsurprising that toward the end of this excerpt, Mr Tan answered his own questions, which sought to wrap up the discussion for this inferential question task. This was so that he could move on with the lesson and discuss the answers for the next task. These challenges also help to clarify why despite Mr Tan's efforts at inviting elaboration or reasoning from students, communicative acts to make reasoning explicit, particularly acts by students were less frequently observed.

Excerpt 5-2 Teacher-Led Discussion on Making Inferences

Speaker	Utterance
Mr Tan	Okay, you have to say something. **F9**.
F9	Because why would you like, why would you be the one blowing the candles when you are celebrating your birth, when you are celebrating a party.
Mr Tan	**M10**, I cannot hear her because you are talking right or not. And it also means that you are also not listening as well. Let's respect each other. Is that clear. **F9**, one more time.
F9	Why would Sue be the one blowing out the candles. It could be anybody else's birthday party.
Mr Tan	Why would Sue be blowing out the candles? It could be anybody else's party. How does that link to what **M15** is saying?

Speaker	Utterance
F9	Because **M15** said they were having a like, they didn't say they have a party afterwards but like he never say whose birthday, whose party it was and didn't state like who was the one.
Mr Tan	Okay, he didn't say that whose party was. But is it possible that it could also be Sue's party as well? Okay, so your statement is actually possible. It's just that you do not have enough information to link it directly to Sue. But is it possible that they're having a party right now?
F9	Yes
Mr Tan	It is right? Okay, so it is possible, okay. Okay. Thank you very much. But we don't have much time. Alright. I'll call upon you another time,
Mr Tan	**F2**. Alright. You had a very nice one as well, **F22** as well alright. Can you share with us what your bad inference was.
F2	Our bad inference is Sue blew out her sister's candles.
Mr Tan	Sue blew out her (.) sister's candles.
Students	[Giggles]
Mr Tan	How? Okay, why is this (.) Why is this a very bad inference?
F2	Because at the end of the day, Sue opened the presents.
Mr Tan	All right. Are you listening? What did she say just now?
M19	Because she opened presents.
Mr Tan	Hello I'm asking alright for, this is rhetorical, all of you, please listen, **F2**. One more time.
F2	Cos at the back, they say Sue opened her presents means that it's her birthday.
Mr Tan	Right, because it refers to Sue's presents. Therefore, we know that it's Sue's birthday. Therefore it would be her candles. Yes or no. Yes. Okay. So that is a very possible one. Of course, unless both of them are twins right, then got nothing to say yes or no, right, but yes.
Mr Tan	Now the good inference is they should celebrate her birthday.
Mr Tan	How about this other inference that Sue is afraid of fire? Is there any clue to tell you that she's afraid of fire? No. Right. So therefore it's a bad inference. Why? Because they there is nothing right, this is not considered an inference at all. Yeah. Okay.

The third excerpt (Excerpt 5-3) is from the lesson on global questions which took place during the third week of lesson observations. In this lesson, Mr Tan went through two practice global questions, after teaching the approach to answering such questions in the previous lesson. This excerpt presented a segment of the discussion that was taking place after students worked in pairs to attempt the first practice global question. The question required students to select from five options, an option that best encapsulated the main point of the paragraph in question. Just prior to this excerpt, M16 and M10 made two distinct contributions on which might be the most suitable option, and Mr Tan was now exploring with the class as to which would be the correct answer.

At the start of this excerpt, Mr Tan repeated the same question four times in succession following the lack of student response. The question was first posed to the entire class, but no one responded. Mr Tan then directed the question to M16 who first mentioned the phrase "roiling water" as the clue to the main point of the paragraph. When that was also greeted with silence, he posed the question to the class again before giving some clues such as "it describes water, it's an adjective" that might help students answer his question. Finally, M10 raised his hand and replied with "Very fast moving." Mr Tan further elaborated on his contribution and asked a follow up question, "what does it tell you about the current and everything," directing the question once again to M16.

After this brief exchange to clarify the meaning of the word "roiling", a clue word which would help them better understand the context of the paragraph and thus help them identify the correct answer, Mr Tan asked students to indicate by raising their hands if they chose (B) as the correct answer. He then directed their attention to option (D) which was close to (B) and then asked students who chose (D) as the correct answer to raise their hands. Mr Tan did not immediately reveal the correct answer after this brief poll. Instead, he directed students' attention to the phrasing of option (D) and invited students to share their understanding of the phrase, "what does it mean? when We say in the thick of something." M10 volunteered his answer again but it was incorrect. Interestingly, Mr Tan did not explicitly say that his explanation was wrong, he used M10's response as a bridge to the correct explanation for the phrase, which meant "You're in the middle of doing it."

Excerpt 5-3 Teacher-Led Discussion on Responding to Global Questions

Speaker	Utterance
Mr Tan	What is roiling by the way?
Mr Tan	**M16** what is roiling you choose roiling right. What is roiling?
Mr Tan	Can Anyone alright? Can anyone tell me what roiling is?
Mr Tan	Number one, it describes water, so it's an adjective. What does it describe about what? What is known about the water roiling water? Yeah.
M10	Very fast moving.
Mr Tan	Very fast moving, alright, roiling itself,

Speaker	Utterance
	Okay, churning waters and so on. Yes. Okay. So if the water is very fast, moving is churning and So on and so forth itself, what does it tell you about the current and everything? Is it weak current? Is it a strong current?
M16	Strong.
Mr Tan	Strong current, right? Because it has to be in order to be churning, roiling and so on, right? So there very strong current would it, would it threaten you know to. What you call that? What what do you use just now to sweep the oars away? That's what you said?
M10	Yeah.
Mr Tan	Right. Would it do that?
Mr Tan	So how many of you chose B? Challenging the river as your answer, raise your hands please. How many, is there another answer that is similar to B? Delta is one, yes or no, in the thick of trying to navigate. So in the middle of trying to navigate, anyone of you chose D instead.
Mr Tan	Okay, so we have a we have some who chose B and some people who choose. D. Alright put your hands down. Thank you very much.
Mr Tan	Now over here you notice that? It is quite similar. Okay. Because if you are challenging the river right, you're also trying to navigate it as well. The only difference of course is that when are you doing it, yes or no, do you notice that for Delta it starts off with in the thick of, what does it mean to say in what does it mean? when We say in the thick of something.
M10	The most dangerous (…)
Mr Tan	No, I mean if you are in the thick of something, what does that mean?
M10	The most dangerous part.
Mr Tan	So may maybe in the most dangerous part itself, Okay, or you're in the middle of is that clear. You are continuing to do it in the thick of it. Okay. You're in the middle of doing it.

The total duration for the episode from which Excerpt 5-3 was taken was close to nine minutes, where Mr Tan used a combination of open and closed questions to continually engage students in a process of sense-making the paragraph and eventually derive the main point of the paragraph, to answer a global question. Comparing the length of Mr Tan's turns in Excerpt 5-3 with those Excerpt 5-1 and Excerpt 5-2, Mr Tan's turns here were noticeably longer, where he did relatively more explaining to help students derive the correct answer. This could be related to the difficulty level of the global question type, being one of the most challenging question types, even though the amount of text students needed to process to answer the question was on par with other reading comprehension question types. Furthermore, the global question as a type of reading comprehension question was new to students, as it was not part of the primary English language curriculum. This could also potentially explain why Mr Tan spent more time articulating his reasoning aloud, to make visible his thought processes to students.

Collectively, these three excerpts offered a snapshot of the kinds of teacher-student interactions taking place during teacher-led discussions in Mr Tan's classroom, where most of the communicative acts were performed by Mr Tan himself. Academic interactions between Mr Tan and his students can be characterised as teacher-directed where Mr Tan like the conductor of an orchestra, led the content and flow of the discussion. While he repeatedly invited student contributions and there were some students who were forthcoming with their responses, there remained many others who kept quiet and did not verbally participate in any of the teacher-led discussions during the lesson observation period.

Student interview data cast some light on students' motivations for speaking up or otherwise. In the words of one of the more reserved students (F1), "I'm a bit scared that like, I got the answer wrong. And like everyone is like looking at me." Among the more vocal students such as M10 and M29, they were of the view that if they did not speak up, they would not know whether they were right or wrong and might end up repeating their mistakes during examinations and adversely affect their academic performance. However, both also conceded that their decision to participate in teacher-led discussion or not was also influenced by their peers' behaviours. For example, M29 shared that he would be more motivated to contribute if his friends were actively contributing. While anecdotal, these findings seem to suggest that academic interactions were strongly influenced by the social norms in this classroom.

Interestingly, none of the student interviewees felt that their use of Fast ForWord for self-directed learning at home influenced their willingness to participate in class. Reasons cited were varied. Firstly, half of student interviewees (F08, M15 & M29) shared that using Fast ForWord helped them to be "better prepared," "helped me pay attention more and listen more in class" and "will help… maybe listening comprehension" respectively. However, F08 was "not sure in what ways" Fast ForWord would help her, and M29, like F01 and F04, did not see how Fast ForWord was related to what they were learning about Reading

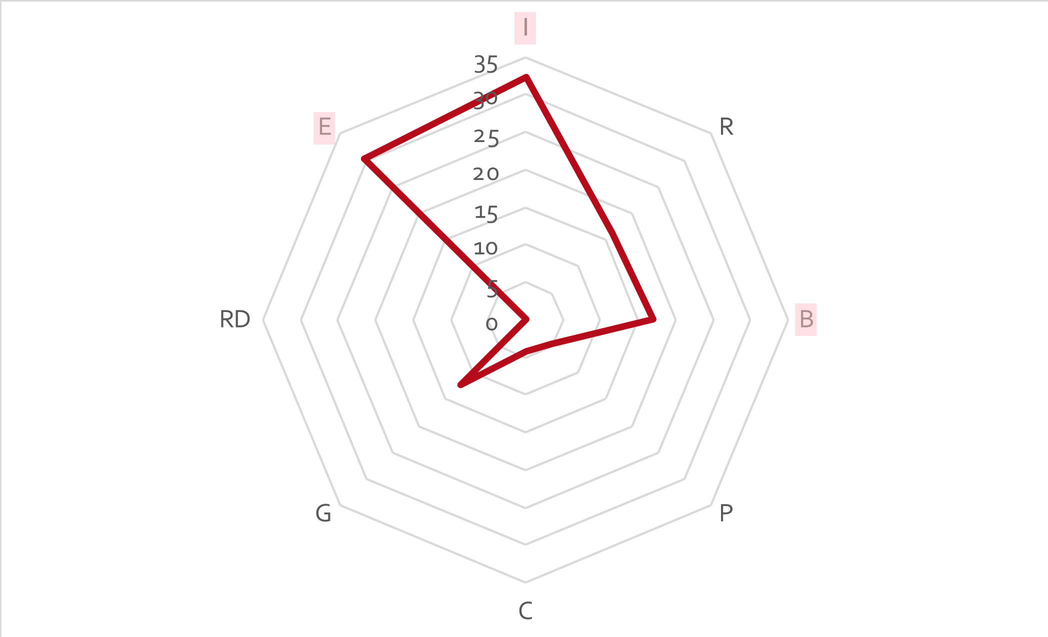
Comprehension in class. Only M10 articulated that there was “a lot of relation with the question and the topic we are learning for English.” However, M10 never logged into Fast ForWord beyond teacher-initiated use of the tool.

Collectively, triangulation of the above-presented findings on the most frequently observed communicative acts with students’ perceptions articulated during their respective interviews and students’ usage of Fast ForWord usage revealed that the tool might not have been well integrated with classroom learning. This could potentially explain why Fast ForWord was almost never featured or even mentioned during the instruction of the lesson unit selected for this research.

5.2.2 Case Study 2: Kusu Secondary

The most frequently observed communicative acts in Ms Aliyah’s classrooms came from the following clusters: invite elaboration or reasoning, express or invite ideas, and build on ideas (Figure 5-4). Most of these acts were performed during group activity, individual activity, and teacher-led discussion. While teacher-led discussion was always initiated by Ms Aliyah, her interactions with students during group and individual activities were sometimes initiated by the students themselves. It is interesting to note that while communicative acts to invite elaboration or reasoning were frequently observed, communicative acts that sought to make reasoning explicit were relatively, less frequently observed. This pattern was repeatedly observed across lessons and academic activity types and will be illustrated through the four excerpts presented below.

Figure 5-4 Communicative Acts (by Averages) Observed in Ms Aliyah's Classroom[27]



The first excerpt is from the first of two lessons on creating a graphic organiser (Excerpt 4). Students needed to learn how to do this as they were expected to produce a graphic organiser as part of their formal assessment task due later in the term. These two lessons thus served as a practice for their graded assignment. Earlier in this lesson, Ms Aliyah assigned each student to a group and set them on the task of creating a graphic organiser that best represented the key information given in a passage. In this excerpt, Ms Aliyah was with a group of students (two boys and three girls) who were working on the task individually rather than collaboratively. Just prior to this, Ms Aliyah asked the group to stop what they were doing, made them turn to face each other and started engaging these students with questions, which sought to elicit students' understanding of the passage and helped them identify the key points of the passage.

At the start of this excerpt, Ms Aliyah sought confirmation from the group "Is that the main, main parts of the article." She had to repeat her question again with "Is it" before she received a response from M21, "Yeah, it's the, the, the topic." The subsequent turns then saw Ms Aliyah prompting M21 for evidence with requests such as, "can you tell me where's

[27] Please refer to <u>Appendix </u>K for the distribution of communicative acts (by clusters) observed in each of Ms Aliyah's lesson.

the information about behavioural changes" and "In which paragraph." M21's responses though brief, were relevant and reflected his understanding of the passage. For example, when asked why he did not include paragraphs 1 to 6 when looking for "information about behavioural changes", he explained that these paragraphs were about teenager choices, i.e., "what their choices are like" and therefore not about the "brain and the behavioural changes." Here, we see Ms Aliyah inviting M21 to explicate his reasoning through what appeared to be a series of closed questions. Arguably, these questions did serve as opportunities for the student to articulate his reasoning, but simultaneously, they could have also curtailed his responses; the seemingly closed nature of these questions could possibly explain why M21's responses tended to be brief.

During this exchange between Ms Aliyah and M21, the other students in the group kept quiet, with most looking down at their handouts and one (F10) looking at Ms Aliyah as she spoke with M21. None of them spoke up even after Ms Aliyah explicitly asked "Do you all agree" which seemed like an attempt to open the discussion to include the rest of the group. The other students in the group merely nodded their head in response and remained silent. Ms Aliyah pressed in, asking the rest of the group to "find me one of these, impulsive behaviours" before adding that, "This is what I want you all to do. Either you agree with him or you think it is something else." It was at this juncture that F10 spoke up, expressing agreement with what M21 had said earlier. She pointed to a paragraph in the passage, "Like here" and highlighted information from the paragraph, "They got say like they are sensitive and responsive to like the influence of friends." Ms Aliyah then turned to the two other female students who had not spoken, and sought their agreement, "Do you all agree with the point?" These students nodded and Ms Aliyah then prompted the three female students to say more with "So then after that?" and "What else?"

From this excerpt, it is evident that the students were mostly talking to Ms Aliyah rather than to each other, even though it was meant to be a group task. For the duration that Ms Aliyah was with the group, most of them made at least one verbal contribution that enabled the group to move forward with their task, and this could be attributed to Ms Aliyah's repeated efforts at seeking agreement and prompting students with questions that sought to elicit their interpretations of the passage. This excerpt illustrated Ms Aliyah's interactions with her students during group work as she spent time engaging different groups of students. Here guidance was given primarily through questions and suggestions; only in one instance Ms Aliyah did gave a direction instruction "This is what I want you all to do" though she did explain why she gave that instruction. Students' reticence was also noticeable here. Even though it was a small group setting, where Ms Aliyah was speaking with five students, she often had to ask the same question twice before she would get a response.

Excerpt 5-4 Teacher-Student Interaction During Group Activity on Creating an Infographic

Speaker	Utterance
Ms Aliyah	Is that the main, main parts of the article?
Ms Aliyah	Is it?
M21	Yeah, it's the, the, the topic.
Ms Aliyah	So about the brain and what again, repeat again, for me.
M21	The brain and the behavioural changes.
Ms Aliyah	The behavioural changes Okay, now can you tell me where's the information about behavioural changes.
M21	The behavioural changes (are)
Ms Aliyah	(In) which paragraph
M21	7, 7 and,
Ms Aliyah	7?
M21	7 and 8.
Ms Aliyah	How about 6? Or 1 to 6.
M21	1 to 6 is about what the what their choices are like.
Ms Aliyah	Do you all agree?
M21	And sometimes and then the some of the impulsive decisions.
Ms Aliyah	From 1 to 6?
M21	Yeah,
Ms Aliyah	Okay. Give me a, can you find me one, you. Each of you find me one of these, impulsive behaviours, is it?
M21	Yeah.
Ms Aliyah	So if you agree with him? If you agree with him. (.) This is what I want you all to do. Either you agree with him or you think it is something else. Okay?
F10	Like here lah[28]. They got say like they are sensitive and responsive to like the influence of friends. You see here right, can be like, it said like if their friends do something they will want to do it as well, just like, be responsive.
Ms Aliyah	So is that what, is that a point? Do you all agree with the point?
Ms Aliyah	Okay.

[28] "Lah" is a colloquial Singaporean English (also known as Singlish) expression that has no meaning. It is often added to the end of a sentence to signal a casual tone or to soften an utterance.

Speaker	Utterance
Ms Aliyah	Okay. Maybe one of you can scribe, right.
Ms Aliyah	Can you put it in your (.) yeah?
Ms Aliyah	Okay. So then after that? (.) after that?
Ms Aliyah	What else?
F10	Impulsivity (of the)
Ms Aliyah	(Is there) anymore of what you have said?
F10	Impulsivity of behaviours.
Ms Aliyah	Are they the same thing? Or two different thing? Or how are they connected?
Ms Aliyah	How are they connected?
Ms Aliyah	There's some connection with the information here. So this is what I want you to do, right? Basically, How are these different different things connected?

The second excerpt is from the second of two lessons on creating a graphic organiser (Excerpt 5-5). Ms Aliyah started this lesson by giving students time to work in their groups to finalise to their graphic organisers and to nominate a member who would present the graphic organiser on behalf of the group. The rest of the students (who were not presenting) would then move from group to group to listen to the various presentations while the student presenters remained where they were to explain their group's graphic organiser to members from the other groups. Each presentation was approximately two minutes. During this time, Ms Aliyah also moved from group to group to listen to the student presentations and ask questions about their graphic organisers. This excerpt presents a brief exchange between Ms Aliyah and one of the groups after the student (F11) had finished her presentation.

Here we see Ms Aliyah prompting F11 with a 'why' question which served as an invitation to explicate the group's rationale for their choice of the graphic organiser. F11 made a reference to "Data Stream," a learning task in Fast ForWord, that influenced the group's choice and mentioned that "it can elaborate better." However, the next bit of her response "the like the" was incomplete, interrupted by another question from Ms Aliyah "What is the relationship between, what are the lines," which was an invitation to elaborate that also shifted the focus of the conversation. F11's initial hesitation "Err" suggested she could be struggling to respond, and before she presented an answer, Ms Aliyah repeated the question again "so what are the lines for" and restated it as "What (is) the relationship from one point to the other." It was after this turn that F11 answered Ms Aliyah's question, "Break it down… explain in impulsivity?" Upon hearing F11's response, Ms Aliyah then modelled for her how she should be presenting her graphic organiser. It is interesting that Ms Aliyah did not comment on her earlier presentation or focused on where she did not do well. Instead, Ms Aliyah seemed to want to understand her key message and helped her refine her presentation.

Ms Aliyah then turned to the rest of the students listening to this presentation and sought their views of the graphic organiser that they just saw, "compared to what you guys have done? (.) Is this better or is yours better?" This served to open the conversation up till now that was between her and F11 to the others present. However, no one responded until M18 stepped up to offer his view, "I like our set better." Even though Ms Aliyah did not probe further, he explained his stance, "this one is like a bit, a bit hard to read, because of like, a lot, the words is here and then it's left." Ms Aliyah sought further clarification, "So it's just about the about the way they have done the thing," to which M18 restated what he said, "So ours is a bit clearer and you can read it as well" instead of answering Ms Aliyah's question directly. At this juncture, Ms Aliyah returned to a point she raised earlier about "relationship", inviting evaluation, "So they have used the lines to show relationship, is that more clear?" However, this discussion was cut short by the 2-minute buzzer and students had to move on to the next group presentation.

Excerpt 5-4 and Excerpt 5-5 revealed a pattern of interaction between Ms Aliyah and her students in small group settings. In both instances, we saw her use questioning to invite elaboration and reasoning, typically with one student in the group, before opening the conversation to include other students in the group. These episodes entailed eliciting students' opinions and interpretations of the passage that they were reading, and the starting point of these interactions tended to be students' contribution, suggesting student-centredness in these teacher-guided conversations. That said, Ms Aliyah was observed to have to repeat her questions during these interactions, which suggested student reticence even when interacting in small groups, where the teacher was present.

Excerpt 5-5 Teacher-Student Interaction During Student Presentation Question-and-Answer

Speaker	Utterance
Ms Aliyah	Okay, why do you go decide on this graphic organizer?

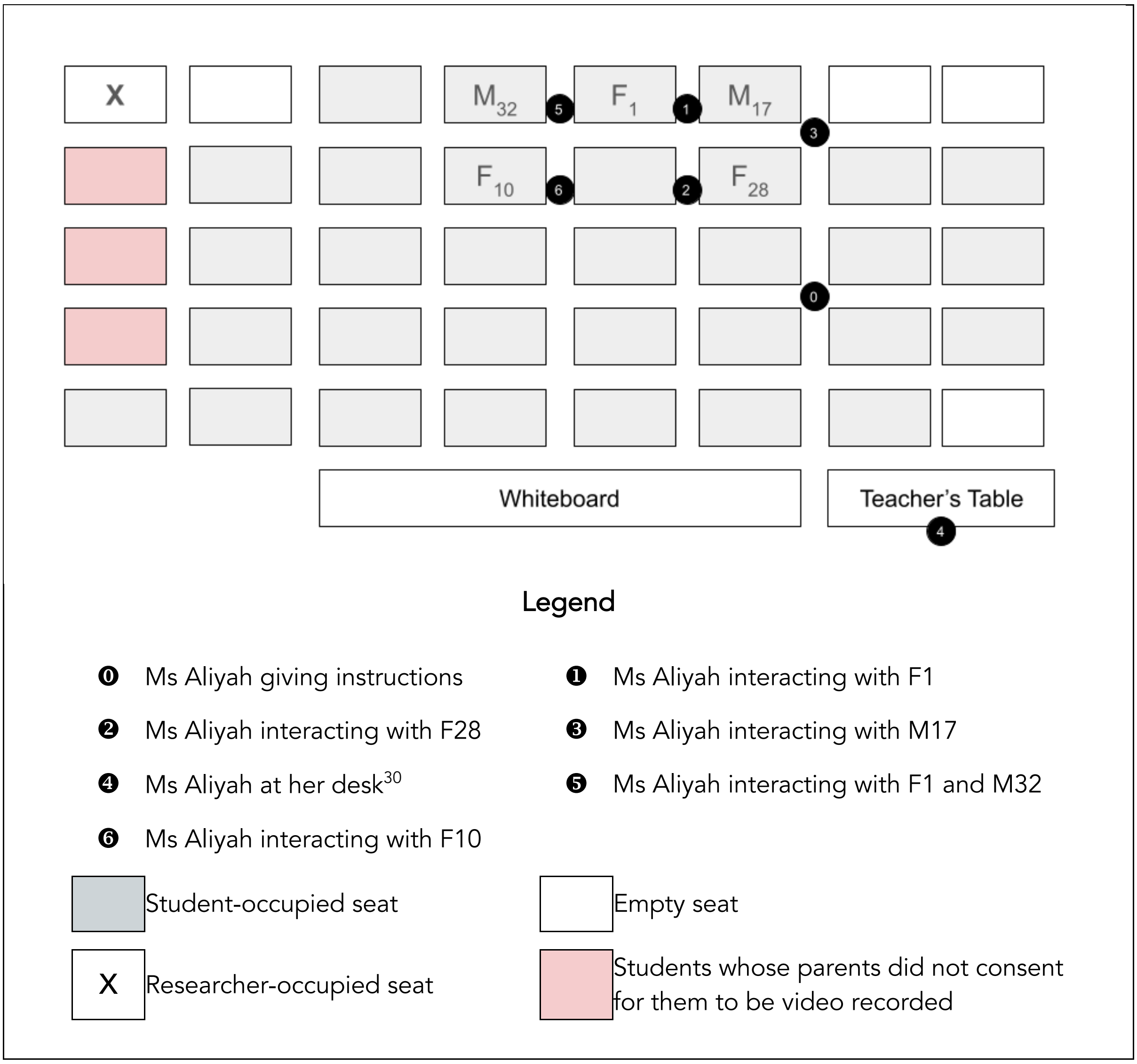
Speaker	Utterance
F11	Because of the Data Stream. So that more of my, like it can elaborate better, the like (the)
Ms Aliyah	(What) is the relationship between, what are the lines
F11	Err, the (graph)
Ms Aliyah	(Yes) so what are the lines for? What the relationship from one point to the other.
F11	Break it down. For example, this one is about risk-taking right. It says that these are impulsive, these are all different like so er, explain in impulsivity?
Ms Aliyah	Okay, so basically, if you were to explain to the rest of the group later what you should be saying is that this is the main, main point of the whole article right? So it's broken up into three sub headers, correct? Yeah. So because of how it has, has affected the the brain, right, in what, in what ways is that they have already, they have, they have made teenagers increase in risk taking, right, increase in difficulty, difficulty in weighing decisions and elimination of irrelevant things Okay and Why is that an increase, an increase in risk taking is because how do we know there's an increase in mistaking? How do they show it? By all these ways. Okay, so that this is how you're supposed to explain.
Ms Aliyah	Okay, compared to what you guys have done? (.) Is this better or is yours better?
M18	I think I think I like. I like our set (better)
Ms Aliyah	(Okay)
M18	But this one is like a bit, a bit hard to read, because of like, a lot, the words is here and then it’s left.
Ms Aliyah	So it's just about the about the way they have done the thing
M18	So ours is a bit clearer and you can read it as well.
Ms Aliyah	Okay. But in terms of the relationships, I remember I asked you about relationship. So they have used the lines to show relationship, is that more clear?
M18	Err
Ms Aliyah	Okay.
Ms Aliyah	Alright, wrap up. And prepare to move now.

Turning our attention to Excerpt 5-6, this is an excerpt from the final lesson on writing discursive essays. In this lesson, Ms Aliyah covered content on writing thesis statements, topic sentences, body paragraphs and conclusions for discursive essays. Just prior to this excerpt, Ms Aliyah found out that many students did not do their homework, which was a thesis statement writing practice, and decided to give them time to complete the task before moving on to talk about topic sentences. As they were writing, Ms Aliyah walked between the desks and interacted with students on their thesis statements. This excerpt presents Ms Aliyah’s interactions with six students while she was walking about, of which four interactions were academic in nature and one (with M17) was organisational in nature.[29] (Please see Figure 5-5 for Ms Aliyah's location when talking with the students during Excerpt 5-6.) Among the four teacher-student academic interactions observed here, two were student-initiated, and the remaining two were teacher-initiated.

The first student-initiated interaction took place right after Ms Aliyah had given her instructions, "I'll give you 5 minutes to complete that now. Try", where F1 raised her hand and sought clarifications on the task requirements. She raised her hand a few moments later, when Ms Aliyah was with F28, but Ms Aliyah did not see her hand. It was only after Ms Aliyah's interaction with M17 and after she walked to the front and middle of the class before she saw F1's raised hand and came to her. During this second student-initiated interaction, F1 sought clarifications on the use of "because" when Ms Aliyah was nearby. And while she was highlighting to F1 the connectors, such as "because," that should not be used to start a sentence, M32 chimed in with a question of his own, "Is this the connector? For this. Or is it both?" Here, both F1 and M32 were forthcoming with questions and demonstrated desire for academic interactions with Ms Aliyah, even though both seldom volunteer their responses during whole class teacher-led discussion.

[29] As organisational teacher-student interactions fall out of the scope of this research Ms Aliyah's interactions with M17 will not be discussed here.

Figure 5-5 Ms Aliyah's Location When Interacting with Students During Individual Activity



The two teacher-initiated interactions with F28 and F10 respectively entailed Ms Aliyah giving feedback to students who have completed their thesis statement writing practice. She first spent a few moments reading what F28 has written, before requesting for further elaboration. Her first utterance was what would appear to be an indirect prompt "I'm proud, you're proud of" which seemed like an invitation to F28 to complete the sentence. However, F28 read what she had written instead. Ms Aliyah had to then tell her directly that "You didn't say you are proud of this in what sense" before leaving F28 to revise her thesis statement. Her

[30] After her interactions with M17 at ❸, Ms Aliyah walked back to her desk before checking on students who were seated near the front and middle portions of the classroom. Upon seeing F1's raised hand (for the second time), she made her way to the back of the classroom to ❺, to hear what F1 had to say.

interaction with F10 was similar, where her first utterance "What is the main point of the thesis statement" served to seek clarification. Ms Aliyah then directed F10's attention to the task requirements, "Look at the question" which seemed to help her realise what was missing from her thesis statement.

Excerpt 5-6 Teacher-Student Interaction During Individual Activity on Thesis Statements

Speaker	Utterance
Ms Aliyah	Okay. Can you, I'll give you 5 minutes to complete that now. Try.
F1	Circle (this?)
Ms Aliyah	(Circle) the connector which helps to show cause and (effect).
F1	(Oh) connector (it's)
Ms Aliyah	(It's) not circle.
F1	Oh, okay.
Ms Aliyah	Can you try to recreate in your homework as much as possible? I'm proud, you're proud of.
F28	Yeah. Despite Singapore's small geographic size, it has punched above its weight globally.
Ms Aliyah	So you're proud of this.
F28	Yeah.
Ms Aliyah	You didn't say you are proud of this in what sense.
M17	I don't think I brought my handout today.
Ms Aliyah	So what do you need to do?
M17	Take out my foolscap.
Ms Aliyah	Okay.
F1	Why I am not able to start the sentence with a because.
Ms Aliyah	(Oh no,)
F1	(Because) over here
Ms Aliyah	Yeah, yeah. I know. So this is very bad example, but next time try not to use because. And the other one is and although and.
M32	But this one (right)
Ms Aliyah	(Cos this) one is supposed to be a connector (in a way)
M32	(Is this the) connector? For this. Or is it both?
Ms Aliyah	Both.
M32	Both.
Ms Aliyah	My answer sheet says both.
Ms Aliyah	Are you done? Let me see.
Ms Aliyah	The main point of the statement, thesis statement. What is the main point of the thesis statement.
F10	The main point is that (the)
Ms Aliyah	(Huh?)
F10	The main point is that (.) little red dot come from like (…)

Speaker	Utterance
Ms Aliyah	(Look at the question.)
F10	The main point is key aspects of the country that gives you a sense of pride.
Ms Aliyah	Uh-huh. So what is missing from your thesis statement
F10	What brings me a sense of pride.
Ms Aliyah	umm. So that part is not there. You're giving all these reasons, but. You're not saying what are these reasons for. Yeah, okay?

Academic interactions presented in Excerpt 5-6 show that students seemed more forthcoming with their responses during 1-to-1 engagement with Ms Aliyah, compared to group activity settings and teacher-led discussions (the latter will be illustrated through Excerpt 5-7). Some students, such as F1 and M32, could be seen to be proactively seeking Ms Aliyah's attention during individual activity. This is in stark contrast to the teacher-student interactions observed in Excerpt 5-7 where Ms Aliyah had to prompt students repeatedly before she would receive a response.

Excerpt 5-7 was taken from the second last lesson on writing discursive essays where Ms Aliyah was teaching students about thesis statements. She started the lesson by explaining what thesis statements were and went through sample thesis statements before asking students to work individually on an evaluation task. Students were expected to review the statements provided in their handout, evaluate if these were thesis statements and explain the reasons for their assessment. Ms Aliyah gave students slightly over nine minutes to complete this task and Excerpt 5-7 follows from this individual activity. Yet, we can see that even though students had the time to work through their responses prior to this teacher-led discussion, students were not forthcoming with their response at the start of this discussion, and Ms Aliyah had to resort to calling names.

When Ms Aliyah called on M23 to share his views, she repeated herself twice before she would get a non-verbal response, where M23 shook his head to signal he did not think that the statement was a thesis statement. After M23 expressed his view non-verbally, Ms Aliyah probed further with questions such as “What explanation did you give?” and “why it's not thesis statement” which served to invite elaboration or justification from M23. However, he remained silent and after waiting for approximately 15 seconds, Ms Aliyah called on M16 to help, "you want to help M23? Do you have the same answer as well?" M16 then proceeded to offer his view "There's no claim" which seemed to be an explanation as to why the statement was not a thesis statement. In this brief turn, M16 did not explicitly state if he took the same position as M23 though his response would suggest that this was the case.

Ms Aliyah repeated M16's contribution, "there's no claim" and followed that with a question "what do you see in this statement, people" that sought to build upon M16's contribution by shifting students' attention from what the statement was not to what the statement could be. The explicit use of "people" here by Ms Aliyah also served as an invitation to extend the current exchange between herself and M16 to the entire class. When she did not receive any response, she directed students' attention to a specific part of the statement "There's this right?" and M20 then responded with "Numerical value." Ms Aliyah then asked more questions, "And this is what?" and "Where do we usually find statistics" which served as leading questions that guided students to the conclusion that the statement was indeed not a thesis statement.

In response to M20's proposition that the statement could be part of the body paragraph, Ms Aliyah asked, "can this be a topic sentence." Some students shook their heads and counter-proposed that it was "a hook." Ms Aliyah acknowledged this possibility, "Possible actually, a hook" and then engaged M20 briefly on which part of the body paragraph this statement could potentially be, with reference to the PEEL (point, evidence, elaboration, and link) structure. Before moving on to discuss the next statement, we see here an extended turn by Ms Aliyah who explained how this statement could be used as a hook and as a piece of evidence to support the point made in a body paragraph. This elaboration stands in stark contrast to students' brief and unelaborated responses, which suggested that students were reluctant to participate in such teacher-led discussion.

Excerpt 5-7 Teacher-Led Discussion on Thesis Statements

Speaker	Utterance
Ms Aliyah	Alright, let's see. Who would like to share? Who would like to answer the second one.
Ms Aliyah	Must call names is it. Let's see, let's call (.) Who have I not called in a long time? (.) **M23**?

Speaker	Utterance
Ms Aliyah	Number 2. Is it a thesis statement?
Ms Aliyah	Is it a thesis statement?
Ms Aliyah	No. Why is, why is it not a thesis statement?
Ms Aliyah	Why is it not a yeah, thesis statement.
Ms Aliyah	Why? What explanation did you give?
Ms Aliyah	Did you write anything there? Do you write anything down?
Ms Aliyah	You didn't. So why? Why do you? Why do you think it's not a thesis statement? You're right. It's not a thesis statement. So tell me why it's not thesis statement.
Ms Aliyah	**M16**, you want to help **M23**? Do you have the same answer as well? It's not a thesis statement.
M16	There’s no claim.
Ms Aliyah	Sorry again, there's no claim.
Ms Aliyah	Okay, what do you see in this statement, people.
Ms Aliyah	There's this right?
M20	Numerical value.
Ms Aliyah	Uh-huh. And this is what?
M24	Data
Ms Aliyah	Data, statistics. Right. Where do we usually find statistics?
M20	Body paragraph.
Ms Aliyah	Body paragraph. So can this be a topic sentence?
Ms Aliyah	Then what? Can it be
Students	a hook
Ms Aliyah	A hook?
M20	Body Paragraph.
Ms Aliyah	A hook? Okay. You say body paragraph? Why do you say body paragraph.
Ms Aliyah	Possible actually, a hook.
Ms Aliyah	Why do you say it's body paragraph?
M20	Because they put the statistic.
Ms Aliyah	In which part of body paragraph PEEL.
M20	P
Ms Aliyah	P, a point.
Ms Aliyah	Okay, you are right right, this can actually be a hook.
Ms Aliyah	It can be a hook if the topic is about (.) I don't know what the topic could. Be about. If you're talking about reading and reading magazines or what or what people read right, or how to get people interested in reading, perhaps. Okay, can, so it could be a hook, right?
Ms Aliyah	It could also be. Can, it can possibly be a a point or topic sentence?
Ms Aliyah	Alright, again depending on what is the title of your essay, Okay, it could also be part of your explanation or your elaboration because you're trying to show the percentage, right? Okay. Of people who actually do read. Do read magazines okay and how they read magazines.

The four excerpts presented here reflect varying levels of student reticence when Ms Aliyah attempted to engage them academically. They appeared to be most reluctant to speak during whole-class teacher-led discussion (e.g., Excerpt 5-7) and least reluctant to speak during one-to-one conversations, such as those that took place while the rest were engaged in individual activity (e.g., Excerpt 5-6). Student interview data revealed that when deciding whether to speak up in class or not, students would consider if it was "appropriate" to do so and how "confident" they were of their response. M18, who was identified by Ms Aliyah and who also self-identified as a quiet student, shared that he would never volunteer a response during teacher-led discussion as he felt "awkward" and "kind of nervous" when speaking in front of the class, which he deemed to be "such a huge audience." F26 shared similar sentiments, and when asked if she felt that safe in class to speak up, she responded, "I don't know." These findings, like those from Ubin Secondary, also suggested that academic interactions were influenced by social norms in the classroom.

In terms of connecting their classroom interactions and learning with their use of Fast ForWord, the student interviewees felt that they were more prepared for the lesson and the group task of creating a graphic organiser when they worked on the Data Stream activities on Fast ForWord as assigned by Ms Aliyah. However, these students did not feel that this enhanced sense of preparedness encouraged them to speak up more in class. Among all the student interviewees, only M32, among the more frequent users of Fast ForWord, could articulate how the tool might be related to what they were learning, "we're doing a lot of essay writing and all those and most of our exams are all about narratives, so [Fast ForWord] will help me with my reading capabilities." These student articulations, triangulated with the most frequently observed communicative acts, would suggest that while there was some integration of Fast ForWord with classroom design mediated by Ms Aliyah's instructional design and in-class facilitation, this was a one-time integration event and was not sustained throughout the integration phase.

Looking across the seven excerpts presented, both Mr Tan and Ms Aliyah made active use of questioning, including both open-ended questions and leading questions, to elicit students' thinking. However, while both teachers often had to repeat their questions, Mr Tan appeared to struggle less than Ms Aliyah with obtaining a response from students, particularly during teacher-led discussion. If Mr Tan were akin to a skilful orchestra conductor trying to draw as many students as possible into a unified conversation, Ms Aliyah could be said to be functioning like a coach, sought out by students for 1-to-1 interactions as opposed to engaging with her during group settings, such as during group activity or teacher-led discussions.

It should also be noted that a fair number of communicative acts from the cluster of guiding direction of dialogue or activity were observed from both Mr Tan and Ms Aliyah's lessons. In fact, the number of such communicative acts observed from Mr Tan's lessons were comparable to the cluster of inviting elaboration or reasoning, the third most frequently observed category of communicative act from Mr Tan's lessons. Classroom-based research in Singapore has consistently identified the structured use of teacher questioning and guided talk as a core and stable feature of instructional practice. Large-scale studies, including those from the CORE Research Programme[31], show that teachers systematically employ guiding questions and sequenced talk moves to scaffold students' understanding and sustain instructional coherence across subjects (Hogan et al., 2013; Kim, 2022). As such, the use of guiding talk moves in Singapore classrooms can be considered well-established, suggesting that it is a pedagogical norm that can be assumed in analyses of classroom interaction, and thus would not be discussed at length for the purposes of this research.

5.3 Rarely Observed Communicative Acts

Communicative acts from the clusters connect and reflect on dialogue or activity were rarely observed in Mr Tan and Ms Aliyah's classroom. Rarely or not observed communicative acts from the connect cluster included referring back, making learning trajectory explicit, linking learning to wider contexts and inviting inquiry beyond the lesson; and rarely or not observed communicative acts from the reflect on dialogue or activity cluster included talking about talk, reflecting on learning and inviting reflection on learning. With reference to Table 5-4, 16 acts

[31] CORE (Classroom Observation Research in Education) is a large-scale, longitudinal research programme examining classroom pedagogies in Singapore's primary and secondary schools. Led by researchers from the National Institute of Education (NIE), it investigates how teachers teach, why they adopt particular pedagogical approaches, and how students learn.

from the connect cluster and five from the reflect on dialogue or activity cluster were observed during Mr Tan's lessons, while 30 acts from the connect cluster and two from the reflect on dialogue or activity cluster were observed during Ms Aliyah's lessons. Table 5-5 gives the breakdown for the connect and reflect on dialogue or activity clusters respectively, which reveals similar patterns of use in both classrooms, in terms of rarely observed communicative acts. As such, findings on rarely observed communicative acts during both Mr Tan and Ms Aliyah's lessons would be presented in an interwoven manner rather than sequentially (which was the case for the early sections of this chapter).

Table 5-5 Rarely Observed Communicative Acts During Mr Tan and Ms Aliyah's Lessons

Communicative Acts	Number of Acts Observed	
	Mr Tan's Lessons	Ms Aliyah's Lessons
Connect Cluster		
Refer back	14	26
Make learning trajectory explicit	0	0
Linking learning to wider contexts	2	4
Inviting inquiry beyond the lesson	0	0
Reflect on Dialogue or Activity Cluster		
Talk about talk	0	0
Reflect on learning process/ purpose/ value/ outcome	0	0
Invite reflection about process/ purpose/ value/ outcome of learning	5	2

First, it is evident from Table 5-5 that both Mr Tan and Ms Aliyah did not perform any communicative act that made the learning trajectory explicit or invited inquiry beyond the lesson. Second, communicative acts linking learning to wider contexts were also extremely rare, particularly when compared with the most frequently observed communicative acts in Mr Tan's and Ms Aliyah's lessons, which was 139 and 181 acts respectively. The two acts by Mr Tan at linking learning to wider contexts took place during the first lesson on reading comprehension, where he first reminded students that "comprehension is not new to you" and then solicited what they already knew about reading comprehension, "what do you want to know about them?" There was no other instance where he was observed to be linking learning to wider contexts. In contrast, Ms Aliyah's four acts to link learning to wider contexts took place during four different lessons, spread across the second, third and fourth weeks of the lesson observation period.

The first act by Ms Aliyah at linking learning to wider contexts took place during the first lesson on the discursive writing unit. This lesson was conducted in the second week of the lesson observation period and was largely centred on unpacking the topic of teenage life. As part of a teacher-led discussion, Ms Aliyah made references to students' experiences as teenagers, "social media is quite a big thing right for you. Okay. And then of course, you had the gaming thing, right?" In doing so, Ms Aliyah made the connection that the topics for students' weighted assessment was "quite similar to what you have raised just now, right about what a teenager, what being a teenager means to you, right?" This seemed like a move to boost students' confidence for the upcoming weighted assessment, where students were required to complete a discursive essay on one of the pre-set topics.

Another act of linking learning to wider context took place during the lesson on creating an infographic, conducted in the third week of the lesson observation period. When Ms Aliyah sat with one of the groups who was working on their infographic, Ms Aliyah asked about their experience using Fast ForWord, "You all did the Data Stream right. What did you all learn from the Data Stream? What did you learn from the Data Stream?" Following this was a series of questions that appeared to elicit students' understanding of data visualisation while helping them clarify the message that the group was trying to communicate. Here, it would seem like Ms Aliyah was attempting to connect students' out-of-school, self-paced learning with Fast ForWord and the in-class group task of creating an infographic.

The two other acts entailed Ms Aliyah linking learning to wider contexts in terms of making references to the wider applicability of what was currently being taught or what was previously taught. During the lesson on writing hooks, Ms Aliyah reminded students that the use of hooks in introduction was not limited to discursive essays, "actually your hook can be used for any kind of writing, maybe narrative." This served as a prompt for students to consider expanding their use of introductory hooks beyond the immediate context of writing discursive essays. In another lesson on writing body paragraphs, Ms Aliyah made a reference to the PEEL structure (point, evidence, elaboration, and link) and drew a connection that "the

P in the discursive essay, the point is also known as the topic sentence." This not only served as a bridge between what students previously learnt and what they were learning then, it could also potentially enable students to exercise mental dexterity by breaking down components of a body paragraph using different frames.

Overall, the links made by Ms Aliyah were more varied, compared to Mr Tan, even though both teachers rarely linked learning to wider contexts. One possible explanation for this difference could be the age and grade level of students. Ms Aliyah was teaching a Secondary Two class and compared to the Secondary One class that Mr Tan was teaching, these Secondary Two students would have accumulated more relevant learning experiences given that they were one year older and one grade level above.

The other rarely observed communicative act from the connect cluster was refer back, and it was the most frequently observed communicative act from the connect cluster, even though its number seemed low when compared with that of the frequently observed communicative acts. Table 5-5 shows that the number of communicative acts performed by Mr Tan and Ms Aliyah that constituted referring back was more than six times those of linking to wider contexts. In terms of the distribution of these communicative acts, it should also be noted that acts of referring back was observed in all but one of Mr Tan's lessons, and in all but two of Ms Aliyah's lessons. The two lessons where Ms Aliyah did not perform any communicative act of referring back entailed students mostly engaged in individual or group activity while the lesson where Mr Tan did not perform any such act was one where he was engaging students in textual analysis of a paragraph.

The acts of referring back observed during Mr Tan and Ms Aliyah's lessons were varied and could be clustered into three broad categories including referring to earlier student contributions, referring to previous instruction and referring to prior learning experiences (Table 5-6). These references could be observed typically at the start or during instruction, and were all performed by the teachers, which suggested that these acts could be a key means through which Mr Tan and Ms Aliyah were articulating the connections between what their students were learning. These observations also suggest that even though communicative acts of referring back were rarely observed, they did not have a diminished presence in either of Mr Tan or Ms Aliyah's lessons.

Table 5-6 Types and Examples of Referring Back by Mr Tan and Ms Aliyah

Types of Referring Back	Example from Mr Tan's Lessons	Examples from Ms Aliyah's Lessons
Referring to earlier student contributions	"Now, F8, you mentioned just now that when we are doing comprehension, we must look at keywords in the question and underline them yes or no,"	"it is actually quite similar to what you have raised just now, right about what a teenager, what being a teenager means to you, right?"
Referring to previous instruction	"Remember, you need to explain what makes it a bad inference. Is that clear?"	"Okay, so I did mention earlier a few lessons earlier, right that you need to really state what the pros and cons are."
Referring to prior learning experience	"Does this look familiar to you? Yes? You are doing your Fast ForWord. Why? Remember I told you during our lesson over in Comp Lab that the whole idea of doing this is to help you to read and to understand what you're reading better. Yes, no, it is to train your comprehension skills, agree? Alright."	"Okay, I'm sure you have been taught reading skills, right? What do you need to do when you read? I don't see all or I don't see anyone using the strategies you've learned. I'm sure in Sec 1 you've learned some strategies, reading strategies."

Turning our attention now to communicative acts from the reflect on dialogue or activity cluster, it is evident from Table 5-5 that both Mr Tan and Ms Aliyah, as well as their students, did not perform any communicative act that constituted talk about talk or reflection on the learning process, purpose, value or outcome. Furthermore, communicative acts inviting reflection about the learning process, purpose, value or outcome were also extremely rare, like those linking learning to wider contexts. In total, Mr Tan performed five communicative acts that constituted an invitation to reflect on the learning process, purpose, value or outcome, and Ms Aliyah performed two such acts. In fact, both acts performed by Ms Aliyah were directed at specific students during one-to-one conversations with them while others were engaged in group activity. While these acts sounded like invitations to reflect on the specific choices made by these students, the almost immediate switch of the conversation focus to something else indicated that there was no follow-up after these acts were performed.

The five communicative acts of inviting reflection were observed during two of Mr Tan's lessons. During the first lesson on the unit, when soliciting what students already knew about reading comprehension, he invited students to reflect on their primary school leaving examination (PSLE) experience, "Was it good memory or traumatic memories for you." He then presented past year PSLE reading comprehension questions which seemed to serve as a transition to direction instruction on reading comprehension question types. The remaining four such communicative acts were observed during a lesson making inferences, as part of a debrief after a pair activity involving role-play and use of context cues. Here, Mr Tan offered a series of prompts that seemed to be inviting students to reflect on their partner's and their actions.

> "So if your partner was doing scenario one, did your partner give you the clues to tell you that he or she was a 7-year-old child that had broken the television? What clues did your partner tell you? Give you? To clue you in."

> "Those who act as scenario two are acting as a 30-year-old adult, reacting to the nephew breaking the television. What clues did you give to your partner, to tell your partner, to show your partner that you were 30-year-old adult."

This activity and the ensuring debrief seemed to also perform a similar transition function and was followed by direct instruction on making inferences to answer reading comprehension questions.

Situating these communicative acts of inviting reflection within the learning episodes from which they were observed, it can be said that these acts were ancillary to the learning focus of the lesson and their occurrences was likely to be due to happenstance rather than by design. Coupled with the absence of the other communicative acts from the reflect cluster, reflection could be said to be a rarely utilised learning tool during both Mr Tan and Ms Aliyah's lessons for the lesson unit that was being observed.

From the lens of Fast ForWord integration, these rarely observed communicative acts could potentially signal missed opportunities for closer integration of the tool with classroom learning. Firstly, the fact that both teachers did not invite inquiry beyond the lesson is potentially an explanation why most students did not seem to have a keen interest in Fast ForWord beyond teacher-initiated use. This could be due to implicit norms (i.e., *Rules*) that might have been set and were caught rather than taught. Secondly, the rarity of communicative acts that invite reflection or contained reflection about learning process, purpose, value or outcome could suggest missed opportunities that if more present, would have created a space and meaningful dialogue for students to sense make how learning with Fast ForWord related with what they were learning in class. Collectively, these rarely observed communicative acts could then be interpreted as avenues through which the integration of Fast ForWord could be improved.

5.4 Chapter Summary

In this chapter, I presented findings on teacher-student interactions observed during the ALS integration phase. I first categorised the types of academic activities observed during Mr Tan and Ms Aliyah's lessons in Ubin Secondary and Kusu Secondary respectively, highlighting similarities and differences between the two classrooms. The observed differences were revealing of *Community* such as teacher-student and student-student dynamics as well as *Rules* such as interaction norms in the classroom. Next, applying SEDA, I illustrated the most frequently observed communicative acts in the two classrooms using transcribed lesson excerpts and drew connections between these classroom findings with students' use of Fast ForWord, to ascertain the extent to which the tool was effectively integrated with classroom learning. I then wrap up this chapter by highlighting rarely observed communicative acts in the two classrooms, which could potentially signal missed opportunities for strengthening the integration of Fast ForWord with classroom learning.

6

Discussion

Chapter Six synthesises the findings from this research and discusses the factors influencing the onboarding and integration of ALS with classroom learning, with particular attention to their implications for classroom interactions. It seeks to also situate these findings within existing literature, highlighting points of convergence, extension, and tension. Drawing together insights from the empirical evidence presented earlier, the discussion moves beyond descriptive accounts of ALS onboarding and integration to interrogate how adaptive technologies intersect with established pedagogical practices, interactional norms, and teachers' professional choices.

6.1 Effectiveness of ALS Integration

Central to this discussion is the recognition that ALS do not operate as standalone instructional agents but are embedded within complex classroom ecologies comprising teachers, students, curricular goals, assessment practices, and institutional constraints. This section thus examines the approach to ALS integration adopted by the two teachers, with reference to key factors influencing EdTech integration, namely curriculum coherence, pedagogical alignment, assessment integration, teacher readiness, and school leadership and culture (see Section 2.3.2 for a review of the literature pertaining to these factors influencing ALS integration).

Starting with curriculum coherence, where technology use is intended to support sustained learning progressions rather than isolated activities, Mr Tan from Ubin Secondary School decided to integrate a Reading Comprehension unit with Fast ForWord, an ALS focused on reading skills development. Ms Aliyah from Kusu Secondary School, however, chose to integrate a Discursive Writing unit with the tool. Ms Aliyah's choice is noteworthy as she has chosen to integrate an EdTech tool for developing reading skills with a lesson unit on writing skills, which did not seem to be a usual practice, and this could potentially explain why it took her quite a long time, longer than that taken by Mr Tan, to decide how she would enact this integration.

Furthermore, even though Fast ForWord was an ALS for reading skills development and was assigning Reading Comprehension activities to the student users, Mr Tan made no specific reference to what the students were learning with Fast ForWord when he was teaching the Reading Comprehension unit. As such, while students were learning about reading comprehension in class and were doing Reading Comprehension activities on Fast ForWord, no link was made for the students between these two types of learning. This shows that curriculum coherence, alignment between the ALS and the instructional objective in this instance, did not necessarily translate into clarity for the students, given that none of the student interviewees showed any awareness of such alignment during their interviews. This supports earlier research that highlights goal clarity as a factor that could influence EdTech integration (Petko et al., 2018). Making linkages explicit is thus an aspect of integration that should not be neglected, even in instances where the link(s) may be obvious.

In Ms Aliyah's case, curriculum coherence may appear to be lacking at the first instance, in view of Fast ForWord's focus on reading skills development and the classroom learning's focus on writing skills development. However, Ms Aliyah was able to make a link between the data visualisation tasks (i.e., Data Stream) on Fast ForWord and a graphic organiser activity that she asked the class to complete as group work. This in-class group activity, which was focused on organising information, served as a means of creating an essay outline, which was part of the Discursive Writing unit. It also served as a practice for what students needed to complete and submit for summative assessment (i.e., weighted assessment) for the term. Here, it becomes evident that curriculum coherence can be "manufactured" and explicitly communicated through instructional design, though what would motivate such effort is not directly observed from this research.

One possible explanation for Ms Aliyah's effort at ensuring curriculum coherence between students' online learning with Fast ForWord and their offline classroom learning experience may be pedagogical alignment. This signals potential interaction among the five factors influencing EdTech integration. Based on the types of academic activities observed in her classroom, Ms Aliyah seemed to marginally favour student activity, where individual activity and group activity collectively occupied more than 50% of her lessons. For this integration, she thus assigned Data Stream activities in Fast ForWord as a pre-learning task for her lesson on creating graphic organisers, which was enacted primarily through group work. By design, this would give all students some prior exposure to the task and ideally would enable all students to participate actively and contribute to the in-class group activity.

While pedagogical alignment in terms of aligned instructional strategies can be deduced from Ms Aliyah's lessons, this was not quite the case for Mr Tan. Mr Tan, who favoured teacher-led discussion and teacher direct instruction and appeared to be more focused on content coverage, seemed to struggle with pedagogical alignment. This is evident from the earlier-mentioned lack of connection or reference to Fast ForWord during lessons on Reading Comprehension, which suggested that the way the tool was used, whether it was by Mr Tan's design or by students' initiative, did not seem to reinforce the classroom learning experience. This finding supports the earlier argument by Harris et al. (2009) who argued for the importance of considering learning activity types (i.e. for pedagogical alignment) as part of planning for EdTech integration.

In fact, Mr Tan's efforts to integrate Fast ForWord appeared to be structural in nature, where he set aside a 35-minute lesson once a fortnight for students to work on Fast ForWord activities in the Computer Lab, where the same lesson in the alternate week was set aside for students to practice editing. This could potentially create a stronger association between Fast ForWord and editing practice rather than Fast ForWord and reading comprehension. As such, while Fast ForWord seemed to be consistently visible as part of students' classroom learning experience, it cannot be said to be integrated with classroom learning of reading comprehension skills.

Another aspect that Mr Tan and Ms Aliyah differed pertained to teacher readiness. Based on their interview responses, Mr Tan seemed to have spent a lot more time incubating ideas about Fast ForWord integration as well as onboarding prior to the start of the integration, compared to Ms Aliyah. While he also took quite a while (like Ms Aliyah) to decide on how he would integrate Fast ForWord with his selected instructional unit, he was able to share various ideas during our informal conversations and during his first interview. This is unlike Ms Aliyah who seemed to have no idea how to integrate Fast ForWord with her selected instructional unit, deduced from her avoidance to talk about integration during her first interview.

The various ideas that Mr Tan was exploring could potentially suggest that Mr Tan was more ready to integrate Fast ForWord than Ms Aliyah. However, when examined alongside considerations of pedagogical alignment and curriculum coherence, a different picture emerged. As mentioned in the paragraphs above, Mr Tan seemed to struggle with pedagogical alignment; he can be said to have achieved it at a structural and potentially superficial level, by allocating a 35-minute lesson every fortnight for students to work on Fast ForWord in school. Furthermore, while curriculum coherence may have been obvious to the teacher and the researcher, it was potentially not so clear or visible to students. Based on these two points, it can also be concluded that Mr Tan's readiness for such integration might be more theoretically than practically achieved.

In Ms Aliyah's case, while she was able to 'manufacture' and communicate curriculum coherence through instructional design and found pedagogical alignment leveraging group activity, her lack of concrete ideas on how to integrate Fast ForWord would also point to her lack of readiness to integrate the tool with classroom learning. As such, even though both teachers declined the researchers' offer to partner them in brainstorming ideas for integration, with reasons that they could manage once they had a chance to try Fast ForWord, collaboration with the researcher or with each other might have enriched teachers' ideation and their eventual efforts at integration.

The brief discussion above on curriculum coherence, pedagogical alignment and teacher readiness seems to also suggest an interaction effect among these factors, and that teacher readiness might be a specific area to focus on. This is because curriculum coherence and pedagogical alignment are dependent on teachers' technological, pedagogical and content knowledge (TPACK), which can be influenced through professional learning activities targeted at equipping teachers to design, enact and integrate learning with ALS (Celik, 2023).

Moving onto assessment integration, which refers to alignment between digital activities and assessment expectations, it can be said that there is little to no such integration in both cases presented. In Ms Aliyah's case, while Fast ForWord was assigned as pre-learning activity for an in-class group activity which was a practice, i.e., dry-run for a segment of their weighted assessment for the term, it was at least two steps removed from the actual assessment, and as such was unlikely to have an effect on students' learning. This is corroborated by the fact that many students did not complete the Fast ForWord pre-learning activity prior to the lesson, despite Ms Aliyah's instructions.

In Mr Tan's case, given that students were given time to do Fast ForWord in class and no linkages were made to the Reading Comprehension unit, students seemed to realise quite quickly that there were no stakes involved where Fast ForWord was concerned. This was deduced from the fact that many students were using Fast ForWord less frequently as the term progressed, and student interviewees admitted that they deprioritised learning with Fast ForWord due to other competing commitments such as homework, co-curricular activities and family engagements.

Given both teachers and students tended to focus on what gets tested (Wiliam, 2001) and students also tended to be deprioritised that which was not assessed, aligning Fast ForWord use with assessment expectations, i.e., achieving assessment integration, should be a key consideration when planning for integration with classroom learning. Furthermore, from the teachers' perspectives, their lack of oversight of students' learning progress on Fast ForWord also hampered their efforts to integrate tool as they have little to no influence over the learning activities that were assigned to students by Fast ForWord. Coupled with the fact that they were under time pressure to complete the unit and ensure students were ready for summative assessment within the stipulated time frame, they would inadvertently focus on covering the unit and helping students master that which would be tested.

Finally, in terms of school leadership and culture, it needs to be reiterated here that both Ubin Secondary School and Kusu Secondary School were selected because the school leadership and culture were supportive of using EdTech for teaching and learning and pedagogical innovations (see Section 3.2.1 for an explication of the criteria used for participant recruitment and selection). Coupled with this was the recent implementation of the National Digital Literacy Programme (NDLP) (see Section 1.2.1 for a brief description), where schools were transiting to a classroom learning environment characterised by every student owning a Personal Learning Devices (PLD), which could be tablet, Chromebook or laptop, to support personalised learning with EdTech, including AI tools, like ALS. Based on these observed contextual factors, it can be said that the school leadership and culture of both schools were favourable for ALS integration.

While findings from this research do not pinpoint the specific effects of a supportive school leadership and culture on ALS integration, prior research (e.g., Seow et al., 2020) suggests that the absence of this condition would likely have a negative effect, such as teachers and students abandoning the use of ALS for reasons of inconvenience or prioritising whatever to be formally assessed. With reference to empirical evidence relating school readiness and teacher readiness, where school leadership and culture is an aspect of school readiness, there appears to be an interaction effect between school leadership and culture and teacher readiness (Petko et al., 2018). In this instance, school leadership and culture is likely to be a mediator of teacher readiness, where the former is a necessary but insufficient condition for supporting pedagogical innovations and classroom change like ALS integration.

Overall, while the five key factors influencing ALS integration were present to varying degrees in both cases, the integration of Fast ForWord with classroom learning can be, at best, characterised as superficial, with Mr Tan from Ubin Secondary School achieving structural integration and Ms Aliyah from Kusu Secondary School achieving integration at the activity level. Challenges encountered by the teachers included lack of oversight of students' learning progress on Fast ForWord as well as the learning activities assigned by the tool, which somewhat impeded curriculum coherence. The teachers' lack of familiarity with ALS in general and their choice to work alone to achieve this integration may also contributed the gaps in teacher readiness.

Finally, given the descriptive nature of this research, no explicit measure was set for assessing the effectiveness of ALS integration (see Consoli et al. (2023) for a systematic review of possible measures for assessing EdTech integration). However, embedded within this research design is the expectation that such integration should improve student learning experiences and outcomes. These desired outcomes are likely to be achieved through curriculum coherence, pedagogical alignment, assessment integration, and teacher facilitation, which also explain why these are key factors influencing effective EdTech integration. This would mean that ALS integration should have an effect on the classroom learning experience, notably on classroom interactions such as teacher-student academic interactions.

6.2 ALS Integration and Classroom Interactions

Based on the findings reported in Chapter 5, both cases reflected fairly similar patterns of classroom interactions despite the two teachers' rather distinct approaches toward ALS integration. Both teachers were observed to favour teacher-led discussion and individual activity over other academic activity types as avenues of engaging with students academically. Both teachers were also found to frequently use communicative acts from the [I] Invite elaboration or reasoning, [B] Build on ideas and [E] Express or invite ideas clusters of SEDA and rarely used communicative acts from the [C] Connect and [RD] Reflect on dialogue or activity clusters. Drawing from both cases, this section will now examine the extent to which ALS integration influenced the nature, focus, and timing of classroom interactions, focusing on teacher–student interactions.

Firstly, student interviewees did not speak about any of the ALS features such as dynamic task recommendations, immediate diagnostic feedback and individualised learning pace when interviewed (see Section 2.2.1 for a review of these features). Based on what students shared of their experience using Fast ForWord, they did not seem to think they received any feedback even though the system did assign them a score at the end of each activity and each move made by students would have been met by a system prompt indicating whether they made the right move or otherwise. Furthermore, almost none of the student interviewees accessed their learning dashboard; most also did not know that there was a learning dashboard which provided an overview of their reading skills development progress. As such it is likely that most students experienced Fast ForWord as a series of activities that they had to complete with little to no understanding of how it related to reading skills development or to the reading comprehension skills that they were learning in class.

Secondly, while the tool offered dynamic task recommendations, students did not seem to notice this feature, which is understandable, given that for each module, students were assigned three out of the four activities each login. And as such, when interacting with their peers, they would likely notice similarities more easily than differences. This would also probably explain why they did not seem to feel that Fast ForWord offered them an individualised learning experience, which may have also potentially contributed to these students' declining use of Fast ForWord. Even though these student interviewees' experiences of the tool differed from what their teacher shared during onboarding, none of the students sought clarification from their teacher about this, which seemed to suggest a lack of investment on these students' part to integrate Fast ForWord with their own learning.

Overall, students' experience of the ALS features seemed to deviate from the individualised learning experience envisaged by their teacher to support personalisation of learning. When asked about their experience using Fast ForWord, student interviewees typically talked about the activities they were assigned, e.g., "the weep and woop activity" (which referred to Sono Lab) and the high volume of questions they needed to complete for each activity. Even when prompted, none could talk specifically about what they have learnt, and most felt that the Fast ForWord activities were not related to what they were learning in class. This is likely why almost all student interviewees did not feel that working on these activities helped them to speak up more in class.

Based on both students' and teachers' recounts, students' ALS use did not seem to be contributing to classroom interactions, which would be logical given the low usage observed among both students and teachers in the two cases. Instead, classroom interactions tended to remain anchored in conventional curricular tasks and teacher-led objectives, with the ALS operating in the background as an individualised practice tool rather than as a focal point for collective sense-making. This corroborates prior research which found that EdTech meaningful influences interaction only when they are discursively taken up as shared objects of teaching and learning (Mercer & Howe, 2012). This then raises the question as to what may be influencing the nature and focus of classroom interactions during ALS integration.

From the excerpts presented in Chapter 5, teacher-student interactions in both classrooms tended to be focused on advancing the learning task and learning goal, rather than on reflective discussion of learning processes, particularly those mediated by the ALS. While this could signal an emphasis on learning progress and achievement, it does not necessarily translate into evidence-based practice. For example, even though ALS dashboards provided both teachers and students with diagnostic insights, these data rarely became explicit resources for classroom dialogue. This might be due to teachers and students not referring to these dashboards, or that system outputs captured by these dashboards were interpreted privately by teachers and students rather than publicly negotiated in the classroom.

Such patterns resonate with earlier findings that teachers' use of learning analytics tended to be limited to the purposes of monitoring and triage, and that they often struggle to translate granular data into interactionally meaningful explanations or discussions that support students' metacognitive understanding (Simon & Zeng, 2024). From a socio-cultural perspective, this absence of interactional reference to ALS and ALS learning data limits students' opportunities to appropriate the language, goals, and evaluative criteria embedded in such systems, potentially constraining transfer and self-regulation (Mercer & Howe, 2012).

Taken together, the findings suggest that integrating ALS without deliberate pedagogical framing may inadvertently reinforce a separation between 'system learning' and 'classroom learning', echoing prior studies that caution against treating adaptive tools as supplementary rather than integrative components of instruction (Pelánek, 2025; Selwyn, 2019). They also underscore that the impact of ALS on classroom interactions is not determined by technical affordances alone but by whether teachers actively position the system as an object of shared inquiry, explanation, and dialogue. Without such interactional work, adaptive learning risks remaining an individualised, opaque activity, limiting its capacity to enrich classroom learning in relational and dialogic terms. This thus calls for further research on ALS integration and classroom interactions, particularly on the impact of ALS on teacher-student academic interactions and if this impact contributes to students' learning attainment.

Bridging the discussion on ALS and classroom interactions with a focused examination of ALS onboarding foregrounds the importance of early pedagogical framing in shaping how such systems are taken up interactionally over time. Findings from this research indicate that ALS integration does not automatically translate into their visibility or uptake within classroom discourse; rather, ALS use often remains individualised and interactionally peripheral unless teachers explicitly position ALS as shared objects of learning and sense-making. This observation resonates with sociocultural and classroom research demonstrating that technologies influence learning primarily through the ways they are introduced, talked about, and embedded in interactional routines (Mercer & Howe, 2012; Sybing, 2021). From this perspective, onboarding constitutes a critical interactional juncture at which expectations, norms, and meanings surrounding ALS use are established.

6.3 Effectiveness of ALS Onboarding

Research on EdTech adoption suggests that initial encounters with digital tools strongly shape learners' perceptions, engagement, and subsequent patterns of use (Davis et al., 1989; Selwyn, 2019). As such, this transition from examining classroom interactions to analysing onboarding reflects a conceptual shift from enacted practice to its formative conditions, i.e., the groundwork laid for integration. By attending to onboarding as an interactional and pedagogical practice in its own right, this section extends the discussion by exploring how early instructional choices and communicative framing may enable—or constrain—the longer-term interactional integration of ALS within classroom learning.

In the context of ALS, onboarding is not merely a technical orientation but a pedagogical process through which teachers articulate the purpose of ALS use, legitimise its role in relation to classroom learning, and model how students should interpret and respond to adaptive feedback (Simon & Zeng, 2024). Where onboarding foregrounds procedural compliance or system navigation alone, students may come to regard ALS as a peripheral or instrumental requirement rather than as an integral component of learning, limiting its later incorporation into classroom interactions. Conversely, onboarding that explicitly connects ALS activities to curricular goals, learning strategies, and classroom discourse can support more coherent integration and facilitate teachers' later efforts to reference system use in interaction.

In the case of Ubin Secondary School, Mr Tan did explicate the purpose of ALS, which was to help students improve their reading skills; however, his intent to integrate such system use with classroom learning of reading comprehension skills was not mentioned during this onboarding phase. This could have created an impression that this ALS use was unrelated to their classroom learning. In the case of Kusu Secondary School, Ms Aliyah focused more on the logistics of accessing the ALS, such as the distribution of login credentials and loan of headsets to students. When introducing the tool, her emphasis was on the Reading Progress Indicator (RPI), a diagnostic assessment and students' first assignment upon their initial login, and how they should approach the RPI. Based on these findings, it can be said that Mr Tan's onboarding efforts were oriented toward pedagogy while Ms Aliyah's efforts appeared to be focused on procedural matters.

In both cases, the teachers did not explicate how learning with ALS would relate to classroom learning during their respective onboarding lessons, though they may have mentioned the link in passing during other lessons that were not observed as part of this research. This lack of explication could potentially result in students coming to view ALS as peripheral rather than integral to learning, which can be inferred from the low student usage of the ALS in both cases. It is also worth noting here that the selected ALS, Fast ForWord was developed primarily for the US context and as such there was also no explicit link made within the system to the local curriculum or learning context. This would further cement any initial impression that what students were learning with the ALS was unrelated to what they were learning in class.

From the above, it becomes clear that when onboarding students to ALS, it is important to clarify how learning with such tools relate to classroom learning, in addition to making broader connections between ALS activities and curricular goals. This is because, according to the student interviewees, students tended to prioritise things that count toward summative assessment or monitored by their teacher, e.g., homework that needed to be submitted for teacher grading.

Furthermore, with reference to first-order and second-order barriers to EdTech adoption and integration that needs to be addressed during onboarding (Ertmer, 1999), it can be said that given Singapore's long history of EdTech implementation starting with its first EdTech Masterplan in 1997 (see Section 1.2 for more details), first-order barriers such as resources, infrastructure and policy had already been largely addressed at a systemic level by the country's Ministry of Education. Instead, both teachers were observed to be grappling with second-order barriers such as teacher beliefs and pedagogical practices, trying to sense-make how the selected ALS fit with what they believed good teaching was and how learning with ALS could complement their classroom teaching practice. The latter is particularly challenging, given that this is an emerging practice with little known precedent that teachers can reference. In the context of Singapore thus, further research on teacher factors and ALS integration, particularly ALS related pedagogy, would be necessary to inform future ALS integration, particularly the design and enactment of classroom learning that complements and optimises learning with ALS.

Till now, this discussion focused primarily on teachers' efforts to onboard students. When triangulating these efforts with students' perceptions of their experience, it would appear that both teachers were less than successful in communicating to their students the curriculum and pedagogical alignment of ALS use with classroom learning. This can be deduced from the partial and inaccurate recounts by student interviewees from both cases, which suggested either a lack of engagement during the onboarding lesson or a lack of 'stickiness' of the key messages that both teachers were trying to communicate. In fact, students' reactions seemed to also suggest that despite their teachers' best efforts, they did not really understand what or why they were learning with ALS, but nonetheless complied with their teachers' instructions, albeit partially, and their use was not sustained.

In retrospect, there could have been some form of interim check for students' onboarding, specifically for curriculum and pedagogical alignment, immediately after the onboarding lesson. This would allow the teachers to offer remediation should they find students to be uncertain about why they were learning with ALS or how to use ALS. Such interim check can be in the form of teacher intervention such as student reflection, ALS intervention such as diagnostic assessment or learner rating, or both. As such, this should be a consideration not only during onboarding, but even earlier, during ALS selection.

One implication arising from the onboarding findings pertained to teacher onboarding. The discussion above signalled that teacher onboarding is an area that needs further investigation and research, given its potential to impact ALS integration and classroom enactment along the lines of curriculum, pedagogy and assessment, and that it may also be a necessary condition for achieving effective ALS, and more broadly EdTech, integration. This is an aspect that deserves more attention as it is often unclear what teacher onboarding entailed and who should be responsible for it. In the context of this research, teacher onboarding was a negotiated process between the researcher and the participating teachers, in so far as the researcher offering to support both teachers in their exploration of the selected ALS and brainstorming on how to integrate ALS use with their pre-selected lesson unit. In both cases, teachers' choices determined how much onboarding activities they engaged in.

In the case of Mr Tan from Ubin Secondary School, he tried to familiarise himself with the selected ALS prior to the onboarding lesson for students. Based on what he shared during pre-research engagement, his explorations centred on discovering the learning content available on the ALS and how to illustrate the relevance of these content to classroom learning. In the case of Ms Aliyah from Kusu Secondary School, she also logged into the selected ALS prior to the onboarding lesson for students though her focus seemed to be on the Reading Progress Indicator (RPI). She shared during her first interview that the RPI had too many questions and she did not manage to complete. From these two illustrations, it would appear that both teachers did not seem to dwell much on ALS integration during their own onboarding. It also raises the question if more systemic onboarding efforts may be needed for teachers, as this could potentially enhance their onboarding efforts for students and subsequent integration with classroom learning.

Another onboarding consideration pertains to the tool itself. In the context of Fast ForWord, the selected ALS for this research, Ms Aliyah and some student interviewees from Kusu Secondary School feedbacked that the Reading Progress Indicator (RPI), a user's first encounter with the system, was cumbersome to complete. And as mentioned in the previous paragraph, Ms Aliyah herself did not manage to complete the RPI; this is despite her emphasising its importance during the onboarding lesson for her students. This may also partially explain why less students, compared to Ubin Secondary School, were using Fast ForWord. Furthermore, this also suggests the importance of first impressions, how a user's (including both teacher and student users) first experience of the tool can influence their subsequent engagement. In this light, ALS selection and onboarding can be said to be somewhat related and the ease at which users can be onboarded should thus be a consideration for ALS selection.

Overall, this research on ALS onboarding stands as an instance of technology onboarding in the education context. The two case studies illustrated an important lesson that can inform ALS onboarding and integration. Firstly, the discussion above alluded to the need to consider the relationship between onboarding and onboarded, where going through the onboarding process does not necessarily lead to the students being onboarded. Based on the teachers' and students' interviews, student factors such as learning attitudes, access to mobile devices such as tablets and prioritisation can also influence the extent to which students were receptive to ALS use and their actual use of such systems. Collectively, they are likely to determine the extent to which students are onboarded, i.e., the extent to which an EdTech tool will become a part of the students' learning routines.

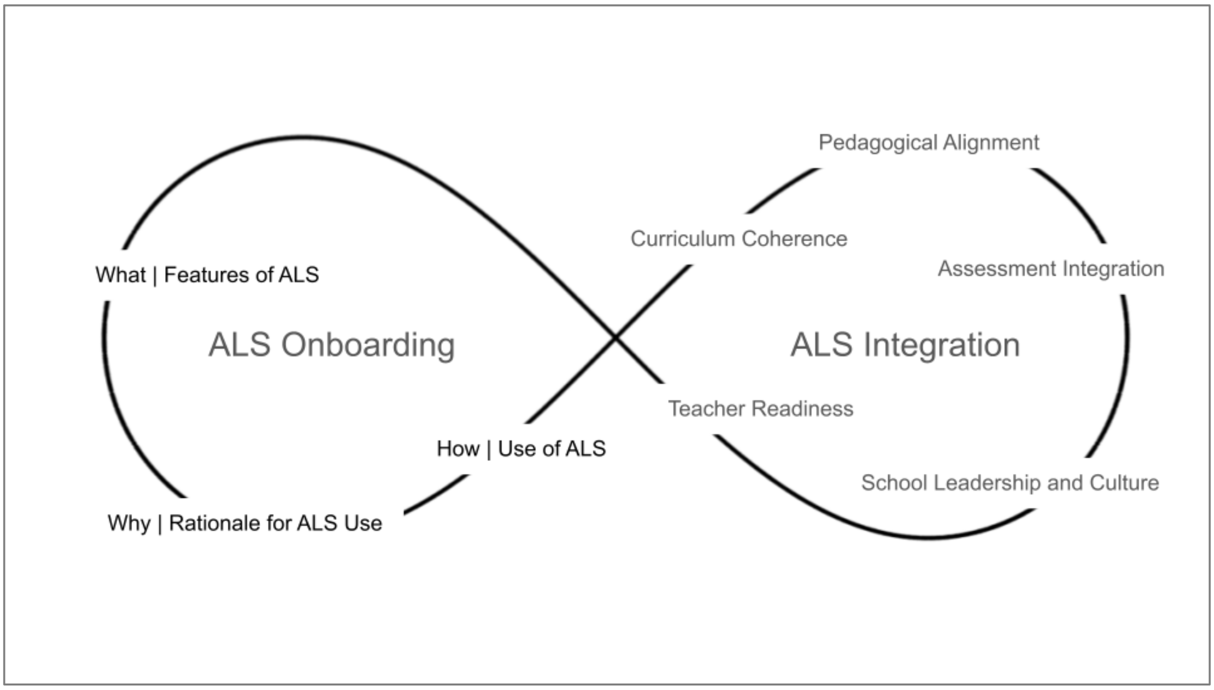
6.4 Creating Positive & Interconnected Activity Systems

Creating positive and interconnected activity systems is central to effective ALS onboarding and integration because such systems inevitably reshape teaching, learning, and organisational practices rather than merely adding a new technological layer. From a socio-cultural perspective, learning is understood as a socially mediated process in which tools, language, and interaction structure cognitive development (Vygotsky & Cole, 1978). ALS therefore function not simply as EdTech tools, but as mediating artifacts that influence how teachers and students engage with content, assessment, and one another.

Activity theory provides a complementary analytical lens by conceptualising ALS integration as a reconfiguration of interconnected activity systems involving subjects (teachers, students), tools (ALS, curricular resources), rules (assessment policies, accountability structures), communities (classrooms, schools, districts), and divisions of labour (roles of teachers, students, and administrators) oriented toward shared objects such as personalised learning or equitable access to instruction (Engeström, 2001). The theory also emphasises that misalignment, i.e., tension, among these elements — such as when ALS-generated pacing conflicts with mandated curricula or assessment practices — can produce contradictions that hinder adoption but also create opportunities for systemic learning and change.

Effective onboarding processes therefore should attend to these tensions proactively through shared sense-making, and iterative refinement of rules and routines. If effective integration entails a reconfiguration of interconnected activity systems, onboarding can be seen as enabling integration. For the purposes of this research, ALS onboarding and ALS integration were conceptualised as two discrete stages. However, findings from this study, such as the need for explicit articulation of the alignment between ALS activities and classroom learning and the need for checks on the extent to which students have been onboarded, suggest a need to reconceptualise ALS onboarding and ALS integration as a mutually reinforcing loop, as opposed to seeing them as two continuous but discrete phases (see Figure 6-1).

Figure 6-1 Reconceptualising ALS Onboarding and Integration as a Mutually Reinforcing Loop



This reconceptualisation of ALS onboarding and ALS integration brings a few implications. Firstly, it would suggest that onboarding activities, such as onboarding lessons by teachers, should already embody characteristics of effective integration such as curriculum coherence and pedagogical alignment. This would mean that onboarding lessons should not be experienced as separate from what was being taught in class, i.e., as a standalone lesson, but instead, be woven into the classroom learning agenda. For example, Ms Aliyah was teaching listening comprehension skills during the onboarding phase of this research. She could have designed the onboarding lesson to emphasise the development of listening skills afforded by the selected ALS. This would allow students to see the immediate relevance of learning with ALS and its connection to classroom learning.

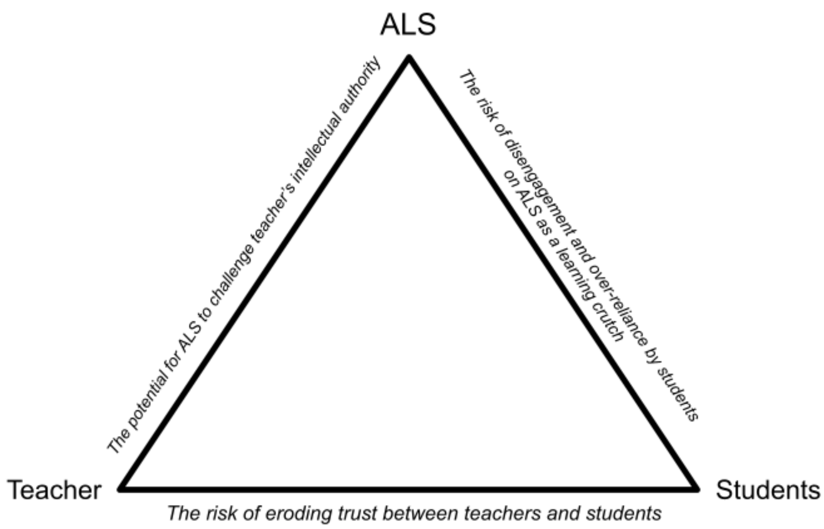
Secondly, this reconceptualisation also signals that onboarding needs to occur not only when an EdTech tool like ALS is being introduced or at the initial stages of EdTech use but throughout integration. This is evident from the finding that both teachers' and students' use of the ALS dipped over time, which is often due to a variety of reasons. This reveals that teachers and students can disengage with EdTech tools at any point in time, and need to be regularly 're-onboarded', such as by reiterating to students the rationale for using ALS or exploring various ways of incorporating ALS use as part of their learning routine.

It also means that, to ensure a positive mutually reinforcing loop, there needs to be mechanisms for regular checks on students' attitudes and use of ALS, following from research which underscores that tools shape not only cognition but also teachers' and students' sense of agency and belonging (Brod et al., 2023; Seifert & Bar-Tal, 2023). Empirical studies of educational technology integration also highlighted that ALS are most effective when embedded in collaborative professional practices, including peer learning communities and coaching structures that support teachers' appropriation of data and adaptive recommendations (Dede, 2014; Penuel et al., 2011). These evidence thus also indicate that ALS onboarding and integration needs to be designed and enacted with reference to both teacher and student competencies, such as data literacy and self-regulation.

Overall, grounding ALS onboarding and integration as mutually reinforcing loops within the sociocultural paradigm reframes them as systemic, relational processes that align tools, practices, and values, fostering sustainable and meaningful transformation in K–12 activity systems. With reference to Activity Theory, I will now dive into three key considerations impacting the activity systems within the ALS onboarding and integration loop. These considerations pertain to elements of the activity system, namely, ALS as the *Mediating Artefact*, *Rules*, and *Community*.

Firstly, ALS as the mediating artefact has already been shown, in the preceding paragraphs, to have a substantial impact on both teaching and learning, and as such, when considering the onboarding and integration of such platforms, three tensions arising from their presence and use needs to be addressed (see Figure 6-2). With reference to ALS affordances for teaching and learning (presented in Section 2.2), there is a risk of ALS undermining teachers as the intellectual authority in the classroom, such as when ALS-generated feedback is misaligned with feedback from the teacher or when teachers exhibit ignorance or inability to address the issues students faced when learning with ALS. Both scenarios are highly plausible when the systems selected were not designed with teacher mediation in mind. Furthermore, most of these commercial ALS were also not developed with the local context in mind and may not be aligned with local curriculum or pedagogical practices. This thus mean that when selecting which ALS to use, it is important to consider the extent to which teachers can not only monitor but also influence students' learning with ALS. This would potentially take the form of teacher features that would allow teachers to influence task recommendations, learning pathways and diagnostic feedback given by the ALS.

Figure 6-2 Tensions Arising from ALS Use on Teacher and Students



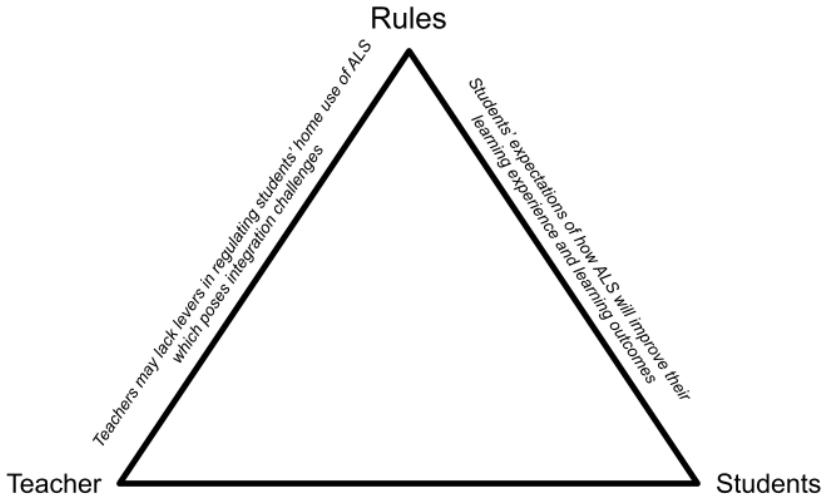
Another tension faced pertains to students' relationship with ALS. Research has shown cognitive over-reliance and disengagement (from the tool) to be two key risks associated with use of EdTech tools that can be detrimental to student learning and development (Ahmed & Abdullah, 2025; Fan et al., 2025). While the former was not observed in this study, the latter was evident from students' decreasing use of ALS over time, signalling that they were checking out of the system which in turn suggested that the system did not seem to be valued by the students as a learning resource and thus their disengagement. Whether it be over-reliance or disengagement, both need to be addressed as part of ALS onboarding and integration, to ensure that students put ALS use in its proper place, and establish a healthy relationship with the ALS as a learning aid rather than as a learning crutch or to dismiss ALS completely.

Another tension that needs to be considered pertains to how ALS can potentially mediate the teacher-student relationship, with eroding trust between the teacher and their students being a possible risk. This is related to the teacher-ALS relationship, whether it is complementary, i.e., alignment between teacher actions and ALS recommendations, or conflicting, where ALS recommendations are in contradiction with the teacher's actions. When receiving conflicting instruction or feedback from their teacher and the ALS, students would need to choose between trusting their teacher's guidance or the ALS recommendations. Helping students sense-make the two sources of input to their learning and engaging in metacognition are thus important considerations during ALS onboarding and integration.

At the heart of the three tensions presented above lies the importance of selecting an appropriate ALS, one that is aligned to with the school curriculum and the teacher's pedagogical practice, and is potentially engaging to the students. To make such an assessment, it is thus vital for teachers to have first-hand experience learning with the ALS and explore if the system features are in accordance with their expectations and fitting for the local context. Given the diversity within both the teacher and student community in each school, should there be plans to implement ALS at scale, the selection of which ALS to use should be carried out at the team or department level, rather than having the decision made by a single or a few individuals.

Moving onto the second consideration that has implications for the activity systems within the ALS onboarding and integration loop, I turn our attention to how teachers and students relate to *Rules* (e.g., accountability structures) when teaching and learning is mediated by ALS (see Figure 6-3). One such tension pertains to accountability structure, where teachers often lack levers in regulating students' home use of ALS. This is pertinent given that ALS integration can be in multiple forms, where these systems can be used in classrooms or at home, and used by students under the direction of their teacher or as part of self-regulated learning. In settings where ALS use is left to students' initiative, teachers may need to put in extra effort in monitoring students' use, particularly where the selected ALS does not provide usage-related notifications. This can potentially be an extra burden on teachers, as well as an opportunity to help students better manage their out-of-school, i.e., informal learning.

Figure 6-3 *Rules*-Related Tensions Arising from ALS Use on Teacher and Students



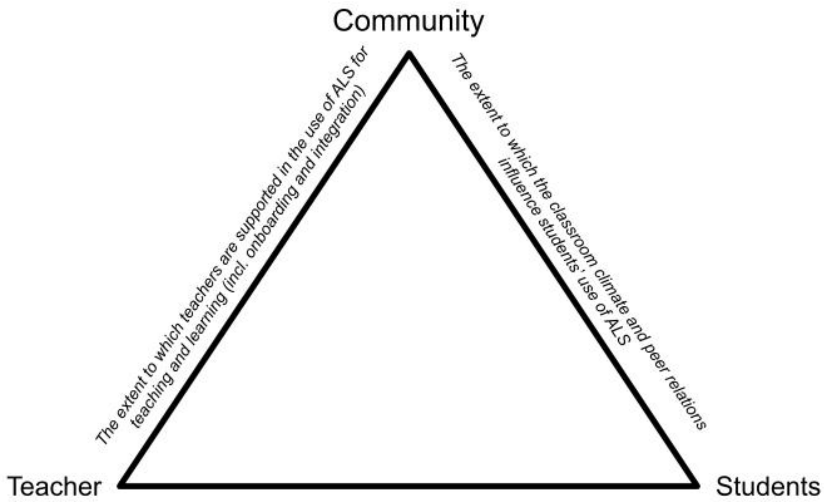
Another *Rules*-related tension pertains to expectations, specifically students' expectations of how the ALS can improve their learning experience and learning outcomes. Findings from this research found that students' expectations may differ from those of their teacher's, where students tended to value near-term improvement in academic performance while teachers tended to focus on long-term mastery. Underlying this tension is the need to address students' attitudes and beliefs about what learning with ALS entails and what constitutes good learning outcomes. Given that attitudes and beliefs take time to shift, influencing students in these aspects not only requires teacher effort in the design and enactment of ALS onboarding and integration, but also to sustain these efforts over time, as there would be other factors, such as peer pressure, influencing students' attitudes and beliefs about learning and ALS.

Collectively, the two highlighted *Rules*-related tensions signal that student mindset shift is part of the work teachers have to do as part of ALS onboarding and integration. They also emphasise the need for clear communication of expectations and regular monitoring of students' attitudes and beliefs about ALS use and learning. It should also be noted that teacher efforts in these areas need to take reference from students' actual use and experience of the ALS, as well as enable them to connect what they are learning with ALS with classroom learning.

Finally, the third consideration that has implications for the activity systems within the ALS onboarding and integration loop pertains to the influence of community on both teachers and students (see Figure 6-4). A *Community*-related tension arising from ALS use is the extent to which teachers are supported in ALS onboarding and integration. As mentioned in the preceding sections (see Section 2.3), school leadership and culture have been found to play an important part in ensuring effective integration (Seow et al., 2020). Furthermore, this research has also demonstrated that teachers struggling alone was not helpful in terms of ensuring effective ALS integration. Being part of a professional learning community could potentially be a way of supporting teachers in their onboarding and integration journey (J. Liu et al., 2024).

The above has implications for ALS onboarding and integration from the perspective of teachers, i.e., onboarding teachers and integration with teaching practice. Similar to student onboarding and integration for student learning, teacher onboarding and integration with teaching practice is an ongoing process through the period where the ALS is in use. Leveraging existing professional development platforms such as professional learning communities (PLCs) create a space for teachers to support each other in addressing emerging challenges and concerns as they occur, and also facilitate sharing of good practices and ideas for onboarding and integration.

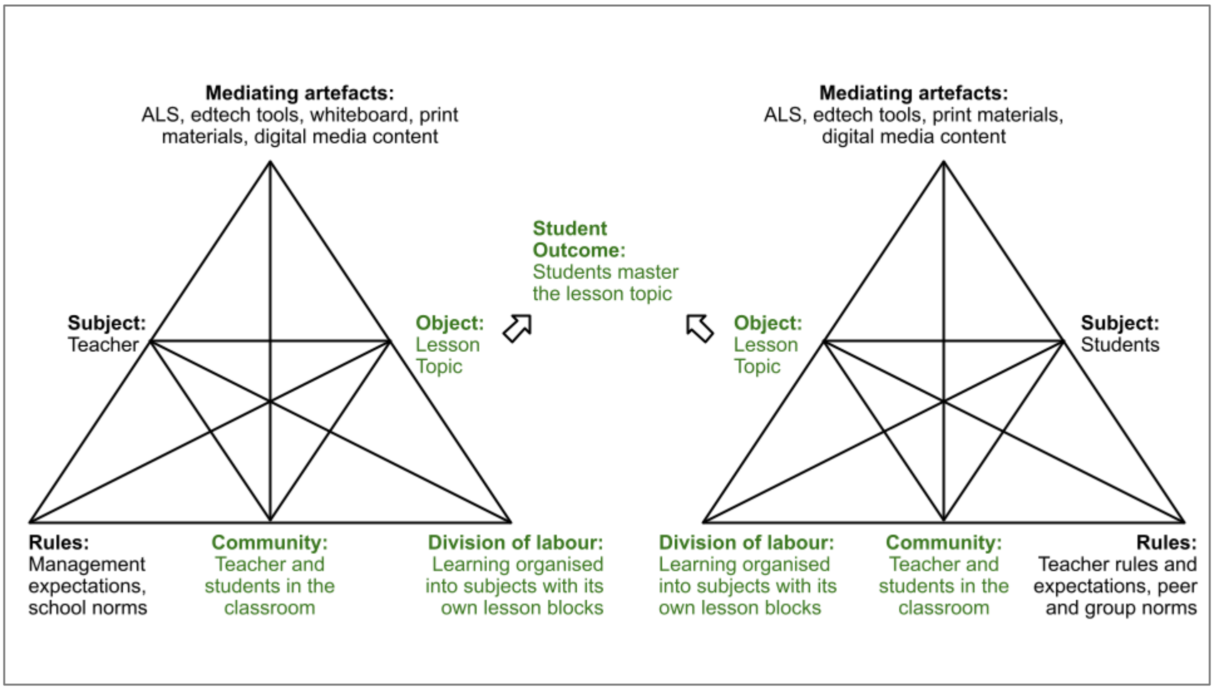
Figure 6-4 *Community*-Related Tensions Arising from ALS Use on Teacher and Students



The second *Community*-related tension arising from ALS use is the extent to which the classroom climate and peer relations influence students' use of ALS. This research has shown students would compare their ALS experience with each other and that their use of ALS seemed to eventually converge to a norm, suggesting peer influence on ALS use. This in turn signalled a need to facilitate and sustain a positive classroom climate supportive of ALS use, such as leveraging peer support to motivate students in their use of ALS. It also highlights the affective and social dimensions to ALS onboarding and integration that teachers should factor into consideration when designing and enacting ALS onboarding and integration. Finally, it should be noted that *Community* can be a double-edged sword, where students can 'gang up' and not use the ALS, particularly when ALS use is not aligned with the school curriculum, teacher pedagogy and assessment expectations. This also requires monitoring and mitigation by teachers.

Finally, in addition to reconceptualising ALS onboarding and ALS integration as a mutually reinforcing loop, the three considerations presented above also suggest a need to unify teaching and learning with a common goal, such as a pre-identified, desired student learning outcome, to bridge teaching and learning activities. Figure 6-5 highlights elements (in green text) in the teaching and learning activity systems that are shared by the teacher and their students and represent the common ground between teaching and learning that can be capitalised upon during ALS onboarding and integration.

Figure 6-5 Unified Teaching and Learning Activity Systems in the Classroom



6.5 Chapter Summary

In this chapter, I first discussed the approach to ALS integration adopted by the two teachers, with reference to key factors influencing EdTech integration, namely curriculum coherence, pedagogical alignment, assessment integration, teacher readiness, and school leadership and culture. Through this discussion, I illustrated how ALS integration in both cases were superficial, with Mr Tan from Ubin Secondary School achieving structural integration and Ms Aliyah from Kusu Secondary School achieving integration at the activity level. Possible reasons for this were also presented and discussed. Next, I examined the classroom interactions observed vis-à-vis ALS integration, highlighting the disconnect between classroom learning and thus teacher-student academic interactions during lessons, and learning with ALS. I attributed this disconnect to the under-utility of the ALS and deduced possible reasons for this, which pointed to the need for onboarding.

I then moved to discuss the teachers' approach to ALS onboarding before highlighting gaps in their efforts with reference to students' response and representation of their onboarding experience. Two considerations were emphasised here; namely the relationship between onboarding and onboarded and student factors such as learning attitudes, access to mobile devices such as tablets and prioritisation. Pulling it together, I applied Activity Theory to the discussion, proposing a reconceptualization of ALS onboarding and ALS integration as a mutually reinforcing loop. I then highlighted three key considerations and their accompanying tensions with reference to elements of the activity system, explicating why and how they could potentially be addressed before concluding with a final proposal to unify the teaching and learning activity systems in the classroom to strengthen common ground between teachers and their students.

7

Conclusion

Chapter Seven concludes the thesis by presenting some implications arising from this research for both policy and practice, which would include considerations for ALS design and design of classroom learning which features use of ALS. It explores possible teacher roles in the process of learning with ALS and the help students may need to optimise their use of ALS. It will also briefly discuss how ALS can be designed to encourage teacher-student interactions and how to bridge interactions in the physical classroom space with those in the digital space in ALS. This is followed by a brief discussion on the limitations of this research as well as suggested areas for future research.

7.1 Research Overview

This research explores the use of an ALS alongside classroom teaching and learning to support development of reading skills in two Singapore classrooms, focused on the onboarding and integration of such systems, and whether teacher-student interactions are influenced by their use. Adopting a case study approach, the research sought to surface benefits, challenges and complexities surrounding ALS onboarding and ALS integration, through the lens of activity theory. Using lesson video data, teacher and student interview data as well as student usage (of ALS) data, this research seeks to answer the following research questions:

1a. How does a teacher design and enact the ALS onboarding experience for students?

1b. How do students respond to the ALS onboarding experience and the selected ALS?
2a. What are the characteristics of the observed teacher-student academic interactions during classroom lessons during the period of ALS integration?

In terms of how the two teachers designed and enacted the ALS onboarding experience for students (RQ1a), both teachers chose to do so primarily through an onboarding lesson during the first week of the ALS subscription. However, this is where the similarity ends. Key differences between the two onboarding lessons include choice of lesson duration, lesson venue and device for students to access Fast ForWord. The two teachers also emphasised different aspects of the ALS during onboarding. While Mr Tan from Ubin Secondary School focused on the activities that students would be doing through the subscription period, Ms Aliyah from Kusu Secondary focused on the diagnostic assessment that students would be encountering upon first login. Interestingly, despite these differences, students' perceptions of the onboarding experience were quite similar,

In terms of students' response to the ALS onboarding experience and the selected ALS (RQ1b), students' articulations during their respective interviews tended to be vague and generic, suggesting unfamiliarity. This is supported by usage data which revealed that many students were not using the ALS or using it infrequently. Quite a few student interviewees from both schools avoided talking about the onboarding experience, which could be interpreted as ambivalence toward the experience or unwillingness to comment on their teachers. All these suggested that students were not quite onboarded and may not see the value of learning with ALS or how it is related to classroom learning.

In terms of the characteristics of the observed teacher-student academic interactions during classroom lessons for the period of ALS integration (RQ2), fairly similar patterns of classroom interactions were observed in both classrooms despite the two teachers' rather distinct approaches toward ALS integration. Both teachers were found to engage primarily in teacher-led discussion and individual activity and spend less time on other academic activity types as avenues of engaging with students academically. Furthermore, both frequently and rarely observed communicative acts in both classrooms, with reference to SEDA, were also found to be similar.

In terms of the relationship between ALS use and classroom interactions, ALS use was found to have little to no influence the nature, focus, and timing of classroom interactions, specifically teacher–student interactions. And this should not be surprising given that low usage of the ALS by students in both schools. Overall, this research revealed rather superficial integration of ALS with classroom learning and that students may not have been onboarded despite teachers' efforts to do so. These findings not only enrich current knowledge base on ALS onboarding and ALS integration (see Section 7.2 on Contributions) but also bring implications for both policy and practice (presented in the Section 7.3).

7.2 Contributions

This research intentionally foregrounds the lived experiences of teachers and students, offering nuanced insights into the social and pedagogical processes that shape ALS use in context. By examining how teachers introduced and framed the ALS, the study highlights onboarding as a critical, yet often under-theorised, phase of implementation that influences students' engagement, sense-making, and perceptions of value. This shifts attention from technical and logistical deployment towards the relational and instructional work required to support meaningful adoption.

The study further contributes by illuminating students' responses to onboarding and their subsequent patterns of ALS use. Students' perceptions of the system, including how they interpreted its purpose and feedback, provide important evidence that engagement with ALS is not merely a function of system design, but is deeply mediated by classroom norms, expectations, and assessment practices. These findings extend existing literature by demonstrating how students actively negotiate the role of ALS in their learning, rather than passively accepting it as a neutral instructional tool. In doing so, the study underscores the importance of student agency and sense-making in shaping EdTech-mediated learning experiences.

Another key contribution of this research lies in its examination of classroom interactions, particularly teacher–student interactions, in contexts where ALS is integrated with face-to-face instruction. The findings challenge assumptions that adaptive technologies inherently transform classroom dynamics, showing instead that teacher–student interactions and broader learning experiences often remain largely unchanged without deliberate pedagogical integration. This insight is significant for both researchers and practitioners, as it highlights the persistence of established instructional patterns and the limits of technology-driven change in the absence of supportive conditions.

Methodologically, the study contributes to the field by demonstrating the value of qualitative approaches in capturing the complexity of technology integration in authentic classroom settings. Through rich descriptions of onboarding practices, student experiences, and interactional patterns, the research offers a holistic perspective that complements large-scale, outcome-focused studies. Conceptually, it advances understanding of ALS integration as a socio-pedagogical process, shaped by teacher beliefs, classroom routines, and student interpretations. Together, these contributions provide a robust foundation for policy, and practice (see Section 7.3 on Implications), and emphasise that the educational impact of adaptive learning systems depends not only on technological sophistication, but also on how they are meaningfully embedded within the social fabric of classroom learning.

7.3 Implications for Policy and Practice

This section outlines key policy and practice implications arising from the findings of this study on the onboarding and integration of ALS with classroom learning. The results indicate that, despite the availability of ALS, classroom practices and learning experiences remained largely unchanged, primarily due to low system usage and the ensuing limited influence on classroom interactions. These findings highlight a persistent gap between technological provision and pedagogical integration. Rather than signalling a failure of adaptive technologies per se, the evidence points to systemic and contextual factors shaping how such tools are adopted and enacted in schools. The implications discussed below, therefore, focus on conditions necessary to support meaningful use of ALS, including ALS design, implementation fidelity, teacher mediation, and realistic expectations for technology-enabled change. Together, these implications aim to inform policymakers, school leaders, and practitioners seeking to move beyond symbolic adoption towards sustained, pedagogically grounded integration of ALS.

Firstly, low usage of the ALS presents two implications for consideration, for ALS design and ALS integration respectively. In terms of ALS design, this low usage is an indication that ALS designs can be further improved to increase educational value and thus utility by designing to amplify, rather than replace, teacher–student interactions. One key design consideration is the provision of interpretable, actionable feedback for teachers that supports in-the-moment instructional dialogue, such as prompts for questioning, grouping, or targeted scaffolding based on students' learning progress. When ALS data are presented in accessible, pedagogically meaningful ways, teachers are better positioned to use the system as a basis for formative conversations with students. Features such as shared dashboards, goal-setting tools, and reflective prompts can also help align digital learning traces with classroom discourse. This would support continuity between online and offline learning experiences, allowing teachers and students to reference ALS activities during face-to-face instruction. By designing ALS as a mediating tool for interaction rather than a standalone platform, systems can better support relational pedagogy and foster meaningful connections between digital learning processes and classroom practice.

In terms of ALS integration, it also suggests that adoption alone, i.e., use, is insufficient without strong implementation fidelity, i.e., integration with classroom learning. Policy should therefore move beyond procurement and outline structured implementation plans that align ALS use with curriculum goals, timetables, and assessment frameworks. Without explicit guidance on *when*, *how*, and *why* ALS should be used, teachers may perceive it as an optional or peripheral tool, resulting in minimal uptake. Practice-oriented policies could require schools to articulate integration strategies during onboarding activities, including alignment with lesson objectives. Clear accountability mechanisms such as implementation milestones or reporting requirements may help ensure consistent usage. From an organisational perspective, school leaders should actively monitor ALS integration and provide instructional leadership to embed it into everyday teaching routines. Such alignment helps normalise ALS use and increases the likelihood that it meaningfully contributes to classroom learning rather than remaining an underused add-on.

Secondly, the superficial integration of ALS with classroom learning observed in both cases suggests that effective ALS integration requires the deliberate design of classroom learning that clearly positions the system within pedagogical routines rather than as an isolated activity. This is centred on the role teachers play in mediating learning with ALS, acting not only as facilitators of system use but also as interpreters of learning data and designers of responsive instruction. This includes guiding students in setting learning goals, modelling productive engagement with ALS tasks, and using system feedback to inform targeted questioning, grouping, or follow-up activities. Such roles emphasise the importance of teacher presence in ensuring that learning with ALS remains socially and instructionally grounded. Furthermore, to optimise students' use of ALS, explicit support is also required. Students may need guidance in navigating the system, interpreting feedback, and developing self-regulated learning strategies such as persistence, reflection, and help-seeking. Without this support, learners may engage superficially or become disengaged, limiting the system's educational value. Consequently, classroom designs that integrate ALS should incorporate structured teacher-led scaffolding and opportunities for dialogue around digital learning experiences, ensuring that adaptive technologies meaningfully contribute to students' learning processes.

In addition, raising the stakes of ALS use through thoughtful assessment integration is another key practice implication. Low usage often reflects students' perceptions that ALS activities are peripheral to "real" classroom learning. Integrating ALS output into formative assessment practices, classroom discussions, or low-stakes summative tasks can signal their importance and legitimacy. Such integration should be pedagogically coherent, ensuring that ALS tasks align with curriculum objectives and assessment criteria, rather than functioning as disconnected digital exercises. Importantly, assessment integration should be used to support learning rather than intensify performance pressure, emphasising feedback, progress, and mastery over comparison or ranking. This approach can strengthen the perceived relevance of ALS while maintaining a supportive learning environment.

Another implication associated with superficial ALS integration could be lack support for teachers, who may need sustained, practice-focused professional development rather than one-off technical training. Aspects of support needed includes understanding how ALS insights can inform instructional decisions, differentiation, and formative assessment, as well as engaging and monitoring students' use of ALS. Professional learning could take the form of ongoing coaching, collaborative planning sessions, and opportunities to reflect on ALS-informed teaching practices. At the local level, schools should embed ALS training within broader pedagogical development rather than treating it as a standalone digital skill. Reframing professional development in this way acknowledges that technology integration is fundamentally a pedagogical challenge, not merely a technical one, and increases the likelihood of meaningful classroom impact.

Thirdly, in terms of ALS onboarding for students, an important implication for practice arising from this study pertains to shifting toward a more student-centred orientation. This is because, while teachers remain critical in shaping classroom learning, ALS onboarding needs to foreground students as active agents in making sense of, and deriving value from, their engagement with such systems. This requires a focus on meaning making, whereby students understand not only how to use ALS, but why it is relevant to their learning goals and progress. Explicit discussion of the purpose, affordances, and limitations of ALS can support students in interpreting feedback, reflecting on learning trajectories, and seeing the system as a tool for growth rather than a compliance task, thus encouraging meaningful and sustained use of such systems. This is also aligned to the reconceptualisation of ALS onboarding and ALS integration as a mutually reinforcing loop When students perceive clear educational value, engagement is more likely to be sustained and purposeful.

Developing a constructive relationship between students and ALS is also central to effective onboarding. Students require guidance in establishing healthy digital habits, including managing time on task, responding productively to automated feedback, and avoiding over-reliance on system cues at the expense of deeper thinking. Teachers play a crucial role in modelling reflective use of ALS, encouraging students to question feedback, seek clarification, and connect digital insights with classroom learning experiences. Embedding opportunities for reflection and dialogue about ALS use can help students develop metacognitive awareness and digital resilience. Such practices support balanced engagement, where ALS is viewed neither as an authoritative judge nor as a passive resource, but as a partner in learning that complements human instruction.

Overall, this research challenges assumptions that the presence and use of ALS will automatically transform teaching and learning. Policymakers may want to embrace more realistic expectations regarding the role of adaptive technologies, positioning them as supportive tools rather than transformative solutions. They can also consider emphasising incremental improvement and evidence-informed scaling rather than rapid, system-wide rollout. In practice, schools should critically evaluate whether ALS use aligns with identified instructional challenges and student needs, shifting away from technology-led reform towards pedagogy-led innovation. Such reframing helps prevent disillusionment among educators and ensures that success is measured in terms of meaningful learning outcomes rather than usage statistics. Finally, it should be noted at this juncture that the implications presented above would need to be considered vis-à-vis the limitations of this study (to be discussed in the next section) and for the readers to calibrate their reactions accordingly.

7.4 Limitations

This section critically reflects on the methodological limitations of this research, focused on the limitations arising from the choice of research design, ALS and qualitative approaches, to contextualise its findings and clarify the boundaries of interpretation. Starting with research design, the two conditions of central provision and local innovation initiated by school leader(s) or external researcher(s) meant that the initiator of the intervention was not the teacher. In both instances, it was thus not clear the extent to which both participating teachers embraced learning with ALS or saw ALS as a solution to an existing instructional challenge(s), or the extent to which these teachers had full agency over their instructional practice with ALS.

Both conditions, centrally provisioned and school- or researcher-initiated innovations, faced significant limitations arising from constrained teacher agency and limited buy-in. In centrally driven approaches, top-down mandates often result in weak teacher ownership, leading to compliance-oriented rather than pedagogically meaningful use, as teachers may perceive technologies as externally imposed and misaligned with classroom realities (Cuban, 2001; Selwyn, 2021). Conversely, school- or researcher-initiated innovations, while potentially more context-sensitive, were often limited by issues of scalability and sustainability, as they tended to rely on motivated individuals or short-term project funding (Coburn, 2003).

In the context of this research, superficial integration potentially arising from limited buy-in was evident from Mr Tan's structural integration and Ms Aliyah's activity integration of the ALS, both of which did not translate into sustained use of the tool among the students from both schools. Both teachers' struggles with designing learning experiences that integrated ALS with the selected lesson unit were further evidence that the teachers' use of ALS was not pedagogically meaningful. While teachers did not seem resistant to using ALS, Ms Aliyah's dissatisfaction with the tool that she chose and the misalignment that Mr Tan reported – that Elements 1 had little to do with what students were learning in class – seemed to signal that Fast ForWord was not aligned with the classroom realities, which in all likelihood contributed to the superficial integration reported.

This in turn could have also contributed to students' limited engagement and low utilisation of the ALS. First, students seemed unfamiliar with the affordances of the ALS beyond the exercises they had to complete. Most students' impression of the tool were the three exercises they were expected to complete for each login session. None of the student interviewees articulated or showed awareness of a learning dashboard tracking their mastery levels or make explicit and concrete links between learning with the ALS and classroom learning. Second, usage data revealed that students' use of the tool tended to be haphazard and it was unlikely that Fast ForWord was ever integrated into any student's learning routine. Utilisation of the tool started to dip after the third week of subscription, and most students had completely stopped accessing the tool by the end of the research period. This limited engagement and low utilisation by the students would have exacerbated the teachers' challenge faced of connecting learning with ALS and classroom learning and hampered the teachers' ability to design pedagogical and authentic learning experiences, resulting in a negative integration loop.

From the brief discussion above, it is evident that limited buy-in coupled with constrained teacher agency is a critical limitation for this research as it undermined both the validity of findings and the depth of pedagogical integration being studied. When teachers have limited control over the selection, adaptation, or implementation of technology, their use tended to be compliance-driven rather than intentional, resulting in superficial enactment of the intervention. This constrained the authenticity of classroom practice, which meant that what was observed in research settings may not reflect how technology would be meaningfully integrated under conditions of professional autonomy (Ertmer & Ottenbreit-Leftwich, 2010). This would in turn limit the transferability of the findings reported though they remained valuable as cases illustrating the initial resistance and challenges teachers and students were likely to face when attempting to integrate ALS use and classroom teaching and learning, especially when such use and integration were not initiated or driven by the teachers themselves.

Furthermore, teacher beliefs —widely recognised as a key determinant of technology use — may remain unengaged or even resistant, leading to discrepancies between the designed intervention and its enacted form (Ertmer et al., 2012). This weakened internal validity, as outcomes cannot be confidently attributed to the EdTech intervention itself but may instead reflect low teacher investment or misalignment with pedagogical goals. In addition, the absence of teacher buy-in often led to low sustainability beyond the research period, raising questions about the long-term relevance and impact of the study. In this light, insufficient teacher agency not only limited the effectiveness of EdTech integration but also compromised the robustness, applicability, and interpretability of classroom-based research such as this study.

Next, focusing on limitations arising from the choice of ALS for this research, a key limitation would be that the selected ALS was not localised and thus not aligned with the local curriculum, presenting challenges for integration with classroom learning. As mentioned in an earlier paragraph, Mr Tan brought to the researcher's attention that Elements 1 was focused on skills that were not covered in the Singapore English Language curriculum, which meant that no connection could be made between Elements 1 and the lesson unit on Reading Comprehension. Even though a Reading Comprehension module was then made available to students, not having progressed through Elements 1, Elements 2, Reading 1, Reading 2 and Reading 3 meant that students' experience of the ALS was adaptive within the module but may not be in, in the grand scheme of reading skills development.

Second, the selected ALS was not designed for teacher mediation, which meant that there was no mechanism for the teacher to feedback to the system or give input on how to dynamically adjust students' learning path on the ALS not only to be in accordance with their learning progression but also to be aligned with classroom learning goals. In fact, the teacher had a very limited role to play with their admin access, where they could only see individual student reports and had no visibility on the type of questions students were engaging with or a diagnosis of students' performance. There was also no aggregated report at the class level that could inform instructional design or inform the remediation of common learning struggles or errors that would benefit from in-class instruction. All these could be said to be hampering ALS integration with classroom learning, further contributing to the eventual superficial integration.

The third limitation arising from the choice of ALS pertained to student user experience. First, student interviewees did not seem to experience any adaptation or personalisation from the ALS. In fact, students reported the similarities noticed, i.e., every student had three exercises per login, and the types of exercises they were assigned to complete were largely the same. Second, some student interviewees reported that the repetitive nature of these exercises could be somewhat off-putting, and these students appeared to be rather disengaged with the ALS. These negative student experiences were not only an explanation for the low utilisation of the tool but also limited deeper integration with classroom learning.

Coupled with the teacher factors presented in the previous paragraph, these limitations collectively reduced the ecological validity of the reported findings and the scalability of the studied intervention, as the ALS did not function as a stable or contextually responsive intervention (Brown, 1992; Cobb et al., 2003). Consequently, the study risked producing findings that are difficult to generalise, interpret, or sustain in authentic educational settings. To mitigate these limitations, rich description of the case contexts, the selected ALS and the methods adopted were provided in this thesis for informed and contextualised interpretation of the reported findings.

The next set of limitations to be discussed pertained to those arising from the choice of qualitative approaches for this research. While qualitative approaches were intentionally selected to capture the complexity of classroom interactions and the nuanced interpretation of ALS onboarding and integration in classroom settings, such methods entail inherent constraints. Acknowledging these limitations is essential for transparent scholarship and for informing the design of future research. The discussion that follows first examines limitations arising from specific research methods adopted before moving to consider issues of transferability, researcher influence, temporal scope, and causal inference, typical of qualitative studies, highlighting how these factors shape the robustness, applicability, and explanatory power of the study's conclusions.

Firstly, classroom observations are susceptible to reactivity and observer effects, where teachers and students may alter their behaviour because they were being observed, potentially reducing the authenticity of the data collected (Cohen et al., 2011). This is particularly problematic in EdTech studies, where technology use may be temporarily intensified or performed for the observer, leading to inflated estimates of integration. Observations were also constrained by selectivity and subjectivity, as what was recorded depended on the researcher's focus, prior assumptions, and observational framework, raising concerns about reliability and potential bias (Angrosino, 2007). Furthermore, observations typically capture surface-level practices rather than underlying cognitive processes, intentions, or beliefs, limiting the depth of insight into why teachers and students use technology in particular ways.

Secondly, semi-structured interviews, while valuable for eliciting participants' perspectives, are subject to self-report bias, including social desirability effects, recall inaccuracies, and post hoc rationalisation, where participants reconstructed their practices in ways that may not accurately reflect actual behaviour (Kvale & Brinkmann, 2009). In EdTech contexts, teachers may overstate their pedagogical use of technology or align their responses with perceived expectations of the researcher or institution. Interviews could also be shaped by the co-constructed nature of meaning, meaning that responses depended on how questions were framed and how the interviewer probed, which could introduce variability and limit comparability across participants (Patton, 2015). Additionally, the relatively small and context-specific sample, typical of interview-based studies, would constrain generalisability, as findings would be embedded in particular institutional and cultural settings (Creswell & Poth, 2016).

Across both methods, a common limitation would be the challenge of triangulating enacted practice with reported beliefs and observed behaviour. Discrepancies between what teachers say (interviews) and what they do (observations) are well documented, and without complementary data sources (e.g., system logs, artefact analysis), it can be difficult to establish a coherent and valid account of EdTech integration (Denzin, 2017). As a result, while classroom observations and semi-structured interviews provided rich, contextualised data, their limitations necessitated careful design, reflexivity, and methodological triangulation to strengthen the robustness of research findings.

To mitigate these limitations arising from classroom observations and semi-structured interviews, students' usage data was included for analysis. This allowed for triangulation of student interviewees' articulations and their actions. However, teacher usage data was not available, as it was not logged by the system, and as such, the researcher could only rely on teacher self-reporting to ascertain their use of the ALS. In addition, classroom observation and semi-structured interview processes were carefully designed to minimise reactivity and self-reported bias. This included a prolonged lesson observation period of 4 weeks, a second coder for the video-recorded observations, repeated interviews guided by an interview protocol that used open-ended and non-leading questions as well as offering both students and teachers as much choice as possible when arranging for these interviews (See Chapter 3 for further elaboration on the data collection processes and how they pre-emptively address the anticipated limitations).

Turning our attention to limitations typical of qualitative studies of classroom research, the first to be addressed will be the issue of transferability. On the one hand, such studies frequently produce richly textured, context-specific accounts that illuminate local dynamics such as teacher routines, school culture, and student cohort characteristics (Bryman, 2016). On the other hand, this very contextual richness constrains transferability, where findings are bounded to a particular classroom, curriculum, or ALS, and may not generalise to other schools, year groups, or technologies. This is a critical limitation, particularly in K-12 educational contexts, because ALS vary in design and deployment, and classroom routines differ across jurisdictions; policymakers or practitioners may therefore misapply lessons beyond the original context. To mitigate this limitation, as mentioned earlier in this section, this study provides detailed contextual descriptions of the school and classroom settings, as well as participant characteristics. Such thick description enables readers to assess the relevance of the findings to their own contexts and supports carefully considered transfer rather than direct empirical extrapolation across K–12 educational settings.

Next, on the issue of researcher influence, the researcher's presence, bias and prior assumptions shape the data produced during classroom lesson observation and qualitative interviewing. Observer effects (e.g., teachers or students altering behaviour when observed) and selective attention (e.g., focusing on particular interactions or technologies used) can threaten the credibility of inferences made about how ALS were being integrated and how ALS integration influenced classroom interactions. To minimise the bias that may develop from observer effects and selective attention, three mitigation strategies were applied. They included prolonged lesson observation of four weeks and triangulation of classroom lesson data with teacher interview and student interview data. Even so, the risk of personal biases and context-insensitive observation instruments to skew findings, and power relations, including student age and institutional accountability) can further complicate authentic observation of routine classroom interactions (Luoto et al., 2023).

It should also be mentioned that, as part of mitigating researcher bias and prior assumptions, a second coder was also enlisted for the qualitative coding of the lesson videos recorded, and inter-rater checks were also conducted. However, agreement between the first and second coder was less than 50% before discussion (see Section 3.5.1), revealing the subjective nature of lesson observations and coding. After discussion, the agreement for data collected was 76% for Ubin Secondary and 64% for Kusu Secondary, which was an improvement and potentially reduced subjectivity in the interpretations derived from these lesson observations. Even though there were originally plans for another round of discussion and coding, real-world constraints such as the availability and commitment of the second coder prevented the third round of discussion and coding, which may potentially lead to higher agreement.

Third, on the issue of temporal scope, qualitative studies often capture interactions at discrete moments (e.g., a term, pilot phase, or single class), providing limited insight into how classroom practices and ALS use co-evolve. In this instance, this research offered a snapshot of an emergent practice of ALS onboarding and ALS integration, providing insights on initial teacher decisions and actions. However, it is not possible to glean from this research if the teachers' practice shifted over time as they become more fluent in the use and integration of ALS with classroom learning. As mentioned in Chapter 6, ALS integration involves iterative teacher adaptation, software updates, student familiarity, and policy shifts; a short-term qualitative snapshot can therefore misrepresent sustainability, scaling challenges, or eventual pedagogical affordances. In K–12 contexts, students' developmental trajectories and curriculum sequencing mean effects and interactions often emerge only longitudinally; hence short-term qualitative inquiry risks overlooking delayed or emergent outcomes and may draw premature conclusions about efficacy or integration. While it is not possible to mitigate this limitation in the current study, adopting a mixed-methods or longitudinal qualitative designs for subsequent research can help to address this gap.

Fourth, on the issue of causal inference, qualitative inquiry excels at explanative and process-level accounts, i.e., how teachers use ALS and what types of interactions occur. However, such inquiry generally lacks the experimental controls or large-scale sampling needed to attribute causal change in attainment to specific interactional patterns or algorithmic adaptations. This limitation is acute in the context of K-12 education because student attainment is influenced by myriad confounds including prior attainment, home background, class composition, and concurrent interventions. There is thus a risk of overstating the pedagogical impact of observed interactions with ALS unless qualitative findings are complemented by robust outcome measurement, quasi-experimental designs, or mixed-methods triangulation. This thus calls for a clear articulation of inference limits, where, in the context of this research, it is not possible to establish any causal or correlational link between student learning outcomes and ALS integration with classroom learning.

In summary, the limitations outlined in this section should not be understood as methodological weaknesses but rather as inherent considerations associated with the qualitative examination of complex educational phenomena. The context-bound nature of classroom interactions and ALS integration necessarily constrains transferability, requiring readers to exercise informed judgment when applying the findings to other K–12 settings.

Similarly, the interpretive role of the researcher and the potential influence of observation on participant behaviour underscore the importance of reflexivity and methodological transparency throughout the research process. While strategies such as prolonged engagement, triangulation, and systematic documentation were employed to enhance credibility, these measures cannot fully eliminate subjectivity in qualitative inquiry.

Furthermore, the temporal scope of the study limits the extent to which longer-term patterns of pedagogical change, system development, and student learning trajectories can be inferred. Adaptive learning technologies evolve dynamically through software updates, teacher appropriation, and shifting institutional priorities. Consequently, the findings reflect a particular phase of implementation rather than stable or universal practices. Finally, the study's qualitative design restricts its capacity to establish causal relationships between observed classroom interactions, the use of ALS, and measurable learning outcomes. Although the analysis offers rich insights into processes and meanings, claims regarding effectiveness must therefore remain cautious and inferential.

Taken together, these limitations delineate the epistemological and practical boundaries within which the study's contributions should be interpreted. By explicitly articulating these constraints, the thesis strengthens the validity of its conclusions and provides a foundation for future research. Subsequent studies may build on this work through longitudinal designs, mixed methods approach, or larger multi-site investigations that combine qualitative depth with broader evidential scope (see next section for suggestions on areas for further research). Such developments would not only address the limitations identified here but also advance a more comprehensive understanding of how adaptive learning systems interact with classroom practice in diverse K–12 educational contexts.

7.5 Suggested Areas for Further Research

Building on the limitations identified in the preceding section, this section now turns to directions for future research that can extend and strengthen understanding of ALS integration in K–12 classrooms. The methodological and contextual constraints discussed above reveal important gaps in current evidence, particularly in relation to teacher decision-making, student experience, and the relationship between classroom processes and learning outcomes. Rather than detracting from the contribution of this study, these limitations provide a productive foundation for identifying targeted research priorities. The following paragraphs propose five theoretically grounded and empirically feasible avenues for future investigation, designed to advance more robust, context-sensitive, and educationally meaningful research in this field.

First, in line with the proposed reconceptualisation of ALS onboarding and ALS integration as a mutually reinforcing loop, further understanding of teacher professional judgement and decision-making is a critical priority as teacher mediation strongly shapes classroom interactions and learning outcomes. One possible sub-area for further study would be how teachers interpret and act upon ALS-generated data as part of evidence-based practice, grounded in teacher cognition theory to illuminate how beliefs, professional knowledge, and contextual constraints influence instructional decisions in data-rich environments. It is also important to situate teachers' decisions within institutional norms, curriculum demands, and classroom relationships through a sociocultural lens for a situated understanding of teacher practice. This line of inquiry is foundational, as it determines whether ALS functions as supportive pedagogical tools or as prescriptive technologies that constrain professional agency.

Second, building upon current understanding that students' ability to self-regulate and their motivation for ALS use influence the extent to which they engage with such systems for self-directed learning. Further research could explore how ALS influence students' motivation, and self-regulated learning across different age groups. Qualitative studies focusing on pupil voice, supported by learning analytics or survey data, could examine how personalisation is experienced and perceived and whether it supports or constrains autonomy. In K–12 settings, developmental differences may shape how students interpret adaptive feedback and pacing. Understanding these experiences is critical for evaluating not only learning outcomes but also the broader educational implications of adaptive technologies for learner identity and engagement.

Third, another valuable area of study is the examination of how ALS use reshapes teacher-student interaction, student-student interaction, collaboration, and classroom discourse when students are actively using such systems. This follows from the finding that students' ALS use did not seem to be contributing to classroom interactions, given the low usage observed among both students and teachers in the two cases. Qualitative classroom studies could analyse whether personalised pathways encourage individualisation at the expense of collaboration, or whether teachers successfully integrate ALS into shared learning activities. In both cases, it would be illuminating to also explore whether and how ALS use by students would mediate classroom interactions and classroom discourse. In K–12 education, collaborative learning and dialogic teaching has been found to be central to social and cognitive development (Mercer & Howe, 2012; Sharma et al., 2024); understanding how ALS intersect with collaborative and dialogic pedagogy would inform more socially responsive implementation models.

Fourth, given the importance of curriculum coherence, pedagogical alignment and assessment integration on ALS integration, future research could investigate the degree of alignment between adaptive learning algorithms, national curriculum frameworks, and classroom assessment practices. Studies might examine how mismatches between system-driven progression and curricular sequencing affect teaching decisions and student learning trajectories. In K–12 contexts, where accountability and standardisation are prominent, misalignment may create pedagogical tensions and student confusion and potentially undermine teacher authority and/or discourage ALS use and integration. Research in this area would support more transparent, curriculum-responsive ALS design and inform school-level adoption decisions.

Fifth, an area that was not addressed through this research pertains to ALS use and student affective development. Further research could thus explore the emotional responses of students to ALS, including experiences of challenge, frustration, confidence, and feedback interpretation. Qualitative methods such as interviews, learning diaries, or experience sampling could be combined with usage and performance data to examine how affect influences engagement and persistence. In K–12 classrooms, emotional responses are closely tied to motivation and learning outcomes (Pekrun et al., 2002; Xie et al., 2025).

Understanding these dimensions would contribute to the design of ALS that support not only cognitive development but also ensure student wellbeing.

Overall, the future research directions outlined in this section point towards a more nuanced, theoretically informed, and methodologically robust research agenda for understanding ALS integration with classroom learning. By addressing the limitations of the present study through longitudinal, comparative, and mixed methods approaches, future work can deepen insight into the complex relationships between technology, pedagogy, classroom interaction, and student learning experiences and outcomes. Collectively, these avenues emphasise the central role of teachers and students in shaping the educational value of ALS, while foregrounding issues of coherence, and affect. Advancing this agenda will be essential for ensuring that adaptive learning technologies are developed, implemented, and evaluated in ways that are pedagogically grounded, and responsive to the realities of classroom practice.

7.6 Closing Remarks

This thesis set out to examine how adaptive learning systems (ALS) are onboarded and integrated within K–12 classroom contexts, with particular attention to teachers' practices, students' responses, and the nature of classroom interactions when digital and face-to-face learning are combined. Through a qualitative lens, the study revealed that the presence of ALS alone does not substantially alter classroom learning experiences. Instead, how the system is introduced, framed, and pedagogically embedded plays a decisive role in shaping students' engagement, perceptions, and use of the technology.

By foregrounding the perspectives and experiences of both teachers and students, this thesis contributes to a more nuanced understanding of adaptive learning technologies in practice. It challenges deterministic narratives that position ALS as inherently transformative and instead emphasises the central role of human mediation, meaning making, and relational pedagogy. The study also points to the need for more thoughtful onboarding processes, clearer integration with classroom practices, and greater attention to student agency and digital learning habits.

In conclusion, this research affirms that the educational value of ALS is not realised through adoption alone, but through deliberate, context-sensitive integration. As schools continue to invest in adaptive technologies, this research highlights the importance of aligning system design, pedagogical intent, and classroom practice to support meaningful and sustainable learning experiences.

References

Ahmed, M., & Abdullah, A. (2025). The Influence of Adaptive AI Learning Systems on Cognitive Load and Academic Persistence. *Review of Applied Management and Social Sciences*, *8*(2), 1057–1072. https://doi.org/10.47067/ramss.v8i2.537

Aishah, A. (2017). The challenges facing the integration of ICT in teaching in Saudi secondary schools. *International journal of education and development using information and communication technology*, *13*(1), 32–51.

Akintola, A., Akintayo, M., Kadri, T., Oforgu, C., Michael, M., & Nwanna, M. (2025). Adaptive AI systems in education: real-time personalised learning pathways for skill development. *J. Artif. Intell. Mach. Learn. Data Sci.*, *3*, 2489–2494.

AlAfnan, M. A. (2024). Taxonomy of Educational Objectives: Teaching, Learning, and Assessing in the Information and Artificial Intelligence Era. *Journal of Curriculum and Teaching*, *13*(4), 173–191.

Aleven, V., McLaughlin, E. A., Glenn, R. A., & Koedinger, K. R. (2017). Instruction Based on Adaptive Learning Technologies. In P. A. Alexander & R. E. Mayer (Eds.), *Handbook of Research on Learning and Instruction* (pp. 538–576). Routledge. https://doi.org/10.4324/9781315736419-33

Aleven, V., Roll, I., McLaren, B. M., & Koedinger, K. R. (2016). Help Helps, But Only So Much: Research on Help Seeking with Intelligent Tutoring Systems. *International journal of artificial intelligence in education*, *26*(1), 205–223. https://doi.org/10.1007/s40593-015-0089-1

Alhaif, A. M., Aleidi, A. I., Ali, D. A., Abdelfatah, H. M., Diab, H. M., & Ibrahem, U. M. (2025). The Future of Learning in the Age of Artificial Intelligence (AI) – The Effects of AI on an Environment of Teaching and Learning. *Libri (København)*, *75*(3), 235–251. https://doi.org/10.1515/libri-2024-0152

Allen, J. P., Pianta, R. C., Gregory, A., Mikami, A. Y., & Lun, J. (2011). An interaction-based approach to enhancing secondary school instruction and student achievement. *Science*, *333*(6045), 1034–1037. https://doi.org/10.1126/science.1207998

Amri, M., & Sert, O. (2022). Establishing understanding during student-initiated between-desk instructions in project work. *Cambridge journal of education*, *52*(6), 667–689. https://doi.org/10.1080/0305764X.2022.2047890

Angrosino, M. (2007). *Doing ethnographic and observational research*. Sage.

Ardasheva, Y., Howell, P. B., & Vidrio Magaña, M. (2016). Accessing the Classroom Discourse Community Through Accountable Talk: English Learners' Voices. *TESOL J*, *7*(3), 667–699. https://doi.org/10.1002/tesj.237

Azevedo, R., & Aleven, V. (2013). Metacognition and learning technologies: An overview of current interdisciplinary research. *International handbook of metacognition and learning technologies*, 1–16.

Azevedo, R., Bouchet, F., Duffy, M., Harley, J., Taub, M., Trevors, G., Cloude, E., Dever, D., Wiedbusch, M., Wortha, F., & Cerezo, R. (2022). Lessons Learned and Future Directions of MetaTutor: Leveraging Multichannel Data to Scaffold Self-Regulated Learning With an Intelligent Tutoring System. *Frontiers in psychology*, *13*, 813632. https://doi.org/10.3389/fpsyg.2022.813632

Bach, K. M., Hofer, S. I., & Bichler, S. (2025). Adaptive learning, instruction, and teaching in schools: Unraveling context, sources, implementation, and goals in a systematic review. *Learning and Individual Differences*. https://doi.org/10.1016/j.lindif.2025.102781

Baker, R. S., & Hawn, A. (2022). Algorithmic Bias in Education. *International journal of artificial intelligence in education*, *32*(4), 1052–1092. https://doi.org/10.1007/s40593-021-00285-9

Balen, R., Blyth, E., Calabretto, H., Fraser, C., Horrocks, C., & Manby, M. (2006). Involving Children in Health and Social Research: 'Human becomings' or 'active beings'? *Childhood (Copenhagen, Denmark)*, *13*(1), 29–48. https://doi.org/10.1177/0907568206059962

Bandura, A. (1971). *Social Learning Theory*. General Learning Press.

Barnes, D. (2008). Exploratory Talk for Learning. In N. Mercer & S. Hodgkinson (Eds.), *Exploratory Talk in School*. SAGE Publications Ltd.

Baxter, P., & Jack, S. (2008). Qualitative Case Study Methodology: Study Design and Implementation for Novice Researchers. *Qualitative report*, *13*(4), 544–559.

Beets, M. W., Flay, B. R., Vuchinich, S., Acock, A. C., Li, K.-K., & Allred, C. (2008). School Climate and Teachers' Beliefs and Attitudes Associated with Implementation of the Positive Action Program: A Diffusion of Innovations Model. *Prev Sci*, *9*(4), 264–275. https://doi.org/10.1007/s11121-008-0100-2

Belloula, S. (2025). Empowering Educators: Leveraging AI to Revolutionize Lesson Planning. *International Journal of Research in Education and Science*, *11*(2), 264–280.

Bennett, R. E. (2011). Formative assessment: a critical review. *Assessment in education : principles, policy & practice*, *18*(1), 5–25. https://doi.org/10.1080/0969594X.2010.513678

BERA. (2018). Ethical Guidelines for Educational Research. In (4th Edition ed.). London.

Bishop, J. P. (2021). Responsiveness and intellectual work: Features of mathematics classroom discourse related to student achievement. *Journal of the Learning Sciences*, *30*(3), 466–508. https://doi.org/10.1080/10508406.2021.1922413

Black, P., & Wiliam, D. (1998). Assessment and Classroom Learning. *Assessment in education : principles, policy & practice*, *5*(1), 7–74. https://doi.org/10.1080/0969595980050102

Black, P., & Wiliam, D. (2009). Developing the theory of formative assessment. *Educational assessment, evaluation and accountability*, *21*(1), 5–31. https://doi.org/10.1007/s11092-008-9068-5

Bloom, B. S. (1984). The 2 Sigma Problem: The Search for Methods of Group Instruction as Effective as One-to-One Tutoring. *Educational researcher*, *13*(6), 4–16. https://doi.org/10.3102/0013189X013006004

Bloome, D., Carter, S. P., Christian, B. M., Otto, S., & Shuart-Faris, N. (2005). *Discourse analysis & the study of classroom language & literacy events : a microethnographic perspective* (1st ed.). L. Erlbaum Associates.

Blundell, C., Lee, K. T., & Nykvist, S. (2020). Moving beyond enhancing pedagogies with digital technologies: Frames of reference, habits of mind and transformative learning. *Journal of Research on Technology in Education*, *52*(2), 178–196. https://doi.org/10.1080/15391523.2020.1726235

Boardman, A. G., Boelé, A. L., & Klingner, J. K. (2018). Strategy Instruction Shifts Teacher and Student Interactions During Text-Based Discussions. *Reading research quarterly*, *53*(2), 175–195. https://doi.org/10.1002/rrq.191

Boden, K. K., Zepeda, C. D., & Nokes-Malach, T. J. (2020). Achievement goals and conceptual learning: An examination of teacher talk. *Journal of Educational Psychology*, *112*(6), 1221–1242. https://doi.org/10.1037/edu0000421

Bonk, C. J. (2009). *The world is open [electronic resource] : how Web technology is revolutionizing education*. Jossey-Bass.

Børte, K., & Lillejord, S. (2024). Learning to teach: Aligning pedagogy and technology in a learning design tool. *Teaching and teacher education*, *148*, 104693. https://doi.org/10.1016/j.tate.2024.104693

Boyd, M. P. (2015). Relations Between Teacher Questioning and Student Talk in One Elementary ELL Classroom. *Journal of literacy research*, *47*(3), 370–404. https://doi.org/10.1177/1086296X16632451

Brod, G., Kucirkova, N., Shepherd, J., Jolles, D., & Molenaar, I. (2023). Agency in educational technology: Interdisciplinary perspectives and implications for learning design. *Educational Psychology Review*, *35*(1), 25.

Brown, A. L. (1992). Design Experiments: Theoretical and Methodological Challenges in Creating Complex Interventions in Classroom Settings. *The Journal of the learning sciences*, *2*(2), 141–178. https://doi.org/10.1207/s15327809jls0202_2

Brusilovsky, P. (2001). Adaptive Hypermedia. *User Modeling and User-Adapted Interaction*, *11*, 87–110.

Bryman, A. (2016). *Social research methods* (Fifth edition. ed.). Oxford University Press.

Cadima, J., Leal, T., & Burchinal, M. (2010). The quality of teacher-student interactions: Associations with first graders' academic and behavioral outcomes. *Journal of School Psychology*, *48*(6), 457–482. https://doi.org/10.1016/j.jsp.2010.09.001

Carnegie Learning. (n.d.). *Fast ForWord (K-12)*. Retrieved 17 November from https://www.carnegielearning.com/solutions/literacy-ela/fast-forword/

Cazden, C., Cope, B., Kalantzis, M., Luke, A., Luke, C., & Nakata, M. (1996). A pedagogy of multiliteracies : Designing social futures. *Harvard educational review*, *66*(1), 60–92.

Cazden, C. B. (2001). *Classroom discourse : the language of teaching and learning*. Heinemann.

Celik, I. (2023). Towards Intelligent-TPACK: An empirical study on teachers' professional knowledge to ethically integrate artificial intelligence (AI)-based tools into education. *Computers in human behavior*, *138*, 107468. https://doi.org/10.1016/j.chb.2022.107468

Chen, G., Zhang, J., Chan, C. K. K., Michaels, S., Resnick, L. B., & Huang, X. (2020). The link between student - perceived teacher talk and student enjoyment, anxiety and discursive engagement in the classroom. *British educational research journal*, *46*(3), 631–652. https://doi.org/10.1002/berj.3600

Cheng, K.-H., & Tsai, C.-C. (2019). A case study of immersive virtual field trips in an elementary classroom: Students' learning experience and teacher-student interaction behaviors. *Computers and Education*, *140*, 103600. https://doi.org/10.1016/j.compedu.2019.103600

Cheng, K.-m. (2020). *Facing the pandemic: Learning at centre stage – observations towards a new normal*.

Chillakuri, B. (2020). Understanding Generation Z expectations for effective onboarding. In *Understanding Generation Z expectations for effective onboarding*: Emerald Group Publishing Limited.

Chiu, T. K. F., Moorhouse, B. L., Chai, C. S., & Ismailov, M. (2024). Teacher support and student motivation to learn with Artificial Intelligence (AI) based chatbot. *Interactive Learning Environments*, *32*(7), 3240–3256. https://doi.org/10.1080/10494820.2023.2172044

Christie, F. (2002). *Classroom discourse analysis : a functional perspective* (1st ed.). continuum.

Clark, R. E. (1994). Media Will Never Influence Learning. *Educational Technology Research and Development*, *42*(2), 21–29. https://doi.org/10.1007/bf02299088

Cobb, P., Confrey, J., diSessa, A., Lehrer, R., & Schauble, L. (2003). Design Experiments in Educational Research. *Educational researcher*, *32*(1), 9–13. https://doi.org/10.3102/0013189X032001009

Coburn, C. E. (2003). Rethinking Scale: Moving beyond Numbers to Deep and Lasting Change. *Educational researcher*, *32*(6), 3–12. https://doi.org/10.3102/0013189X032006003

Cohen, L., Manion, L., & Morrison, K. (2011). *Research methods in education* (7th Edition ed.). routledge.

Colley, C. J. (2018). *Responsive Teaching and Responsive Coaching: Opportunities to Advance Practice and Foster Student Sensemaking* ProQuest Dissertations Publishing].

Collins, A., & White, B. Y. (2015). How Technology Is Broadening the Nature of Learning Dialogues. In C. Asterhan, L. Resnick, & S. Clarke (Eds.), *Socializing intelligence through academic talk and dialogue* (pp. 231–240). American Educational Research Association.

Conati, C., & Kardan, S. (2013). Student Modeling: Supporting Personalized Instruction, from Problem Solving to Exploratory Open - Ended Activities. *AI Magazine*, *34*(3), 13–26. https://doi.org/10.1609/aimag.v34i3.2483

Consoli, T., Désiron, J., & Cattaneo, A. (2023). What is “technology integration” and how is it measured in K-12 education? A systematic review of survey instruments from 2010 to 2021. *Computers and Education*, *197*, 104742. https://doi.org/10.1016/j.compedu.2023.104742

Creswell, J. W., & Miller, D. L. (2000). Determining Validity in Qualitative Inquiry. *Theory Into Practice*, *39*(3), 124–130. https://doi.org/10.1207/s15430421tip3903_2

Creswell, J. W., & Poth, C. N. (2016). *Qualitative inquiry and research design: Choosing among five approaches*. Sage publications.

Crompton, H., Jones, M. V., & Burke, D. (2022). Affordances and challenges of artificial intelligence in K-12 education: a systematic review. *Journal of Research on Technology in Education*, 1–21. https://doi.org/10.1080/15391523.2022.2121344

Cuban, L. (2001). *Oversold and underused : computers in the classroom* (1st ed.). Harvard University Press. https://doi.org/10.4159/9780674030107

Cuban, L. (2013). *Inside the black box of classroom practice: Change without reform in American education*. Harvard Education Press.

Cuban, L., Kirkpatrick, H., & Peck, C. (2001). High Access and Low Use of Technologies in High School Classrooms: Explaining an Apparent Paradox. *American educational research journal*, *38*(4), 813–834. https://doi.org/10.3102/00028312038004813

Cui, W., Xue, Z., & Thai, K.-P. (2019). Performance comparison of an AI-based Adaptive Learning System in China.

Curriculum Planning and Development Division. (2020). *English Language Syllabus Secondary E/N(A) Course*. Singapore: Ministry of Education

Davila, N., & Pina-Ramirez, W. (2023). *Effective onboarding* (1st edition ed.). Association for Talent Development.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User Acceptance of Computer Technology: A Comparison of Two Theoretical Models. *Management science*, *35*(8), 982–1003. https://doi.org/10.1287/mnsc.35.8.982

Deci, E. L., & Ryan, R. M. (1985). The general causality orientations scale: Self-determination in personality. *Journal of research in personality*, *19*(2), 109–134. https://doi.org/10.1016/0092-6566(85)90023-6

Deckker, D., Sumanasekara, S., & Fakhrou, A. (2025). AI-Powered Personalised Learning: Promise and Pitfalls.

Dede, C. (2014). *The Role of Digital Technologies in Deeper Learning. Students at the Center: Deeper Learning Research Series*.

Denessen, E., Keller, A., Bergh, L. v. d., & Broek, P. v. d. (2020). Do Teachers Treat Their Students Differently? An Observational Study on Teacher-Student Interactions as a Function of Teacher Expectations and Student Achievement. *Education Research International*. https://doi.org/10.1155/2020/2471956

Deng, Z., & Gopinathan, S. (2016). PISA and high-performing education systems: explaining Singapore's education success. *Comparative education*, *52*(4), 449–472. https://doi.org/10.1080/03050068.2016.1219535

Denzin, N. K. (2017). *The research act: A theoretical introduction to sociological methods*. Routledge.

Derry, S. J., Pea, R. D., Barron, B., Engle, R. A., Erickson, F., Goldman, R., Hall, R., Koschmann, T., Lemke, J. L., Sherin, M. G., & Sherin, B. L. (2010). Conducting Video Research in the Learning Sciences: Guidance on Selection, Analysis, Technology, and Ethics. *The Journal of the learning sciences*, *19*(1), 3–53. https://doi.org/10.1080/10508400903452884

Desimone, L. M. (2009). Improving Impact Studies of Teachers' Professional Development: Toward Better Conceptualizations and Measures. *Educational researcher*, *38*(3), 181–199. https://doi.org/10.3102/0013189X08331140

Dever, D. A., Sonnenfeld, N. A., Wiedbusch, M. D., Schmorrow, S. G., Amon, M. J., & Azevedo, R. (2023). A complex systems approach to analyzing pedagogical agents' scaffolding of self-regulated learning within an intelligent tutoring system. *Metacognition and learning*, *18*(3), 659–691. https://doi.org/10.1007/s11409-023-09346-x

Dexter, S. (2011). School Technology Leadership: Artifacts in Systems of Practice. *Journal of school leadership*, *21*(2), 166–189. https://doi.org/10.1177/105268461102100202

Dexter, S., & Barton, E. A. (2021). The development and impact of team-based school technology leadership. *Journal of educational administration*, *59*(3), 367–384. https://doi.org/10.1108/JEA-12-2020-0260

Dexter, S., & Richardson, J. W. (2020). What does technology integration research tell us about the leadership of technology? *Journal of Research on Technology in Education*, *52*(1), 17–36. https://doi.org/10.1080/15391523.2019.1668316

Dieterle, E., Dede, C., & Walker, M. (2024). The cyclical ethical effects of using artificial intelligence in education. *AI Soc*, *39*(2), 633–643. https://doi.org/10.1007/s00146-022-01497-w

Divanji, R. A., Bindman, S., Hoffman, M., & Casteneda, L. (2025, 2025). The Impacts of Adaptive Learning Technologies on K-12 Teachers' Sense of Autonomy, Competence, and Relatedness with Their Students. Proceedings of the 24th Interaction Design and Children, New York, NY, USA.

Donevska-Todorova, A., Dziergwa, K., & Simbeck, K. (2022). Individualizing Learning Pathways with Adaptive Learning Strategies: Design, Implementation and Scale. CSEDU (2),

Dong, L., Seah, W. T., Cao, Y., & Clarke, D. (2019). Student talk in large-size mathematics classrooms: a case study of a sequence of ten consecutive lessons in China. *Asia Pacific education review*, *20*(3), 449–466. https://doi.org/10.1007/s12564-019-09577-1

Durlach, P. J., & Ray, J. M. (2011). *Designing Adaptive Instructional Environments: Insights from Empirical Evidence* (7035454225).

Dziuban, C., Moskal, P., Johnson, C., & Evans, D. (2017). *Current Issues in Emerging eLearning Adaptive Learning: A Tale of Two Contexts* (Current Issues in Emerging eLearning, Issue. https://scholarworks.umb.edu/cieeAvailableat:https://scholarworks.umb.edu/ciee/vol4/iss1/3

Dziuban, C. D., Moskal, P. D., Cassisi, J., & Fawcett, A. (2016). Adaptive Learning in Psychology: Wayfinding in the Digital Age Background on Adaptiveness as a Learning Principle. *Online Learning*, *20*(3), 74–96.

Ellis, C. (2007). Telling Secrets, Revealing Lives: Relational Ethics in Research With Intimate Others. *Qualitative inquiry*, *13*(1), 3–29. https://doi.org/10.1177/1077800406294947

Elo, S., & Kyngäs, H. (2008). The qualitative content analysis process. *Journal of advanced nursing*, *62*(1), 107–115. https://doi.org/10.1111/j.1365-2648.2007.04569.x

Engeström, Y. (1993). Developmental studies of work as a testbench of activity theory: The case of primary care medical practice. In J. Lave & S. Chaiklin (Eds.), *Understanding Practice: Perspectives on Activity and Context* (pp. 64–103). Cambridge University Press. https://doi.org/DOI: 10.1017/CBO9780511625510.004

Engeström, Y. (2001). Expansive Learning at Work: Toward an activity theoretical reconceptualization. *Journal of education and work*, *14*(1), 133–156. https://doi.org/10.1080/13639080020028747

Engeström, Y., Miettinen, R., & Punamäki-Gitai, R.-L. (1999). *Perspectives on activity theory*. Cambridge University Press.

Ennouamani, S., & Mahani, Z. (2017). An overview of adaptive e-learning systems. 8th IEEE International Conference on Intelligent Computing and Information Systems (ICICIS 2017),

Ertmer, P. A. (1999). Addressing First- and Second-Order Barriers to Change: Strategies for Technology Integration. *Educational Technology Research and Development*, *47*(4), 47–61. https://doi.org/10.1007/bf02299597

Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher Technology Change: How Knowledge, Confidence, Beliefs, and Culture Intersect. *Journal of Research on Technology in Education*, *42*(3), 255–284. https://doi.org/10.1080/15391523.2010.10782551

Ertmer, P. A., Ottenbreit-Leftwich, A. T., Sadik, O., Sendurur, E., & Sendurur, P. (2012). Teacher beliefs and technology integration practices: A critical relationship. *Computers & Education*, *59*(2), 423–435. https://doi.org/https://doi.org/10.1016/j.compedu.2012.02.001

Essa, A. (2016). A possible future for next generation adaptive learning systems. *Smart Learning Environments*, *3*(1). https://doi.org/10.1186/s40561-016-0038-y

European Commission. (2020). *Defining Artificial Intelligence: Towards an operational definition and taxonomy of artificial intelligence* (JRC Technical Reports, Issue.

Fairclough, N. (2013). *Critical discourse analysis : the critical study of language* (Second edition ed.). Taylor & Francis. https://doi.org/10.4324/9781315834368

Fan, Y., Tang, L., Le, H., Shen, K., Tan, S., Zhao, Y., Shen, Y., Li, X., & Gašević, D. (2025). Beware of metacognitive laziness: Effects of generative artificial intelligence on learning motivation, processes, and performance. *British Journal of Educational Technology*, *56*(2), 489–530. https://doi.org/10.1111/bjet.13544

Farhood, H., Nyden, M., Beheshti, A., & Muller, S. (2025). Artificial intelligence-based personalised learning in education: a systematic literature review. *Discover Artificial Intelligence*, *5*(1), 331–341. https://doi.org/10.1007/s44163-025-00598-x

Fernandez, L., Heng, M. A., & Kim Eng, C. L. (2022). Voices on "voice": A juxtaposition of teachers' and students' perspectives on the possibilities and challenges of student voice in teaching and learning. *Asia Pacific journal of education*, 1–14. https://doi.org/10.1080/02188791.2022.2037512

Finkelstein, S., Yarzebinski, E., Vaughn, C., Ogan, A., Cassell, J., Lane, H. C., Yacef, K., Pavlik, P., & Mostow, J. (2013). The Effects of Culturally Congruent Educational Technologies on Student Achievement. In *Artificial Intelligence in Education* (pp. 493–502). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-39112-5_50

Fleckenstein, J., Liebenow, L. W., & Meyer, J. (2023). Automated feedback and writing: a multi-level meta-analysis of effects on students' performance. *Front Artif Intell*, *6*, 1162454. https://doi.org/10.3389/frai.2023.1162454

Flyvbjerg, B. (2006). Five Misunderstandings About Case-Study Research. *Qualitative inquiry*, *12*(2), 219–245. https://doi.org/10.1177/1077800405284363

Fovet, F. (2021). *Applying universal design for learning across disciplines : case studies on implementation*. IGI Global.

Frambach, J., Driessen, E., Beh, S. L., & Vleuten, C. P. M. v. d. (2013). Quiet or Questioning? Students' Discussion Behaviors in Student-Centered Education Across Cultures. *Studies in Higher Education*. https://doi.org/10.1080/03075079.2012.754865

France, P. E., & Tomlinson, C. A. (2019). *Reclaiming personalized learning : a pedagogy for restoring equity and humanity in our classrooms*. Corwin.

Frøsig, T. B., & Romero, M. (2024). Teacher agency in the age of generative AI: towards a framework of hybrid intelligence for learning design. https://doi.org/10.48550/arxiv.2407.06655

Galway, G. J., Maddigan, B., & Stordy, M. (2020). Teacher educator experiences of iPad integration in pre-service teacher education: successes and challenges. *Technology, pedagogy and education*, *29*(5), 557–575. https://doi.org/10.1080/1475939X.2020.1819397

Garcia, A., Stamatis, K., & Kelly, M. (2018). Invisible Potential: The Social Contexts of Technology in Three 9th-Grade ELA Classrooms. *Research in the teaching of English*, *52*(4), 404–426.

Gardner, J., Brooks, C., & Baker, R. (2019, 2019). Evaluating the Fairness of Predictive Student Models Through Slicing Analysis. Proceedings of the 9th International Conference on Learning Analytics & Knowledge, New York, NY, USA.

Garet, M. S., Porter, A. C., Desimone, L. M., Birman, B. F., & Kwang, S. Y. (2001). What makes professional development effective?: Results from a national sample of teachers. *American educational research journal*, *38*(4), 915–945. https://doi.org/10.3102/00028312038004915

Gerlich, M. (2025). AI Tools in Society: Impacts on Cognitive Offloading and the Future of Critical Thinking. *Societies*, *15*(1), 6. https://doi.org/10.3390/soc15010006

Gerring, J. (2006). *Case study research: Principles and practices*. Cambridge university press.

Ghergulescu, I., Moldovan, A.-N., Muntean, C. H., & Muntean, G.-M. (2019). Evaluation of an Interactive Personalised Virtual Lab in Secondary Schools. 11th International Conference, CSEDU 2019, Heraklion, Crete, Greece.

Gläser-Zikuda, M., Hagenauer, G., & Stephan, M. (2020). The Potential of Qualitative Content Analysis for Empirical Educational Research. *Forum, qualitative social research*, *21*(1). https://doi.org/10.17169/fqs-21.1.3443

Goldman, R., Pea, R., Barron, B., & Derry, S. J. (2014). *Video research in the learning sciences*. Routledge.

Gonzalez, M. C. (2000). The Four Seasons of Ethnography: a creation-centered ontology for ethnography. *International journal of intercultural relations*, *24*(5), 623–650. https://doi.org/10.1016/S0147-1767(00)00020-1

Goodwin, C. (2000). Action and embodiment within situated human interaction. *Journal of pragmatics*, *32*(10), 1489–1522. https://doi.org/10.1016/S0378-2166(99)00096-X

Graf, S., & Kinshuk. (2012). Personalized Learning. In N. M. Seel (Ed.), *Encyclopedia of the Sciences of Learning* (pp. 2592–2594). Boston, MA: Springer.

Granic, A. (2022). Educational Technology Adoption: A systematic review. *Education and Information Technologies*, *27*(7), 9725–9744. https://doi.org/10.1007/s10639-022-10951-7

Gray, R., Rogan - Klyve, A., & Canipe, M. M. (2022). Investigating the impact of eliciting and being responsive to students' initial ideas on productive disciplinary engagement across a unit. *Science education (Salem, Mass.)*, *106*(2), 312 – 334. https://doi.org/10.1002/sce.21701

Green, J., & Thorogood, N. (2004). *Qualitative methods for health research* (First Edition ed.). SAGE Publications Ltd.

Gump, P. V. (1967). *The classroom behavior setting: Its nature and relation to student behavior.* U. o. K. Press.

Gumperz, J. J. (1982). *Discourse strategies*. Cambridge University Press.

Hafen, C. A., Hamre, B. K., Allen, J. P., Bell, C. A., Gitomer, D. H., & Pianta, R. C. (2015). Teaching Through Interactions in Secondary School Classrooms: Revisiting the Factor Structure and Practical Application of the Classroom Assessment Scoring System–Secondary. *J Early Adolesc*, *35*(5-6), 651–680. https://doi.org/10.1177/0272431614537117

Harper, B. (2018). Technology and Teacher–Student Interactions: A Review of Empirical Research. *Journal of Research on Technology in Education*, *50*(3), 214–225. https://doi.org/10.1080/15391523.2018.1450690

Harrell, S., & Bynum, Y. (2018). Factors Affecting Technology Integration in the Classroom. *Alabama Journal of Educational Leadership*, *5*, 12.

Harris, J., Mishra, P., & Koehler, M. (2009). Teachers' Technological Pedagogical Content Knowledge and Learning Activity Types: Curriculum-based Technology Integration Reframed. *Journal of Research on Technology in Education*, *41*(4), 393–416. https://doi.org/10.1080/15391523.2009.10782536

Hattie, J., & Timperley, H. (2007). The Power of Feedback. *Review of educational research*, *77*(1), 81–112. https://doi.org/10.3102/003465430298487

Heath, C., Hindmarsh, J., & Luff, P. (2010). *Video in Qualitative Research: Analysing Social Interaction in Everyday Life*. SAGE Publications, Inc. https://doi.org/10.4135/9781526435385

Hecht, M., & Crowley, K. (2020). Unpacking the Learning Ecosystems Framework: Lessons from the Adaptive Management of Biological Ecosystems. *The Journal of the learning sciences*, *29*(2), 264–284. https://doi.org/10.1080/10508406.2019.1693381

Henderson, J., & Corry, M. (2021). Teacher anxiety and technology change: a review of the literature. *Technology, pedagogy and education*, *30*(4), 573–587. https://doi.org/10.1080/1475939X.2021.1931426

Hennessy, S., Rojas-Drummond, S., Higham, R., Márquez, A. M., Maine, F., Ríos, R. M., García-Carrión, R., Torreblanca, O., & Barrera, M. J. (2016). Developing a coding scheme for analysing classroom dialogue across educational contexts. *Learning, culture and social interaction*, *9*, 16–44. https://doi.org/10.1016/j.lcsi.2015.12.001

Hogan, D., Kwek, D., Towndrow, P., Rahim, R. A., Tan, T. K., Yang, H. J., & Chan, M. (2013). Visible learning and the enacted curriculum in Singapore. In *Globalization and the Singapore curriculum: From policy to classroom* (pp. 121–149). Springer.

Holmes, A. G. D. (2020). Researcher Positionality--A Consideration of Its Influence and Place in Qualitative Research--A New Researcher Guide. *Shanlax International Journal of Education*, *8*(4), 1–10.

Holmes, W., Bialik, M., & Fadel, C. (2019a). *Artificial intelligence in education: promises and implications for teaching and learning*.

Holmes, W., Bialik, M., & Fadel, C. (2019b). *Artificial Intelligence in Education: Promises and implications for Teaching and Learning*. Center for Curriculum Redesign.

Holstein, K., & Aleven, V. (2022). Designing for human – AI complementarity in K - 12 education. *The AI magazine*, *43*(2), 239 – 248. https://doi.org/10.1002/aaai.12058

Horvers, A., Kooi, R., Knoop-van Campen, C. A. N., Dijkstra, R., Baars, M., & Molenaar, I. (2024). How does co-regulation with Adaptive Learning Technologies affect primary school students' goal-setting, regulation of practice behavior and learning outcomes? *Frontiers in education (Lausanne)*, *9*. https://doi.org/10.3389/feduc.2024.1435483

Howe, C., Hennessy, S., Mercer, N., Vrikki, M., & Wheatley, L. (2019). Teacher–Student Dialogue During Classroom Teaching: Does It Really Impact on Student Outcomes? *Journal of the Learning Sciences*, *28*(4-5), 462–512. https://doi.org/10.1080/10508406.2019.1573730

Huang, A. Y. Q., Lu, O. H. T., & Yang, S. J. H. (2023). Effects of artificial Intelligence–Enabled personalized recommendations on learners' learning engagement, motivation, and outcomes in a flipped classroom. *Computers and Education*, *194*, 104684. https://doi.org/10.1016/j.compedu.2022.104684

Huang, H., Li, M., & Dai, C. (2025). Adapting to Complexity: Teacher-Student interactions in synchronous online language classes through a dynamic systems lens. *System (Linköping)*, *133*, 103732. https://doi.org/10.1016/j.system.2025.103732

Huang, S.-L., & Shiu, J.-H. (2012). A User-Centric Adaptive Learning System for E-Learning 2.0. *Educational Technology & Society*, *15*(3), 1176–3647.

Hughes, J. (2021). The deskilling of teaching and the case for intelligent tutoring systems. *Journal of Ethics and Emerging Technologies*, *31*(2), 1–16.

Hunter, J. (2017). Developing interactive mathematical talk: investigating student perceptions and accounts of mathematical reasoning in a changing classroom context. *Cambridge journal of education*, *47*(4), 475–492. https://doi.org/10.1080/0305764X.2016.1195789

Hymes, D. H. (1974). *Foundations in sociolinguistics : an ethnographic approach*. University of Pennsylvania Press.

Inan, F. A., & Lowther, D. L. (2010). Factors affecting technology integration in K-12 classrooms: a path model. *Educational Technology Research and Development*, *58*(2), 137–154. https://doi.org/10.1007/s11423-009-9132-y

James, W. (1900). *Talks to teachers and students*. New York (State): Holt, 1900.

Jewitt, C. (2012). An introduction to using video for research.

Jewitt, C., Brown, B., & Price, S. (2013). Multimodal Methods for Researching Digital Technologies. In *The SAGE Handbook of Digital Technology Research* (pp. 250–265). SAGE Publications Ltd. https://doi.org/10.4135/9781446282229.n18

Jia, J., & Miao, Y. (2021). The Customized Mathematic Instruction Supported by an Intelligent Tutoring System and Its Effect During the COVID-19 Epidemic. In R. Li, S. K. S. Cheung, C. Iwasaki, L.-F. Kwok, & M. Kageto, *Blended Learning: Re-thinking and Re-defining the Learning Process.* Cham.

Jones, S. A. (2021). A Local Research Evidence Base for English Language Education (ELE) in Singapore from 2010 to 2020 (early childhood to secondary school). *Asia Pacific journal of education*, *41*(4), 641–656. https://doi.org/10.1080/02188791.2021.1997712

Kabudi, T., Pappas, I., & Olsen, D. H. (2021). AI-enabled adaptive learning systems: A systematic mapping of the literature. *Computers and education. Artificial intelligence*, *2*, 100017. https://doi.org/10.1016/j.caeai.2021.100017

Kapur, M. (2025). *Productive Failure : Unlocking Deeper Learning Through the Science of Failing* (First edition. ed.). John Wiley & Sons, Inc.

Kasneci, E., Sessler, K., Küchemann, S., Bannert, M., Dementieva, D., Fischer, F., Gasser, U., Groh, G., Günnemann, S., Hüllermeier, E., Krusche, S., Kutyniok, G., Michaeli, T., Nerdel, C., Pfeffer, J., Poquet, O., Sailer, M., Schmidt, A., Seidel, T.,…Kasneci, G. (2023). ChatGPT for good? On opportunities and challenges of large language models for education. *Learning and individual differences*, *103*, 102274. https://doi.org/10.1016/j.lindif.2023.102274

Kaur, B. (2009a). Characteristics of good mathematics teaching in Singapore grade 8 classrooms: a juxtaposition of teachers' practice and students' perception. *ZDM*, *41*(3), 333–347. https://doi.org/10.1007/s11858-009-0170-z

Kaur, B. (2009b). Characteristics of Good Mathematics Teaching in Singapore Grade 8 Classrooms: A Juxtaposition of Teachers' Practice and Students' Perception. *ZDM*. https://doi.org/10.1007/s11858-009-0170-z

Keane, T., Boden, M., Chalmers, C., & Williams, M. (2020). Effective principal leadership influencing technology innovation in the classroom. *Education and Information Technologies*, *25*(6), 5321–5338. https://doi.org/10.1007/s10639-020-10217-0

Kelly, D. (2008). Adaptive Versus Learner Control in a Multiple Intelligence Learning Environment. *Journal of Educational Multimedia and Hypermedia*, *17*(3), 307–336.

Kershner, R., Hennessy, S., Wegerif, R., Ahmed, A., & Bloomsbury. (2020). *Research methods for educational dialogue*. Bloomsbury Academic.

Keuning, T., & van Geel, M. (2021). Differentiated Teaching With Adaptive Learning Systems and Teacher Dashboards: The Teacher Still Matters Most. *IEEE transactions on learning technologies*, *14*(2), 201–210. https://doi.org/10.1109/TLT.2021.3072143

Kim, H., & Song, J. (2023). Exploring the Potential of Teacher-Learner Interactions Through Feedback in Online Formative Assessment: Demonstration Cases of Pre-service Physics Teachers. *Research in science education (Australasian Science Education Research Association)*, *53*(6), 1145–1161. https://doi.org/10.1007/s11165-023-10127-4

Kim, M. (2022). Student Agency and Teacher Authority in Inquiry-Based Classrooms: Cases of Elementary Teachers' Classroom Talk. *International journal of science and mathematics education*, *20*(8), 1927–1948. https://doi.org/10.1007/s10763-021-10233-7

Kim, Y., & Baylor, A. L. (2006). A Social-Cognitive Framework for Pedagogical Agents as Learning Companions. *ETR&D*, *54*(6), 569–596.

Klein, H. J., Polin, B., & Wanberg, C. R. (2012). Are Organizations On Board with Best Practices Onboarding? In *The Oxford Handbook of Organizational Socialization*. Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199763672.013.0014

Klem, A. M., & Connell, J. P. (2004). Relationships Matter: linking Teacher Support to Student Engagement and Achievement. *Journal of School Health*, *74*(7), 262–273.

Knoblauch, H., & Schnettler, B. (2012). Videography: analysing video data as a 'focused' ethnographic and hermeneutical exercise. *Qualitative research : QR*, *12*(3), 334–356. https://doi.org/10.1177/1468794111436147

Koedinger, K. R., Corbett, A., & Sawyer, R. K. (2005). Cognitive Tutors: Technology Bringing Learning Sciences to the Classroom. In *The Cambridge Handbook of the Learning Sciences* (pp. 61–78). Cambridge University Press. https://doi.org/10.1017/CBO9780511816833.006

Konwar, U. (1900). *Effect of Training Pupil in Developing Their Questioning Behaviour in Classroom Through the Use of Simulation and Gaming in Social Studies at Primary Level* ProQuest Dissertations Publishing].

Kruse, K. (2025, 3 Feb 2025). *Forget VUCA. The World Is BANI Now*. Forbes. Retrieved 4 Jan from https://www.forbes.com/sites/kevinkruse/2025/02/03/forget-vuca-bani-is-the-new-framework-world/

Kuchah, K., & Annamaria, P. (2012). 'Was this an interview?' Breaking the power barrier in adult-child interviews in an African context. *Issues in educational research*, *22*(3), 283.

Kulik, J. A., & Fletcher, J. D. (2016). Effectiveness of Intelligent Tutoring Systems: A Meta-Analytic Review. *Review of educational research*, *86*(1), 42–78. https://doi.org/10.3102/0034654315581420

Kumpulainen, K., & Wray, D. (2002). *Classroom interaction and social learning : from theory to practice*. RoutledgeFalmer.

Kvale, S., & Brinkmann, S. (2009). *InterViews : learning the craft of qualitative research interviewing* (2nd edition. ed.). SAGE.

Larsen, D. P., Nimmon, L., & Varpio, L. (2019). Cultural Historical Activity Theory: The Role of Tools and Tensions in Medical Education. *Acad Med*, *94*(8), 1255–1255. https://doi.org/10.1097/ACM.0000000000002736

Learning, S. (n.d.). *Fast ForWord Programs*. https://soniclearning.com.au/our-programs/fast-forword-brain-training/fast-forword-programs/

Leite, W. L., Zhang, H., Rana, S., Hao, Y., Hatch, A. D., Kong, L., & Kuang, H. (2025). Do intelligent tutoring systems benefit K-12 students? A meta-analysis and evaluation of heterogeneity of treatment effects in the U.S. https://doi.org/10.48550/arxiv.2511.04997

Lerang, M. S., Ertesvåg, S. K., & Havik, T. (2019). Perceived Classroom Interaction, Goal Orientation and Their Association with Social and Academic Learning Outcomes. *Scandinavian Journal of Educational Research*, *63*(6), 913–934. https://doi.org/10.1080/00313831.2018.1466358

Létourneau, A., Deslandes Martineau, M., Charland, P., Karran, J. A., Boasen, J., & Léger, P. M. (2025). A systematic review of AI-driven intelligent tutoring systems (ITS) in K-12 education. *NPJ Sci Learn*, *10*(1), 29–13. https://doi.org/10.1038/s41539-025-00320-7

Li, T., Fan, Y., Tan, Y., Wang, Y., Singh, S., Li, X., Raković, M., van der Graaf, J., Lim, L., Yang, B., Molenaar, I., Bannert, M., Moore, J., Swiecki, Z., Tsai, Y.-S., Shaffer, D. W., & Gašević, D. (2023). Analytics of self-regulated learning scaffolding: effects on learning processes. *Frontiers in psychology*, *14*, 1206696. https://doi.org/10.3389/fpsyg.2023.1206696

Lim, W., Lee, J.-E., Tyson, K., Kim, H.-J., & Kim, J. (2020). An Integral Part of Facilitating Mathematical Discussions: Follow-up Questioning. *International journal of science and mathematics education*, *18*(2), 377–398. https://doi.org/10.1007/s10763-019-09966-3

Limarutti, A., Maier, M. J., Mir, E., & Gebhard, D. (2021). Pick the Freshmen Up for a "Healthy Study Start" Evaluation of a Health Promoting Onboarding Program for First Year Students at the Carinthia University of Applied Sciences, Austria. *Front Public Health*, *9*, 652998. https://doi.org/10.3389/fpubh.2021.652998

Liu, H., Zhang, Y., & Jia, J. (2024). The Design of Guiding and Adaptive Prompts for Intelligent Tutoring Systems and Its Effect on Students' Mathematics Learning. *IEEE transactions on learning technologies*, *17*, 1353–1363. https://doi.org/10.1109/TLT.2024.3382000

Liu, J., Aziku, M., Qiang, F., & Zhang, B. (2024). Leveraging professional learning communities in linking digital professional development and instructional integration: evidence from 16,072 STEM teachers. *International Journal of STEM Education*, *11*(1), 56.

Loh, C. E., & Liew, W. M. (2016). Voices from the ground: The emotional labour of English teachers' work. *Teaching and teacher education*, *55*, 267–278. https://doi.org/10.1016/j.tate.2016.01.016

Luckin, R., Holmes, W., Griffiths, M., & Forcier, L. B. (2016). *Intelligence Unleashed: An argument for AI in Education*.

Luke, A. (2025). AI and the Deskilling of Teachers' Work. *Australian Journal of English Education Volume*, *60*(1), 13.

Luoto, J., Klette, K., & Blikstad-Balas, M. (2023). Possible biases in observation systems when applied across contexts: conceptualizing, operationalizing, and sequencing instructional quality. *Educational assessment, evaluation and accountability*, *35*(1), 105–128. https://doi.org/10.1007/s11092-022-09394-y

Major, L., Francis, G. A., & Tsapali, M. (2021). The effectiveness of technology - supported personalised learning in low - and middle - income countries: A meta - analysis. *British Journal of Educational Technology*, *52*(5), 1935 – 1964. https://doi.org/10.1111/bjet.13116

Major, L., Warwick, P., Rasmussen, I., Ludvigsen, S., & Cook, V. (2018). Classroom dialogue and digital technologies: A scoping review. *Education and Information Technologies*, *23*(5), 1995–2028. https://doi.org/10.1007/s10639-018-9701-y

Martin, F., Gezer, T., & Ceviker, E. (2025). Exploring multidimensional factors influencing teachers' technology integration in K–12 education: A systematic review. *Journal of Research on Technology in Education*, 1–35. https://doi.org/10.1080/15391523.2025.2534951

Mashburn, A. J., Pianta, R. C., Hamre, B. K., Downer, J. T., Barbarin, O. A., Bryant, D., Burchinal, M., Early, D. M., & Howes, C. (2008). Measures of Classroom Quality in Prekindergarten and Children's Development of Academic, Language, and Social Skills. *Child Dev*, *79*(3), 732–749. https://doi.org/10.1111/j.1467-8624.2008.01154.x

Matthews, K., Janicki, T., He, L., & Patterson, L. (2019). Implementation of an Automated Grading System with an Adaptive Learning Component to Affect Student Feedback and Response Time. *Journal of Information Systems Education*, *23*(1), 71–83.

Mavroudi, A., Giannakos, M., & Krogstie, J. (2017). Supporting adaptive learning pathways through the use of learning analytics: developments, challenges and future opportunities. *Interactive Learning Environments*, *26*(2), 206–220. https://doi.org/10.1080/10494820.2017.1292531

McBride, A. (2021). *The Edtech Coaching Primer : Supporting Teachers in the Digital Age Classroom* (First edition. ed.). International Society for Technology in Education.

McKnight, K. (2016). Teaching in a Digital Age: How Educators Use Technology to Improve Student Learning. *Journal of research on technology in education.*, *48*(3), 194–211. https://doi.org/info:doi/

McNeil, L. (2012). Using talk to scaffold referential questions for English language learners. *Teaching and teacher education*, *28*(3), 396–404. https://doi.org/10.1016/j.tate.2011.11.005

McNicholl, J., & Blake, A. (2013). Transforming teacher education, an activity theory analysis. *JOURNAL OF EDUCATION FOR TEACHING*, *39*. https://doi.org/10.1080/02607476.2013.799846

Mehan, H. (2014). *Learning Lessons : Social Organization in the Classroom* (Reprint 2014 ed.). Harvard University Press.

Mehrabi, N., Morstatter, F., Saxena, N., Lerman, K., & Galstyan, A. (2022). A Survey on Bias and Fairness in Machine Learning. *ACM computing surveys*, *54*(6), 1–35. https://doi.org/10.1145/3457607

Mekheimer, M. A. (2025). Effective technology integration in higher education: a mixed-methods study of professional development. *Education and Information Technologies*, *30*(17), 25013–25058. https://doi.org/10.1007/s10639-025-13750-y

Mercer, N. (1995). *The guided construction of knowledge : talk amongst teachers and learners*. Multilingual Matters.

Mercer, N., & Howe, C. (2012). Explaining the dialogic processes of teaching and learning: The value and potential of sociocultural theory. *Learning, culture and social interaction*, *1*(1), 12–21. https://doi.org/10.1016/j.lcsi.2012.03.001

Mercer, N., & Littleton, K. (2007). *Dialogue and the Development of Children's Thinking*. Taylor & Francis Group.

Merriam, S. B. (1998). *Qualitative Research and Case Study Applications in Education. Revised and Expanded from" Case Study Research in Education."*. ERIC.

Miles, M. B., Huberman, A. M., & Saldaña, J. (2014). *Qualitative data analysis : a methods sourcebook* (Third edition. ed.). SAGE Publications, Inc.

Ministry of Education. (2020, 29 December 2020). *Blended Learning to Enhance Schooling Experience and Further Develop Students into Self-Directed Learners* https://www.moe.gov.sg/news/press-releases/20201229-blended-learning-to-enhance-schooling-experience-and-further-develop-students-into-self-directed-learners

Ministry of Education. (2021, 18 October 2021). *21st Century Competencies*. Retrieved 22 June from https://www.moe.gov.sg/education-in-sg/21st-century-competencies

Ministry of Education. (2023, 20 September). *More Support for Schools and Students to Shape the Future of Learning* https://www.moe.gov.sg/news/press-releases/20230920-more-support-for-schools-and-students-to-shape-the-future-of-learning

Ministry of Education. (2025). *Singapore Teachers Embrace Digital Technologies and Benefit from Strong Professional Development: OECD TALIS 2024 Study* https://www.moe.gov.sg/news/press-releases/20251007-singapore-teachers-embrace-digital-technologies-and-benefit-from-strong-professional-development-oecd-talis-2024-study

Mishra, P., & Koehler, M. J. (2006). Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge. *Teachers College record (1970)*, *108*(6), 1017–1054. https://doi.org/10.1177/016146810610800610

Mohseni, Z., Masiello, I., & Martins, R. M. (2023). Co-Developing an Easy-to-Use Learning Analytics Dashboard for Teachers in Primary/Secondary Education: A Human-Centered Design Approach. *Education sciences*, *13*(12), 1190. https://doi.org/10.3390/educsci13121190

Molenaar, I., Horvers, A., & Baker, R. S. (2019, 2019). Towards Hybrid Human-System Regulation: Understanding Children' SRL Support Needs in Blended Classrooms. Proceedings of the 9th International Conference on Learning Analytics & Knowledge, New York, NY, USA.

Moltudal, S. H., Krumsvik, R. J., & Høydal, K. L. (2022). Adaptive Learning Technology in Primary Education: Implications for Professional Teacher Knowledge and Classroom Management. *Frontiers in education (Lausanne)*, *7*. https://doi.org/10.3389/feduc.2022.830536

Moore, O. (2024). The Top 100 Gen AI Consumer Apps (3rd Edition). https://a16z.com/100-gen-ai-apps-3/

Moskal, P., Carter, D., & Johnson, D. (2017). *7 Things You Should Know About Adaptive Learning*. https://library.educause.edu/resources/2017/1/7-things-you-should-know-about-adaptive-learning

Murphy, P. K., Wilkinson, I. A. G., Soter, A. O., Hennessey, M. N., & Alexander, J. F. (2009). Examining the Effects of Classroom Discussion on Students' Comprehension of Text: A Meta-Analysis. *Journal of Educational Psychology*, *101*(3), 740–764. https://doi.org/10.1037/a0015576

Mwalongo, A. I. (2016). Using Activity Theory to Understand Student Teacher Perceptions of Effective Ways for Promoting Critical Thinking through Asynchronous Discussion Forums. In D. S. P. Gedera & P. J. Williams (Eds.), *Activity Theory in Education: Research and Practice* (pp. 17–34). Brill. https://doi.org/https://doi.org/10.1007/9789463003872_003

National Research Council. (2015). *Identifying and supporting productive STEM programs in out-of-school settings*. The National Academies Press.

Ng, D. T. K., Leung, J. K. L., Su, J., Ng, R. C. W., & Chu, S. K. W. (2023). Teachers' AI digital competencies and twenty-first century skills in the post-pandemic world. *Educ Technol Res Dev*, *71*(1), 137–161. https://doi.org/10.1007/s11423-023-10203-6

Oakley, B., Johnston, M., Chen, K.-Z., Jung, E., & Sejnowski, T. J. (2025). The Memory Paradox: Why Our Brains Need Knowledge in an Age of AI. https://doi.org/10.48550/arxiv.2506.11015

OECD. (2021). *OECD Digital Education Outlook 2021: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots*. O. Publishing.

OECD. (2023). *PISA 2022 Results (Volume I and II) - Country Notes: Singapore*. https://www.oecd.org/en/publications/pisa-2022-results-volume-i-and-ii-country-notes_ed6fbcc5-en/singapore_2f72624e-en.html

Owan, V. J., Abang, K. B., Idika, D. O., Etta, E. O., & Bassey, B. A. (2023). Exploring the potential of artificial intelligence tools in educational measurement and assessment. In (Vol. 19, pp. em2307). East Sussex.

Owan, V. J., Etta, E. O., & Abang, K. B. (2023). Exploring the potential of artificial intelligence tools in educational measurement and assessment. In *Exploring the* *potential of artificial intelligence tools in educational measurement and assessment*: Modestum.

Padayachee, K. (2017). A snapshot survey of ICT integration in South African schools. *SACJ*, *29*(2), 36–65. https://doi.org/10.18489/sacj.v29i2.463

Pardo, A., Jovanovic, J., Dawson, S., Gašević, D., & Mirriahi, N. (2019). Using learning analytics to scale the provision of personalised feedback. *British Journal of Educational Technology*, *50*(1), 128–138. https://doi.org/10.1111/bjet.12592

Patton, M. Q. (2015). *Qualitative research & evaluation methods : integrating theory and practice* (Fourth edition. ed.). SAGE.

Pea, R. D. (1985). Beyond Amplification: Using the computer to Reorganize Mental Functioning. *Educational psychologist*, *20*(4), 167–182. https://doi.org/10.1207/s15326985ep2004_2

Pearson, & EdSurge. (2016). *Decoding Adaptive*. https://www.pearson.com/content/dam/one-dot-com/one-dot-com/uk/documents/educator/primary/Pearson-Decoding-Adaptive-Report.pdf

Pekrun, R., Goetz, T., Titz, W., & Perry, R. P. (2002). Academic Emotions in Students' Self-Regulated Learning and Achievement: A Program of Qualitative and Quantitative Research. *Educational psychologist*, *37*(2), 91–105. https://doi.org/10.1207/S15326985EP3702-4

Pelánek, R. (2025). Adaptive Learning is Hard: Challenges, Nuances, and Trade-offs in Modeling. *International journal of artificial intelligence in education*, *35*(1), 304–329. https://doi.org/10.1007/s40593-024-00400-6

Pennington, M. C. (2004). Cycles of Innovation in the Adoption of Information Technology: A View for Language Teaching. *Computer assisted language learning*, *17*(1), 7–33. https://doi.org/10.1076/call.17.1.7.29705

Penuel, W. R., Fishman, B. J., Cheng, B. H., & Sabelli, N. (2011). Organizing Research and Development at the Intersection of Learning, Implementation, and Design. *Educational researcher*, *40*(7), 331–337. https://doi.org/10.3102/0013189x11421826

Peters, M. A., White, E. J., Besley, T., Locke, K., Redder, B., Novak, R., Gibbons, A., O'Neill, J., Tesar, M., & Sturm, S. (2021). Video ethics in educational research involving children: Literature review and critical discussion. *Educational philosophy and theory*, *53*(9), 863–880. https://doi.org/10.1080/00131857.2020.1717920

Petko, D., Prasse, D., & Cantieni, A. (2018). The Interplay of School Readiness and Teacher Readiness for Educational Technology Integration: A Structural Equation Model. *Computers in the schools*, *35*(1), 1–18. https://doi.org/10.1080/07380569.2018.1428007

Plakitsi, K. (2013). *Activity Theory in Formal and Informal Science Education*. Brill | Sense.

Premlatha, K. R., Dharani, B., & Geetha, T. V. (2016). Dynamic learner profiling and automatic learner classification for adaptive e-learning environment. *Interactive Learning Environments*, *24*(6), 1054–1075. https://doi.org/10.1080/10494820.2014.948459

Pugliese, L. (2016, 2016/11//). *Adaptive Learning Systems: Surviving the Storm*. https://er.educause.edu/articles/2016/10/adaptive-learning-systems-surviving-the-storm

Purdy, J. (2008). Inviting conversation: meaningful talk about texts for English language learners. *Literacy (Oxford, England)*, *42*(1), 44–51. https://doi.org/10.1111/j.1467-9345.2008.00479.x

Ratinho, E., & Martins, C. (2023). The role of gamified learning strategies in student's motivation in high school and higher education: A systematic review. In *The role of gamified learning strategies in student's motivation in high school and higher education: A systematic review*: Elsevier.

Rebelo, M. (2024). The best AI productivity tools in 2024. https://zapier.com/blog/best-ai-productivity-tools/

Reich, J. (2020). *Failure to disrupt : why technology alone can't transform education*. Harvard University Press.

Reiss, S. (2012). Intrinsic and Extrinsic Motivation. *Teaching of psychology*, *39*(2), 152–156. https://doi.org/10.1177/0098628312437704

Resnick, L. B., Michaels, S., & O'Connor, M. C. (2010). How (Well-Structured) Talk Builds the Mind. In D. D. Preiss & R. J. Sternberg (Eds.), *Innovations in educational psychology : perspectives on learning, teaching, and human development* (pp. 163–194). Springer Publishing Company, LLC.

Risko, E. F., & Gilbert, S. J. (2016). Cognitive Offloading. *Trends Cogn Sci*, *20*(9), 676–688. https://doi.org/10.1016/j.tics.2016.07.002

Rogers, E. M. (2003). *Diffusion of Innovations* (5th Edition ed.). Simon and Schuster.

Rogoff, B. (2003). *The cultural nature of human development*. Oxford university press.

Rojas Briñez, D. K., Duart, J. M., & Galvis Panqueva, Á. H. (2023). Findings and derived challenges concerning how school leaders should support ICT integration at schools. In (Vol. 43, pp. 497–524). Abingdon: Routledge.

Roth, W.-M., & Lee, Y.-J. (2007). "Vygotsky's Neglected Legacy": Cultural-Historical Activity Theory. *Review of educational research*, *77*(2), 186–232. https://doi.org/10.3102/0034654306298273

Rowe, W. E. (2014). Positionality. In D. Coghlan & M. Brydon-Miller (Eds.), *The SAGE Encyclopedia of Action Research* (pp. 628–628). SAGE Publications Ltd. https://doi.org/10.4135/9781446294406

Rzevski, G. (2023). *The Future Is Digital: How Complexity and Artificial Intelligence Will Shape Our Lives and Work* (1 ed.). Springer International Publishing AG. https://doi.org/10.1007/978-3-031-37810-2

Sancho-Gil, J. M., Rivera-Vargas, P., & Miño-Puigcercós, R. (2020). Moving beyond the predictable failure of Ed-Tech initiatives. *Learning, Media and Technology*, *45*(1), 61–75. https://doi.org/10.1080/17439884.2019.1666873

Santelices, M. V., & Wilson, M. (2010). Unfair Treatment? The Case of Freedle, the SAT, and the Standardization Approach to Differential Item Functioning. *Harvard educational review*, *80*(1), 106–134. https://doi.org/10.17763/haer.80.1.j94675w001329270

Sari, H. E., Tumanggor, B., & Efron, D. (2024). Improving educational outcomes through adaptive learning systems using AI. *International Transactions on Artificial Intelligence*, *3*(1), 21–31.

Scherer, R., Siddiq, F., & Tondeur, J. (2019). The technology acceptance model (TAM): A meta-analytic structural equation modeling approach to explaining teachers' adoption of digital technology in education. *Computers and Education*, *128*, 13–35. https://doi.org/10.1016/j.compedu.2018.09.009

Schilling, H., Wittner, B., Hirschberger, S., & Kauffeld, S. (2025). Introduction and Evaluation of a Digital Onboarding Tool for Higher Education Students. *European Journal of Education*, *60*(4). https://doi.org/10.1111/ejed.70369

Schmidt, C. (2019). Classroom observations through video recordings – Methodological approaches and ethical considerations. In N. Wahlström (Ed.), *Classroom research: Methodology, categories and coding* (pp. 16).

Schmitz, M.-L., Antonietti, C., Consoli, T., Cattaneo, A., Gonon, P., & Petko, D. (2023). Transformational leadership for technology integration in schools: Empowering teachers to use technology in a more demanding way. *Computers and Education*, *204*, 104880. https://doi.org/10.1016/j.compedu.2023.104880

Scoro. (n.d., 26 November). New Software Onboarding – The What, Why, and How. https://www.scoro.com/blog/new-software-onboarding/

Sedova, K., Sedlacek, M., Svaricek, R., Majcik, M., Navratilova, J., Drexlerova, A., Kychler, J., & Salamounova, Z. (2019). Do those who talk more learn more? The relationship between student classroom talk and student achievement. *Learning and Instruction*, *63*. https://doi.org/10.1016/j.learninstruc.2019.101217

Seifert, T., & Bar-Tal, S. (2023). Student-teachers' sense of belonging in collaborative online learning. *Education and Information Technologies*, *28*(7), 7797–7826. https://doi.org/10.1007/s10639-022-11498-3

Selwyn, N. (2019). *Should robots replace teachers? : AI and the future of education*. Polity Press.

Selwyn, N. (2021). *Education and technology : key issues and debates* (Third edition. ed.). Bloomsbury Academic, Bloomsbury Publishing Plc.

Selwyn, N., Hillman, T., Eynon, R., Ferreira, G., Knox, J., Macgilchrist, F., & Sancho-Gil, J. M. (2019). What's next for Ed-Tech? Critical hopes and concerns for the 2020s.

Seow, P., Lung Hsiang, W., & Longkai, W. (2020). *Local Evidence Synthesis on Information & Communications Technology (ICT) in Education* (Local Evidence Syntheses (LES) Series, Issue.

Sharma, K., Nguyen, A., & Hong, Y. (2024). Self - regulation and shared regulation in collaborative learning in adaptive digital learning environments: A systematic review of empirical studies. *British Journal of Educational Technology*, *55*(4), 1398 – 1436. https://doi.org/10.1111/bjet.13459

Shemshack, A., & Spector, J. M. (2020). A systematic literature review of personalized learning terms. *Smart Learning Environments*, *7*(1), 1–20. https://doi.org/10.1186/s40561-020-00140-9

Sherin, M., & van Es, E. (2005). Using Video to Support Teachers' Ability to Notice Classroom Interactions. *Journal of technology and teacher education*, *13*(3), 475.

Shin, M., Yoo, H., & Jang, J. (2022). Barriers and Solutions of Edtech Integration in Schools: Focused on Leading Teachers' Perceptions. *Journal of Educational Technology*, *38*(4), 219–250. https://doi.org/10.17232/KSET.39.1.219

Simon, P., & Zeng, L. (2024). Behind the Scenes of Adaptive Learning: A Scoping Review of Teachers' Perspectives on the Use of Adaptive Learning Technologies. *Education sciences*, *14*(12), 1413. https://doi.org/10.3390/educsci14121413

Sinclair, J., & Coulthard, M. (1978). *Towards an analysis of discourse : the English used by teachers and pupils*. London.

Smith, J., & de Villiers-Botha, T. (2023). Hey, Google, leave those kids alone: Against hypernudging children in the age of big data. *AI & society*, *38*(4), 1639–1649. https://doi.org/10.1007/s00146-021-01314-w

Sosa-Díaz, M. J., Sierra-Daza, M. C., Arriazu-Muñoz, R., Llamas-Salguero, F., & Durán-Rodríguez, N. (2022). "EdTech Integration Framework in Schools": Systematic Review of the Literature. *Frontiers in education (Lausanne)*, *7*. https://doi.org/10.3389/feduc.2022.895042

Stake, R. E. (2005). Case Studies. In N. K. Denzin & Y. S. Lincoln (Eds.), *The SAGE handbook of qualitative research* (3rd ed., pp. 435–454). Sage.

Sukhanova, K. (2024, 29 May 2024). *AI in Education Market Statistics – Key Trends & Figures For 2024*. Retrieved 23 August from https://techreport.com/statistics/software-web/ai-in-education-market-statistics-2024/

Sum, E. S. W., & Kwon, O. N. (2020). Classroom talk and the legacy of Confucian culture in mathematics classroom. *Teaching and teacher education*, *88*, 102964. https://doi.org/10.1016/j.tate.2019.102964

Sybing, R. (2021). Examining dialogic opportunities in teacher-student interaction: An ethnographic observation of the language classroom. *Learning, culture and social interaction*, *28*, 100492. https://doi.org/10.1016/j.lcsi.2021.100492

Tan, X., Cheng, G., & Ling, M. H. (2025). Artificial intelligence in teaching and teacher professional development: A systematic review. *Computers and education. Artificial intelligence*, *8*, 100355. https://doi.org/10.1016/j.caeai.2024.100355

Tang, S. K. (2019). Singapore rolls out national strategy on artificial intelligence for 'impactful' social, economic benefits. *ChannelNewsAsia*. https://www.channelnewsasia.com/singapore/singapore-national-strategy-ai-economic-benefits-heng-swee-keat-849691

Tao, Y., & Chen, G. (2024). The relationship between teacher talk and students' academic achievement: A meta-analysis. *Educational research review*, *45*, 100638. https://doi.org/10.1016/j.edurev.2024.100638

Tay, L. Y., & Lim, C. P. (2016). An Activity Theoretical Approach towards Distributed Leadership for One-to-One Computing in a Singapore Elementary School. In D. S. P. Gedera & P. J. Williams (Eds.), *Activity Theory in Education: Research and Practice* (pp. 87–104). Brill. https://doi.org/https://doi.org/10.1007/978-94-6300-387-2

Tellis, W. (1997). Application of a Case Study Methodology. *Qualitative report*. https://doi.org/10.46743/2160-3715/1995.2015

Theofanos, M., Choong, Y.-Y., & Jensen, T. (2024). *AI Use Taxonomy: A Human-Centered Approach* (NIST Trustworthy and Responsible AI, Issue. https://tsapps.nist.gov/publication/get_pdf.cfm?pub_id=956852

Thi Diem Hang, K., Saito, E., & Gillies, R. M. (2019). Key issues in productive classroom talk and interventions. *Educational Review*, *71*(3), 334–349. https://doi.org/10.1080/00131911.2017.1410105

Tobin, G. A., & Begley, C. M. (2004). Methodological rigour within a qualitative framework. *J Adv Nurs*, *48*(4), 388–396. https://doi.org/10.1111/j.1365-2648.2004.03207.x

Tondeur, J., van Braak, J., Ertmer, P. A., & Ottenbreit-Leftwich, A. (2017). Understanding the relationship between teachers' pedagogical beliefs and technology use in education: a systematic review of qualitative evidence. *Educational Technology Research and Development*, *65*(3), 555–577. https://doi.org/10.1007/s11423-016-9481-2

Valiente, C., Swanson, J., DeLay, D., Fraser, A. M., & Parker, J. H. (2020). Emotion-related socialization in the classroom: Considering the roles of teachers, peers, and the classroom context. In *Developmental psychology* (Vol. 56, pp. 578–594): NLM (Medline).

Van Seters, J. R., Ossevoort, M. A., Tramper, J., & Goedhart, M. J. (2012). The influence of student characteristics on the use of adaptive e-learning material. *Computers and Education*, *58*(3), 942–952. https://doi.org/10.1016/j.compedu.2011.11.002

VanLehn, K. (2011). The Relative Effectiveness of Human Tutoring, Intelligent Tutoring Systems, and Other Tutoring Systems. *Educational psychologist*, *46*(4), 197–221. https://doi.org/10.1080/00461520.2011.611369

Voultsiou, E., & Moussiades, L. (2025). A systematic review of AI, VR, and LLM applications in special education: Opportunities, challenges, and future directions. *Education and Information Technologies*, *30*(13), 19141–19181. https://doi.org/10.1007/s10639-025-13550-4

Vygotsky, L. S. (1978). *Mind in Society: The Development of Higher Psychological Processes*. Harvard University Press.

Vygotsky, L. S., & Cole, M. (1978). *Mind in society : the development of higher psychological processes*. Harvard University Press.

Walsh, S. (2006). *Investigating classroom discourse*. Routledge.

Wang, S., Christensen, C., Cui, W., Tong, R., Yarnall, L., Shear, L., & Feng, M. (2020). When adaptive learning is effective learning: comparison of an adaptive learning system to teacher-led instruction. *Interactive Learning Environments*, 1–11. https://doi.org/10.1080/10494820.2020.1808794

Warschauer, M., & Kern, R. (2000). *Network-based language teaching : concepts and practice* (1st ed.). Cambridge University Press.

Warschauer, M., & Meskill, C. (2000). A Brief History of Technology and Language Learning. In J. Rosenthal (Ed.), *Handbook of Undergraduate Second Language Education*. Lawrence Erlbaum Assoc Incorporated.

Webb, C. E., & Dennis, N. A. (2020). Memory for the usual: the influence of schemas on memory for non-schematic information in younger and older adults. *Cognitive neuropsychology*, *37*(1-2), 58–74. https://doi.org/https://doi.org/10.1080/02643294.2019.1674798

Webb, M., Gibson, D., & Forkosh-Baruch, A. (2013). Challenges for information technology supporting educational assessment. *Journal of Computer Assisted Learning*, *29*(5), 451–462. https://doi.org/10.1111/jcal.12033

Weber, G. (2012). Adaptive Learning Systems. In *Encyclopedia of the Sciences of Learning*. New York: Springer.

Wegerif, R. (2010). Dialogue and teaching thinking with technology. In K. Littleton & C. Howe (Eds.), *Educational dialogues: Understanding and promoting productive interaction* (pp. 304–322). Taylor & Francis Group.

Wiliam, D. (2001). What is wrong with our educational assessments and what can be done about it. *Education Review*, *15*(1).

Williamson, B. (2018). Silicon startup schools: technocracy, algorithmic imaginaries and venture philanthropy in corporate education reform. In *Silicon startup schools: technocracy, algorithmic imaginaries and venture philanthropy in corporate education reform*: Taylor & Francis.

Wisniewski, B., Zierer, K., & Hattie, J. (2020). The Power of Feedback Revisited: A Meta-Analysis of Educational Feedback Research. *Front Psychol*, *10*, 3087. https://doi.org/10.3389/fpsyg.2019.03087

Wu, T., & Weiland, C. (2024). Leveraging Modern Machine Learning to Improve Early Warning Systems and Reduce Chronic Absenteeism in Early Childhood. EdWorkingPaper No. 24-1081. *Annenberg Institute for School Reform at Brown University*.

Xie, J., Cho, K. W., Wei, T., Xu, J., & Fan, M. (2025). The effects of academic emotions on learning outcomes: A three-level meta-analysis of research conducted between 2000 and 2024. *Learning and motivation*, *90*, 102109. https://doi.org/10.1016/j.lmot.2025.102109

Yaseen, H., Mohammad, A. S., Ashal, N., Abusaimeh, H., Ali, A., & Sharabati, A.-A. A. (2025). The Impact of Adaptive Learning Technologies, Personalized Feedback, and Interactive AI Tools on Student Engagement: The Moderating Role of Digital Literacy. *Sustainability*, *17*(3), 1133. https://doi.org/10.3390/su17031133

Yazan, B. (2015). Three Approaches to Case Study Methods in Education: Yin, Merriam, and Stake. In (Vol. 20, pp. 134–152). Fort Lauderdale: Nova Southeastern University, Inc.

Yin, R. K. (2018). *Case study research and applications : design and methods* (Sixth edition. ed.). Sage.

Yue, M., Jong, M. S.-Y., & Dai, Y. (2022). Pedagogical Design of K-12 Artificial Intelligence Education: A Systematic Review. *Sustainability*, *14*(23), 15620. https://doi.org/10.3390/su142315620

Zepeda, C. D., Hlutkowsky, C. O., Partika, A. C., & Nokes-Malach, T. J. (2019). Identifying Teachers' Supports of Metacognition Through Classroom Talk and Its Relation to Growth in Conceptual Learning. *Journal of Educational Psychology*, *111*(3), 522–541. https://doi.org/10.1037/edu0000300.supp

Zhai, C., Wibowo, S., & Li, L. D. (2024). The effects of over-reliance on AI dialogue systems on students' cognitive abilities: a systematic review. *Smart Learning Environments*, *11*(1), 28–37. https://doi.org/10.1186/s40561-024-00316-7

Zhai, N., & Ma, X. (2023). The Effectiveness of Automated Writing Evaluation on Writing Quality: A Meta-Analysis. *Journal of Educational Computing Research*, *61*(4), 875–900. https://doi.org/10.1177/07356331221127300

Zliobaite, I., Bifet, A., Gaber, M., Gabrys, B., Gama, J., Minku, L., & Musial, K. (2012). Next challenges for adaptive learning systems. *SIGKDD Explorations*, *14*(1), 48–55. https://doi.org/https://doi.org/10.1145/2408736.2408746

Appendix A

Adaptive Learning System (ALS) Shortlist

Last updated on 17 Oct 2022

Consideration	Fast ForWord https://www.carnegielearning.com/solutions/literacy-ela/fast-forword/	iReady https://www.curriculumassociates.com/programs/i-ready-learning/personalized-instruction	Quindew https://quindew.com/
Target Audience	K-12 (Kindergarten to Pre-University equivalent)	K-8 (Kindergarten to Secondary 2 equivalent)	Grade 1-12 (Primary 1 to Pre-University equivalent)
Key Features	**Reading Assistant Plus** which offers real-time corrective feedback from a virtual personal tutor	**Diagnostic assessment**: adaptive assessments that pinpoints student ability level and identifies the specific skills students need to learn	**Reading assessment** that includes diagnostic, benchmark and summative assessments that tracks students' progress and measure their growth
	Learning data where students receive easy-to-interpret progress reports and teachers see progression and reading gains made by students	**Diagnostic data**: diagnostic reports for individual students and for the class, also offers suggestions for instructional groupings **Growth data**: reports that track how students progress toward growth measures, for both individual students and for the entire class	**Learning dashboard** where the teacher can access both the class dashboard and student dashboards to review and manage student information and learning
	Gamification features for engaging and motivating students to make progress on their learning	**Toolbox**: resources to support teacher-led instruction and scaffold comprehension	**Gamification features** and **nudges** to motivate students and help them stay on course

Consideration	**Fast ForWord** https://www.carnegielearning.com/solutions/literacy-ela/fast-forword/	**iReady** https://www.curriculumassociates.com/programs/i-ready-learning/personalized-instruction	**Quindew** https://quindew.com/
	For more details, please refer to attachment: FF Flyer.pdf FF Flyer 110412_SG.docx FF Flyer 110412_SG.docx	More details here: https://ebooks.curriculumassociates.com/story/assessment-for-instruction/page/4	More details here: https://quindew.com/free-reading-program-features
Teacher Onboarding	**Demo accounts** will be provided free of charge to teachers to familiarise themselves with the tool prior to commencement of the subscription period	**Demo accounts** and **training** (if needed) will be provided free of charge to teachers to familiarise themselves with the tool prior to commencement of the subscription period	**N.A.**
Cost	**$2,800 ($2,996 w/ GST) for 3 months subscription** Subscription cost per student is $72 for 3 months and $100 for 6 months. Minimum number of licenses per school is 40 Teacher account(s) is provided free of charge *Pending confirmation with vendor if GST will be charged*	**$2,800 ($2,996 w/ GST) for 12 months subscription** Annual subscription cost per student is $56 ($59.92 w/ GST) Minimum number of licenses per school is 50 Teacher account(s) is provided free of charge Only annual subscription plans are available	**Free**

Appendix B

Fast ForWord Elements I and Reading Comprehension

The information presented below was extracted from *Fast ForWord Scope & Sequence Guide* provided by Carnegie Learning. It comprised (a) the scope of skills covered by Elements I and Reading Comprehension, and (b) an overview of the exercises available to students.

(A) Scope for Elements I and Reading Comprehension

Skills	Elements I	Reading Comprehension	Skills Definition
Pre-Reading Skills			
Auditory Sequencing	●		The ability to understand and recall the order of sounds and words.
Auditory Word Recognition			The ability to identify spoken words and distinguish between similar-sounding words.
Listening Accuracy	●		The ability to discriminate between speech sounds and to correctly identify sounds and sound sequences.
Language Skills			
English Grammar		●	The ability to understand the structural features of the English language, including syntactic features like word order and parts of speech, and morphological features like prefixes, suffixes, plurals, and subject-verb agreement.
Capitalization & Punctuation			The ability to apply knowledge of print conventions to clarify the meaning of sentences and their elements when reading.
Spelling			The ability to apply knowledge of letter-sound mappings, spelling rules and patterns, and irregular spellings to create a visual representation of a word.

Skills	Elements I	Reading Comprehension	Skills Definition
Word Learning Strategies		●	The ability to clarify the meaning of unknown words using strategies such as morphemic and contextual analysis.
Academic Language		●	The ability to use the language needed for success in school, including general academic words (which appear frequently in print, but rarely in social conversations), discipline-specific terms, and multiple meaning words.
Speaking and Listening Skills			
Following Directions		●	The ability to attend to and retain details, then plan an appropriate sequence of steps to carry out verbal instructions.
Listening Comprehension			The ability to listen to and comprehend spoken language and derive meaning from oral texts.
Foundational Reading Skills			
Phonological Awareness	●		The ability to recognize and manipulate units of sound in spoken language such as words, syllables, onset and rime, and phonemes.
Print Concepts			The ability to approach print with an understanding of its organization and basic features, to recognize and name all upper and lower case letters of the alphabet, and to interpret punctuation.
Phonics		●	The ability to relate speech sounds to specific letters and apply that knowledge to the process of sounding out and reading words.
Word Structure & Knowledge		●	The ability to recognize and apply knowledge of words and word parts such as morphemes.
High-Frequency Words			The ability to quickly and automatically read and understand common high-frequency words.
Fluency		●	The ability to read texts with accuracy, appropriate rate, and expression to support comprehension.
Monitoring Comprehension		●	The ability of learners to recognize whether they understand what they are reading, and if necessary, to

Skills	Elements I	Reading Comprehension	Skills Definition
			take steps to repair their comprehension before continuing to read.
Reading Informational or Literary Texts			
Craft & Structure		●	The ability to describe the overall structure (e.g., cause/effect, problem/solution) of events, ideas, concepts, or information in a text or part of a text.
Drawing Inferences		●	The ability to refer to details and examples in a text to draw inferences from it.
Interpreting Visual Information		●	The ability to use information gained from illustrations and the words in a text to demonstrate understanding of the text.
Key Ideas & Details		●	The ability to distinguish key ideas from supporting details, and to summarize the text.
Cognitive Learning Skills			
Memory	●	●	The ability to use both working memory and long-term memory to understand and retain information. Working memory is the capacity to keep information in mind over the short term, while integrating or manipulating it. Long-term memory is the capacity to store and retrieve information over hours, days, or years.
Attention	●	●	The ability to focus on specific information, to sustain that focus, and to ignore distractions, while carrying out a task.
Processing	●	●	The ability to rapidly interpret and integrate auditory and/or visual information. For example, interpreting a complex burst of acoustic information to identify a phoneme, or integrating a set of lines and curves to recognize a letter.
Sequencing	●	●	The ability to track the order of things like the sounds in a word, the words in a sentence, the sentences in a paragraph, or the events in a timeline.

(B) Overview of Fast ForWord Exercises Available to Students

Elements I

Exercise	Goal/Task	Language/Reading Skills	Cognitive Skills
AI Assistant	Develop English grammar and vocabulary skills by identifying the picture that best represents a sentence or answers a question.	• English Grammar • Word Structure & Knowledge • Listening Comprehension	• Memory • Attention • Processing • Sequencing
Ocean Explorer	Develop listening accuracy and auditory sequencing skills by reproducing a sequence of two sound sweeps.	• Listening Accuracy • Auditory Sequencing	• Memory • Attention • Processing • Sequencing
SonoLab	Develop listening accuracy skills by detecting when a new syllable interrupts a repeated syllable.	• Listening Accuracy • Phonological Awareness	• Memory • Attention • Processing
Space Salvage	Develop auditory word recognition and phonological awareness skills by matching pairs of syllables and words.	• Listening Accuracy • Auditory Word Recognition • Phonological Awareness	• Memory • Attention • Processing

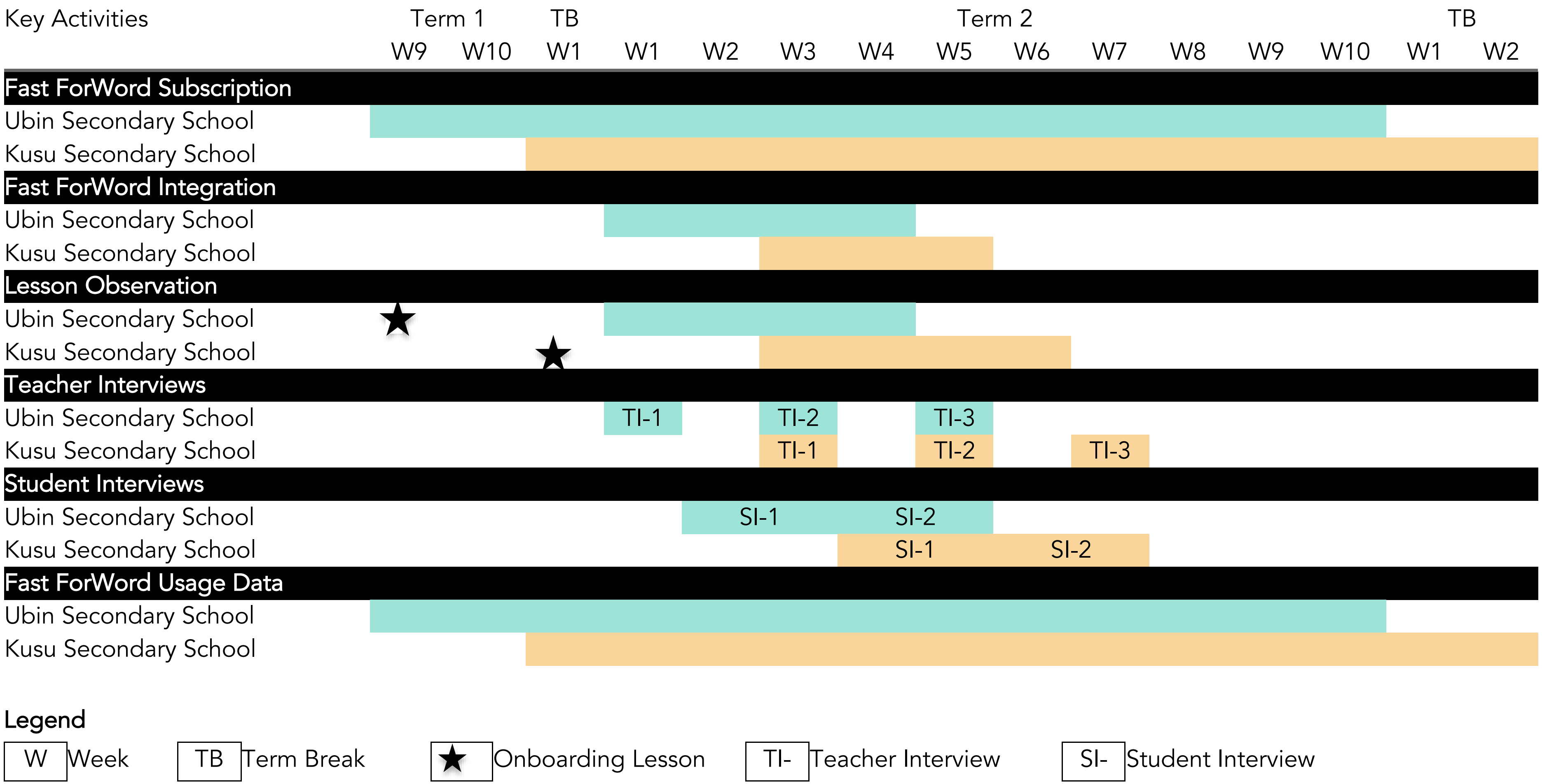
Reading Comprehension

Exercise	Goal/Task	Language/Reading Skills	Cognitive Skills
Art Walk	Develop reading comprehension skills by manipulating grammatical forms and structures to construct sentences about visual information.	• English Grammar • Word Structure & Knowledge • Fluency • Word Learning Strategies • Academic Language • Independent Reading • Monitoring Comprehension	• Memory • Attention • Processing • Sequencing

Exercise	Goal/Task	Language/Reading Skills	Cognitive Skills
		• Interpreting Visual Information	
Cognobot	Develop reading comprehension skills by answering literal, cause-and-effect, relationship, and inferential questions about fiction and nonfiction texts, schedules, instructions, and tables.	• Following Directions • Fluency • Word Learning Strategies • Academic Language • Key Ideas & Details • Independent Reading • Monitoring Comprehension • Craft & Structure • Drawing Inferences • Interpreting Visual Information	• Memory • Attention • Processing • Sequencing
Data Stream	Develop reading comprehension strategies by answering questions about fiction and nonfiction texts, and working with graphic organizers and summaries.	• Fluency • Word Learning Strategies • Academic Language • Key Ideas & Details • Independent Reading • Monitoring Comprehension • Craft & Structure • Drawing Inferences • Interpreting Visual Information	• Memory • Attention • Processing • Sequencing
Print Shop	Develop reading comprehension skills by selecting the correct paraphrase of a narrative text.	• English Grammar • Word Structure & Knowledge • Fluency • Key Ideas & Details • Independent Reading • Monitoring Comprehension	• Memory • Attention • Processing • Sequencing
Road Trip	Develop reading comprehension skills by selecting the right word to complete a sentence.	• Phonics • Word Structure & Knowledge • Fluency • Word Learning Strategies • Academic Language • Independent Reading • Monitoring Comprehension	• Memory • Attention • Processing • Sequencing

Appendix C

Data Generation Timeline



Appendix D

Enactment of Selected Lesson Unit by Participating Teachers

(A) Enactment of Lesson Unit in Ubin Secondary School (Mar – Apr 2023)

Mr Tan's intention was to use three of the four lessons each week (on Tuesday, Wednesday, and Friday) to complete the lesson unit on Reading Comprehension. The 35-minute lesson on Thursday was designated to alternate between editing practice and time for students to use Fast ForWord in the Computer Lab. However, this plan practically did not materialise for any of the four weeks dedicated to the teaching of this lesson unit.

From the table below, it is evident that there was some disruption to lessons every week. In Week 1, Mr Tan could not start on the unit as planned as he needed another lesson to complete the previous lesson unit on Effective Communications. In Week 2, due to Home-Based Learning (HBL) day[32], Mr Tan had to redesign a classroom lesson as a self-paced online learning experience. In Week 3, Mr Tan lost yet another lesson due to public holiday where schools were closed and in Week 4, Mr Tan was unable to come to class due to sickness[33].

Furthermore, considering that the Timed Practice lesson in Week 4 was akin to mock assessment and did not involve any teaching, the actual classroom time that Mr Tan had to teach and complete the lesson unit was much lesser than planned (coloured cells in the table below). Finally, it should also be noted that while visual text comprehension is part of reading comprehension, according to the national examination syllabus, the teaching syllabus

[32] This Home-Based Learning (HBL) day was communicated to the teachers at the staff meeting held one week earlier.

[33] The school leadership made the executive decision to run Wednesday's timetable on Monday that week, and this decision was communicated to teachers at the same staff meeting that informed them of the HBL day.

covered visual text comprehension separately and was thus not considered part of this lesson unit.

	Monday	Tuesday	Wednesday	Thursday	Friday
Week 1		70 mins Effective Communication	70 mins Factual Questions Quotation Questions	35 mins Editing Practice	35 mins Factual Questions Quotation Questions
Week 2		70 mins Home-Based Learning	70 mins Inferential Questions	35 mins Fast ForWord Lesson	35 mins Inferential Questions
Week 3		70 mins In-Your-Own Words Questions Global Questions	70 mins In-Your-Own Words Questions / Editing Practice	35 mins Global Questions / Visual Text Comprehension	35 mins (Public Holiday)
Week 4	70 mins (Teacher on Medical Leave)	70 mins Timed Practice		35 mins Fast ForWord Lesson	35 mins Visual Text Comprehension

(B) Enactment of Lesson Unit in Kusu Secondary School (Apr 2023)

Kusu Secondary School operated a fortnightly class timetable where Ms Aliyah saw the class three times each week. Total lesson duration for odd weeks was two hours 40 minutes and that for even weeks was three hours. According to the scheme of work, Ms Aliyah planned to complete the lesson unit on Discursive Writing in four weeks. This was to ensure that students were ready for their weighted assessment at the end of this unit. As this assessment counted toward their final grade awarded at the end of the year, the submission deadline could not be extended, and Ms Aliyah also had to ensure that students' grades were submitted by the marking deadline.

However, due to a bout of sickness the week before, which kept her away from school for two days, she was unable to complete the previous lesson unit on Listening Comprehension in time. Coupled with losing another 60-minute lesson to the mass vaccination exercise, Ms Aliyah did not manage to start on Discursive Writing until the second week of the classroom lesson observation. Furthermore, another 60-minute lesson in Week 4 was cancelled due to public holiday where schools were closed, resulting in even less time to complete the lesson unit on Discursive Writing (coloured cells in the table below).

	Monday	Tuesday	Wednesday	Thursday	Friday
Week 1	60 mins Listening Comprehension	60 mins (Mass Vaccination Exercise)	40 mins[34] Listening Comprehension		
Week 2	60 mins Listening Comprehension	60 mins Topical Discussion: Teenage Life		60 mins Creating an Infographic	
Week 3	60 mins Creating an Infographic	60 mins Discursive Writing Introduction Writing Hooks	40 mins Writing Hooks		
Week 4	60 mins (Public Holiday)	60 mins Writing Thesis Statements		60 mins Writing Body Paragraphs Writing Conclusions	

[34] I was unable to observe and record this 40-minute lesson due to scheduling conflict as I had to be in Ubin Secondary School at the same time for another classroom lesson observation.

Appendix E

Teacher Interview Protocols

Protocol for First Teacher Interview

Warm Up Questions about Interviewee (5 min)

1. Invite the teacher to introduce himself/herself.
    a. Years in service
    b. Years in school
    c. [If applicable] previous school and/or HQ posting(s)

Questions about the Class and Students (10 min)

2. Invite the teacher to share more about the class to be observed.
    a. Academic performance, i.e., where they stand among the rest of the cohort, the range or type of learners in the class.
    b. Social emotional observations, i.e., what are the cliques, and who are the ringleaders or lone rangers.
3. [If the teacher did not touch upon that in Q2] Invite the teacher to share more about the enthusiastic contributors in class, and when or whether their contributions are constructive and/or disruptive.
4. Invite the teacher to share more about students in the class who tend to go unnoticed 'fall under the radar' and how s/he currently engages them or ensure that they are not neglected.

Questions about FFW Onboarding (10 min)

5. Invite the teacher to share how he onboarded the class to FFW and his rationale for doing so.

6. Invite the teacher to share how he felt about the onboarding process and his perception of students' response.

Questions about the Teacher's Experience Using FFW (20 min)

7. Invite the teacher to share his/her first impressions of FFW, i.e., what s/he likes or dislikes, most used feature, least used feature. <u>Additional Prompt</u>: How did the teacher onboarded himself/herself to using this tool?

8. Invite the teacher to share how s/he has been using FFW, e.g., how often does she log into the teacher and/or demo account, what does s/he do each session and how does that support (or not) his/her lesson preparation.

9. Invite the teacher to predict students' responses to FFW, including what they might like and dislike about it as well as anticipated student struggles. <u>Additional Prompt</u>: How would these affect the teacher's plans for classroom instruction and learning?

Questions about the Selected Topic for FFW Integration (15 min)

10. Invite the teacher to share about their choice of topic to teach with FFW, i.e., what was the topic chosen and why it was chosen.

11. Invite the teacher to share how s/he intend to use FFW in and out of class, and what s/he has asked students to do on the FFW thus far.

12. Invite the teacher to reflect on how FFW has been a hindrance and/or helpful to his/her classroom teaching.

Protocol for Second and Third Teacher Interviews

Warm-Up (10 min)

1. Invite the teacher to share what s/he had hoped to achieve through the week's lessons and if s/he has achieved those goals.

Questions About the Week's Lessons (20 min)

2. Invite the teacher to share her top 3 moments of the week, where s/he felt the lesson went well and what about the segment and/or interaction that had a positive effect on him/her.
3. Invite the teacher to share her lowest points in class that week, and on hindsight, if she would have responded differently from the way she did. <u>Additional prompt</u>: Did the teacher adjust her subsequent lesson(s) in anyway, following the episode?
4. Invite the teacher to share his/her perspectives on teacher-student interaction over the past week and her aspirations for the next week.
5. Invite the teacher to consider, if s/he had the opportunity to return to last week, what would s/he do differently?

Questions About Teacher's Use of FFW (20 min)

6. Invite the teacher to share how s/he has been using FFW, e.g., how often does she log and what does s/he do each session.
7. Invite the teacher to share about how s/he has incorporated FFW in his/her lessons through the week.
8. Invite the teacher to share how s/he has made use of FFW (data) in her lesson preparation, if at all.
9. Invite the teacher to share his/her observations about how students are using or not the FFW as assigned.
10. Invite the teacher to share his/her intentions for integrating FFW with classroom learning in the coming week(s).

Appendix F

Student Interview Protocols

Protocol for First Student Interview

Warm Up Questions about Interviewee (5 min)

1. Invite the student to introduce himself/herself.
    a. Co-curricular activity(s)
    b. Hobbies and interests
    c. Habits of using mobile devices and social media

Question about the Student and his/her Participation (10 min)

2. Invite the student to share about their classroom learning so far.
    a. Describe their most memorable lesson (+/-), what they enjoyed most and what they enjoyed least so far.
    b. How they have participated in class discussions, and why they did or did not participate in the instances mentioned.
3. Invite the student to reflect on their own participation, i.e., if they would see themselves as vocal or quiet learners. (If applicable: Explore with the student what discouraged active participation).
4. Invite the student to reflect on how the teacher tried to encourage student participation during class discussions and if the teacher's efforts were effective, in general and for the student personally.

Questions about FFW Onboarding (10 min)

5. Invite the student to share how FFW as introduced to the class, and what he liked and disliked about the onboarding process.
6. Invite the student to share if s/he experienced any initial struggle(s) using FFW, and how s/he overcome these struggles and if the onboarding process helped in anyway.

Questions about the Student's Experience Using FFW (20 min)

7. Invite the student to share about their use of FFW in the past week e.g., frequency of use and duration of use per session. Additional Prompt: Did the student use the FFW beyond the teacher's instructions? What did they enjoy most and enjoy least about FFW?
8. Review together with student the screen recording of their FFW use. Invite students to reflect on how they made use of FFW, what features did they use most frequently, what feature(s) did they find most useful and what features they ignored. Encourage students to postulate why this might be the case.

Questions about the FFW and Classroom Learning (10 min)

9. Invite the student to rate the usefulness of FFW and solicit reasons for their rating. Additional Prompt: Did using the FFW made students feel better prepared for the lesson?
10. Invite the student to reflect on their expectations of their teacher in terms of FFW use, e.g., did the student expect the teacher to check their FFW work, or refer to it during the next lesson?

Questions about Students' Readiness to Learn (5 min)

11. Invite the student to reflect if the use of FFW has made them feel better able to participate in class discussions, and why this is so.
12. [Last question before concluding the interview] Invite the student to rate on a scale of 1 to 10, how s/he feels about her academic interactions in class over the past week and share why s/he has rated as such.

Protocol for Second Student Interview

Warm-Up (10 min)

1. Invite the student to share how they use technology to learn over the past week, e.g., the tools used, and the frequency of use.

Questions about the Week's Lessons (20 min)

2. Invite the student to share how they have participated in class discussions over the past week, and why they did or did not participate in the instances mentioned.
3. Invite the student to reflect on the past week's lessons, if there were any moments where they wanted to participate but did not. Explore with the student what stopped them from doing so.
4. Invite the student to reflect if the use of FFW has made them feel better able to participate in class discussions, and why this is so.
5. Invite the student to rate on a scale of 1 to 10, how s/he feels about her academic interactions in class over the past week and share why s/he has rated as such.

Questions about the Student's Use of FFW (20 min)

6. Invite the student to share about their use of FFW in the past week e.g., frequency of use and duration of use per session. Additional Prompt: Did the student use the FFW beyond the teacher's instructions? What did they enjoy most and enjoy least about FFW?
7. Invite students to reflect on how they made use of FFW, what features did they use most frequently, what feature(s) did they find most useful and what features they ignored. Encourage students to postulate why this might be the case.
8. Invite students to consider how their teacher has been supporting (or not) their use of FFW, e.g., taking them to the Computer Lab and monitoring their progress.

Appendix G

Teacher and Student Interview Coding Scheme

Category: Fast ForWord Onboarding

Code	Reference Sample
Teacher actions (teacher articulation)	that day I gave out all the passwords and the user names and then I just got them to the RPI. So that was our onboarding. – Ms Aliyah
Teacher actions (student articulation)	He brought us to the library. Then he was telling us all about the benefits of Fast ForWord and how is it going to impact us on the learning? And then, and then he brought us to the Computer Lab, to like, give us a demonstration on how to use Fast ForWord another time. – M10
Teacher expectations of students (teacher articulation)	I just reminded them about the expectations, that they have to log in at least three times, and I actually told them that, this will be in lieu of the book reports that the rest of the students in other classes are doing. – Mr Tan
Teacher expectations of students (student articulation)	I think she mentioned that we should like just try and log in whenever we can. Because yeah, if I'm not wrong is whenever we can, whenever we can. – F27
Teacher expectations of Fast ForWord	I tried to use the demo account but it got a little bit frustrating also because in a sense, they don't actually tell you what's the answer, especially for the RPI. Right? So it's like, I wasn't sure where I stood. I wanted to know where I stood as well. – Ms Aliyah
Student expectations of Fast ForWord	–
Student reactions to onboarding experience (teacher articulation)	there was some intense concentration, some of them. Some of them, the boys looked like they were having fun. – Ms Aliyah
Student reactions to onboarding experience (student articulation)	Yeah, I like the Comp Lab experience… Sometimes very hot day so I prefer the air-con. If not, almost every lesson, paper and pen dependent, like sometimes you have to go to the Computer Lab to like to do like Fast ForWord, it's like more fun. – F08

Code	Reference Sample
Teacher reactions to Fast ForWord	I kind of was feeling a bit lost, because the instructions simply were just let students do it on their own, and teachers just do hands off situation. And I felt a bit worried at that point in time, because if anything goes wrong, you know, and I need to know, the stuff and so on. So I would have appreciated a bit more direction actually, from the company itself. – Mr Tan
Student reactions to Fast ForWord	You must listen attentively because I kept struggling because I couldn't differentiate the sound. So I keep on getting wrong at that time. And that was the hardest, of the three activities. – M29

Category: Fast ForWord Integration

Code	Reference Sample
Student expectations of Teacher	I think I would prefer you take some time to go through the Fast ForWord because I'm a bit curious too, some of my classmates like if they did well in it or how well they did in it. – M34
Student expectations of Self	–
Teacher monitoring students' Fast ForWord usage	I will login extremely infrequently. Essentially, I just go into just check because ultimately what I've been talking to is that I will have hands off for them and so on. – Mr Tan
Teacher plans to integrate Fast ForWord	I'm actually Still thinking about it? Because of the way it is set, it will be good if it could be something like I could also choose the type of activity that I want to assign to the students, because then it will be more relevant to what I'm doing at the moment. I know it's supposed to, the system is supposed to follow the students ability, right? But that also means that the students all might be at different levels. – Ms Aliyah
Teacher actions to integrate Fast ForWord	So the best thing I can do essentially is to remind them about how reading and ... understanding the question, understand the passage and answering the questions. They are both important. They're both equally important to reading comprehension. – Mr Tan
Teacher struggles to integrate Fast ForWord	So it's very difficult because I can't really tell with Fast ForWord, even though I know that it's supposed to be something that they do on their own. Right. So suppose to be self paced and all that but it gets a little bit frustrating because I am not able to talk about it with them. – Ms Aliyah

Code	Reference Sample
Student Preparedness to Learn (teacher articulation)	–
Student Preparedness to Learn (student articulation)	It [Fast ForWord] creates the experience even before you actually learn it so that when it's first taught then you won't struggle and understand. – M10
Student Class Participation (teacher articulation)	Firstly, if I asked questions, it would be easier to get responses rather than having to really name each student to answer my question. Of course, sometimes I get answers from the same people. So it's like, I also feel very bad when I sort of ignore them and then try to get somebody else to answer but it's really about getting responses. – Ms Aliyah
Student Class Participation (student articulation)	the activities I've done gave me more confidence when I was doing my listening compre for sure. Because I definitely didn't understand what's going on but to make me be more willing to participate maybe not because it's not if you can do it. I mean it does say you can do it after every like a few few questions, but it's not in a sense, but I do want to show now for life just made me feel more confident. – M17

Category: Student Usage of Fast ForWord

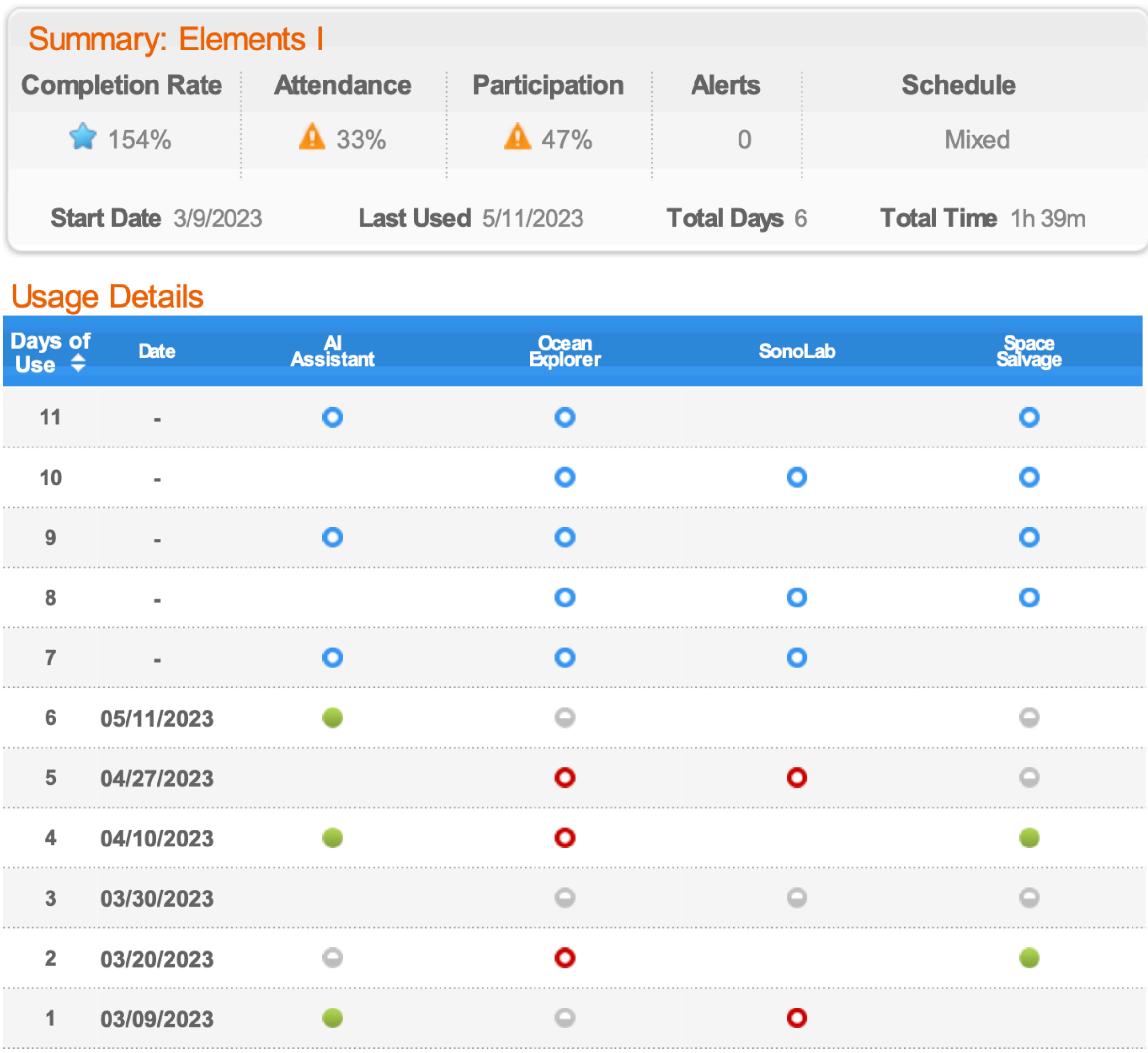
Code	Reference Sample
Student frequency of use	Maybe three times. I remember I didn't do it on weekends. I think around three times. – M32
Student duration of use (per login)	On Monday I, I stayed in fast forward for about, for about 15 minutes because I had homework to do and on, during the weekend which is on Saturday. I stayed on Fast ForWord for 30 minutes because I had more free time. – M15
Description of activities attempted	On last week, there was this activity. I react to those different tones. And then if you pressed three buttons they would give you an initial tone, whether it's a high tone or low tone, and you press three buttons, whichever correctly match that tone, you would unlock a piece of a puzzle. Then after you've done all of them, you will get a picture. – M10

Category: Student Evaluation of Fast ForWord

Code	Reference Sample
Perceived ease of using Fast ForWord	I mean, our teacher gave us a link so we just kept on learning immediately. Didn't really have a problem because I saved my password already. – M17
Perceived enjoyment of using Fast ForWord	Yes. It's very fun. I feel like my younger self will enjoy it more. Okay, because it's very colourful. And then there's the special effects and some really cool. – F26
Perceived usefulness of Fast ForWord	Fast ForWord really helped me like really helped me pay attention more and listen more in class. – M15

Appendix H

Sample Fast ForWord Usage Report (Individual Student)



Summary: Elements I

Completion Rate	Attendance	Participation	Alerts	Schedule
154%	33%	47%	0	Mixed

Start Date 3/9/2023 Last Used 5/11/2023 Total Days 6 Total Time 1h 39m

Usage Details

Days of Use	Date	AI Assistant	Ocean Explorer	SonoLab	Space Salvage
11	-				
10	-				
9	-				
8	-				
7	-				
6	05/11/2023				
5	04/27/2023				
4	04/10/2023				
3	03/30/2023				
2	03/20/2023				
1	03/09/2023				

Minutes/Questions

Days of Use	Date	AI Assistant		Ocean Explorer		SonoLab		Space Salvage	
		Min	Ques	Min	Ques	Min	Ques	Min	Ques
6	05/11/2023	10	59	1	8	-	-	1	39
5	04/27/2023	-	-	0	-	0	-	8	266
4	04/10/2023	11	73	0	-	-	-	7	201
3	03/30/2023	-	-	10	93	6	45	1	39
2	03/20/2023	8	45	0	-	-	-	12	187
1	03/09/2023	15	90	6	48	0	-	-	-

Start Time

Days of Use	Date	AI Assistant		Ocean Explorer		SonoLab		Space Salvage	
		Min	Start	Min	Start	Min	Start	Min	Start
6	05/11/2023	10	1:13 P	1	1:24 P	-	-	1	1:26 P
5	04/27/2023	-	-	0	-	0	-	8	1:12 P
4	04/10/2023	11	9:48 A	0	-	-	-	7	10:00 A
3	03/30/2023	-	-	10	1:18 P	6	1:15 P	1	1:29 P
2	03/20/2023	8	11:40 P	0	-	-	-	12	11:27 P
1	03/09/2023	15	2:25 P	6	2:42 P	0	-	-	-

Total Minutes

	AI Assistant	Ocean Explorer	SonoLab	Space Salvage
Total Time	44m	18m	6m	30m

Appendix I

Definitions of Communicative Acts

(Hennessy et al., 2016)

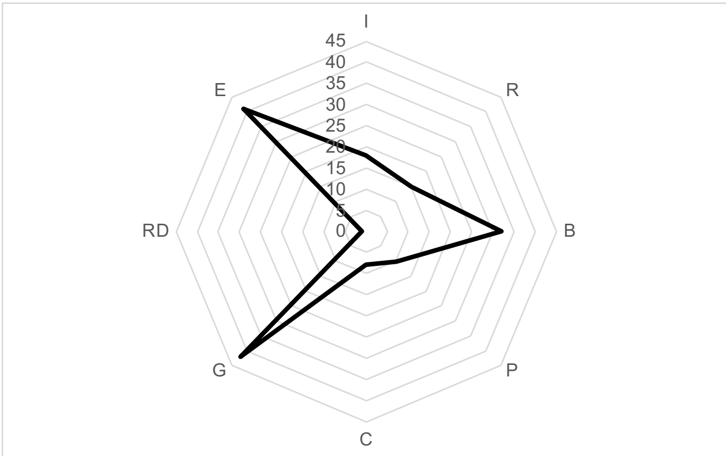
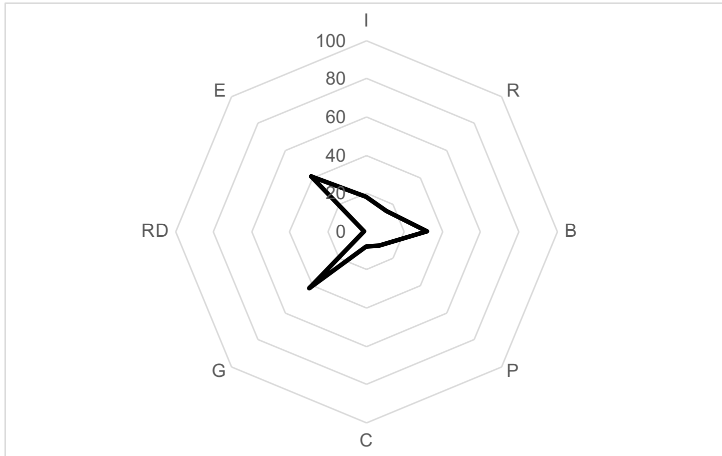
	Cluster		Communicative Act	Definition
I	Invite elaboration or reasoning	I1	Ask for explanation or justification of another's contribution	Ask participant(s) to explain or justify another's or collective ideas, reasoning or the process of arriving at a solution.
		I2	Invite building on / elaboration / (dis)agreement / evaluation of another's contribution or view	Use previous contribution to **elicit further** responses, inviting addition to or elaboration/ clarification/(dis)agreement/ positioning/ comparison/ evaluation of another's contribution or idea.
		I3	Invite possibility thinking based on another's contribution	**Invite speculation/** imagining**, hypothesis,** conjecture, or question posing based on another's contribution.
		I4	Ask for explanation or justification	Ask other(s) for **justification/** evidence or explanation of reasoning or the process of arriving at a solution.
		I5	Invite possibility thinking or prediction	**Invite speculation/** imagining**, hypothesis,** conjecture, or question posing.
		I6	Ask for elaboration or clarification	Probe/ask for clarification **or elaboration or extension or example.**
R	Make reasoning explicit	R1	Explain or justify another's contribution	Provide or elaborate **justification/ evidence** or explanation of another's reasoning or the process of arriving at a solution.
		R2	Explain or justify own contribution	Provide or elaborate **justification/ evidence** or explanation of own reasoning or the process of arriving at a solution.
		R3	Speculate or predict on the basis of another's contribution	Speculate, hypothesise, conjecture, imagine or express one or more different possibilities on the basis of another's contribution

	Cluster		Communicative Act	Definition
		R4	Speculate or predict	**Speculate, hypothesise**, conjecture, imagine or express one or more different **possibilities or theories**.
B	Build on ideas	B1	Build on/clarify others' contributions	**Build on**, **explain, clarify, revoice, elaborate, make explicit, highlight** or transform contributions provided by other(s) or collective idea, opinion or reasoning.
		B2	Clarify/elaborate own contribution	Clarify, **elaborate, exemplify** or extend **own** opinion/idea/ belief (without justification) or question.
E	Express or invite ideas	E1	Invite opinions/beliefs/ ideas	Invite the expression of **opinions/ideas/ beliefs/knowledge** from others.
		E2	Make other relevant contribution	Offer a pertinent, **contribution** /suggestion /idea / perspective/ information that progresses the collective activity at hand.
P	Positioning and Coordination	P1	Synthesise ideas	Synthesise or summarise others' or collective ideas
		P2	Evaluate alternative views	**Compare/ evaluate** different opinions/perspectives / beliefs.
		P3	Propose resolution	Propose a resolution after discussing a task, issue or problem.
		P4	Acknowledge shift of position	Participants acknowledge that they have **shifted their position** in response to the preceding dialogue.
		P5	Challenge viewpoint	Challenge viewpoint / assumption
		P6	State (dis)agreement/ position	State that one or more participants (dis)agree with others or acknowledge differences
RD	Reflect on dialogue or activity	RD1	Talk about talk	Participants talk about talk, reinforce protocols of dialogue, or model effective dialogic techniques.
		RD2	Reflect on learning process/ purpose/ value/ outcome	**Comment / talk about the process** of carrying out the collective activity or evaluate own performance. Or **reflect on the importance,** usefulness, purpose or outcomes of learning or of the task , as part of a collective activity.

	Cluster		Communicative Act	Definition
		RD3	Invite reflection about process/ purpose/ value/ outcome of learning	**Invite others to reflect** on the importance, usefulness, processes or outcomes of learning from collective activity.
C	Connect	C1	Refer back	**Refer back to prior contributions** or observations or knowledge objects or discussions after contributions.
		C2	Make learning trajectory explicit	Make learning trajectory explicit, providing continuity **within and across lessons**, including **by highlighting relevance to prior or future activity.**
		C3	Link learning to wider contexts	**Make links** between what is being learned and a **wider context**.
		C4	Invite inquiry beyond the lesson	Ask others to pursue their own inquiry before, or after lessons.
G	Guide direction of dialogue or activity	G1	Encourage student-student dialogue	Encourage student-student dialogues by giving pairs/groups or class the responsibility for the direction and/or outcomes of the dialogue or the collective activity.
		G2	Propose action or inquiry activity	**Propose possible courses of action or an inquiry activity**.
		G3	Introduce authoritative perspective	Explicitly introduce **authoritative perspective or explanation as part of the flow of dialogic interaction**, in response to participants' level of understanding.
		G4	Provide informative feedback	**Provide informative feedback** on which others can build.
		G5	Focusing	**Focusing the dialogue on key aspects of the activity**
		G6	Allow thinking time [optional when not verbally explicit]	**Invite or propose** to pause to think, reflect, or respond or talk.

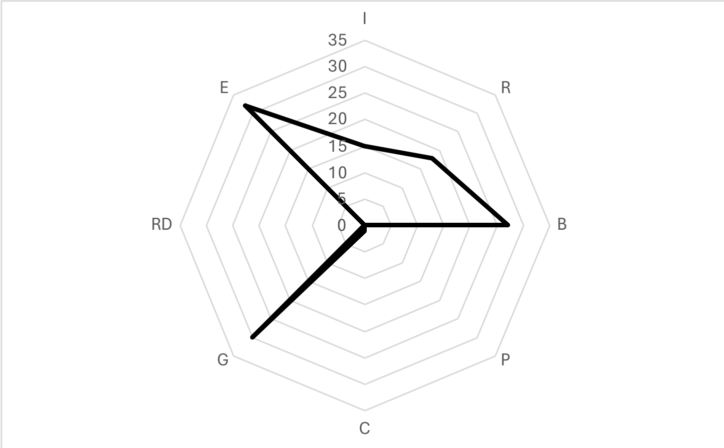
Appendix J

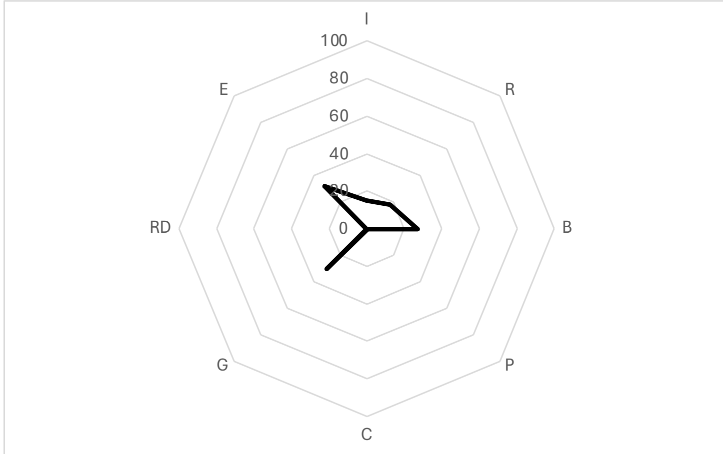
Distribution of Communicative Acts Observed in Mr Tan's Lessons

Lesson Information	Radar Chart (Raw Scale)	Radar Chart (Standardised Scale)
Lesson 1		
Unit Focus: Factual questions, Quotation questions Number of Communicative Acts: 167 Interaction Duration: 23 min 46 sec		

Lesson 2

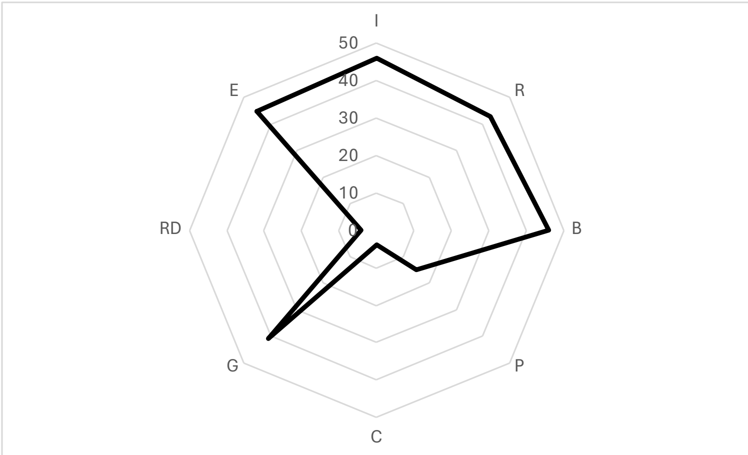
Unit Focus: Factual questions, Quotation questions
Number of Communicative Acts: 123
Interaction Duration: 17 min 09 sec

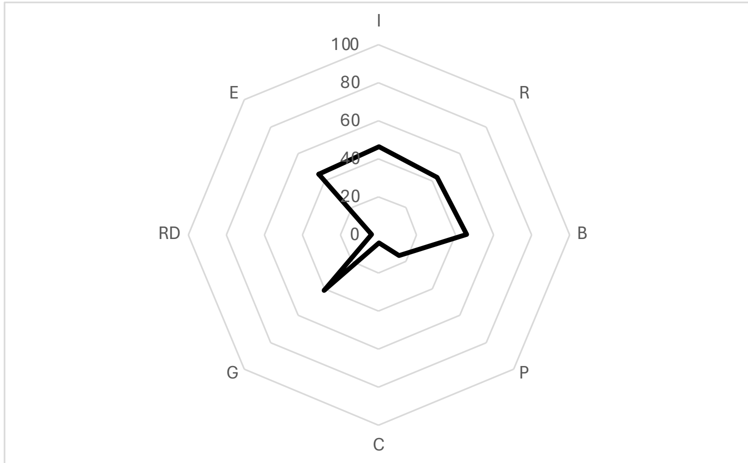




Lesson 3

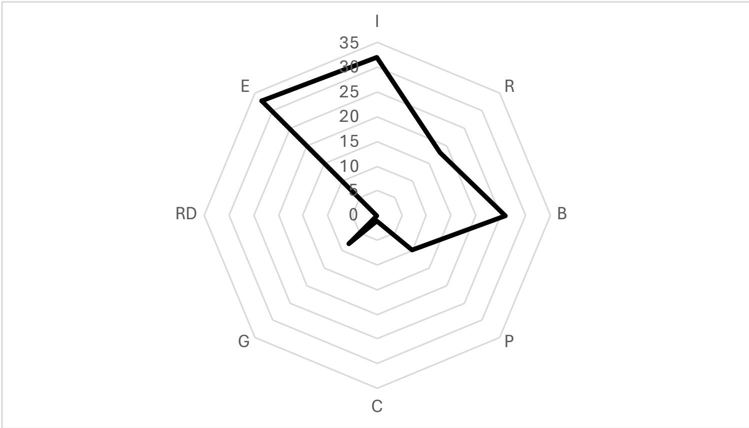
Unit Focus: Inferential questions
Number of Communicative Acts: 244
Interaction Duration: 27 min 58 sec

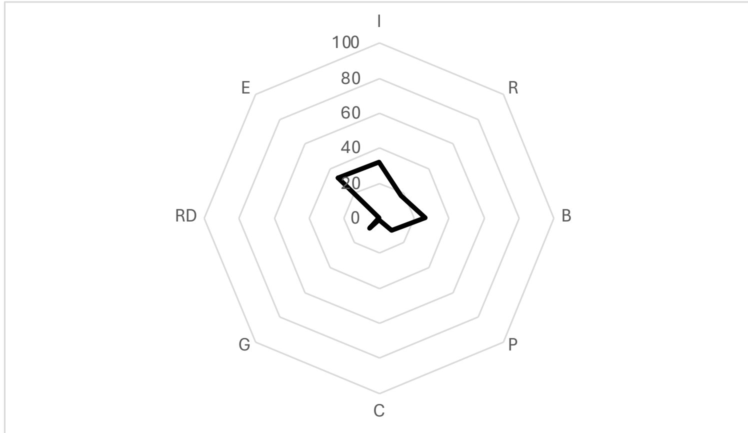




Lesson 4

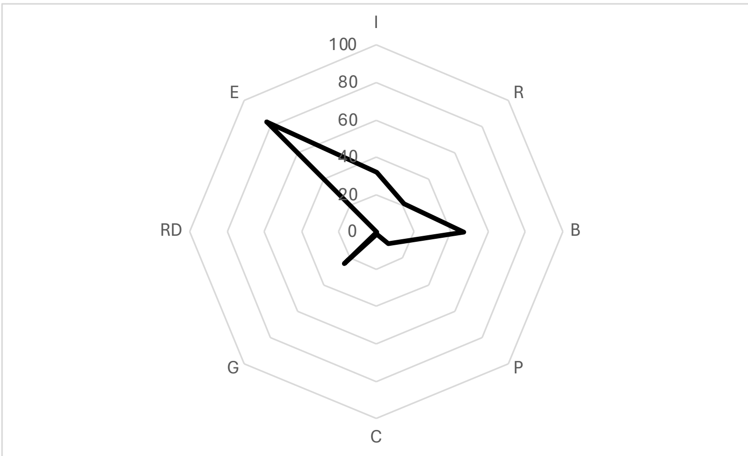
<u>Unit Focus</u>: Inferential questions
<u>Number of Communicative Acts</u>: 128
<u>Interaction Duration</u>: 17 min 16 sec

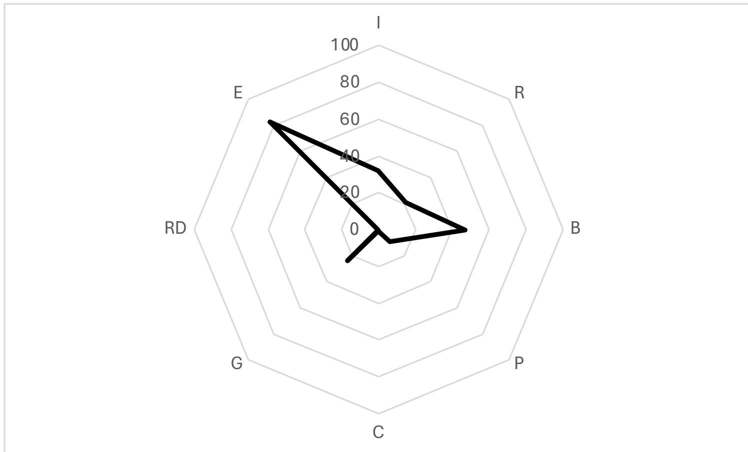




Lesson 5

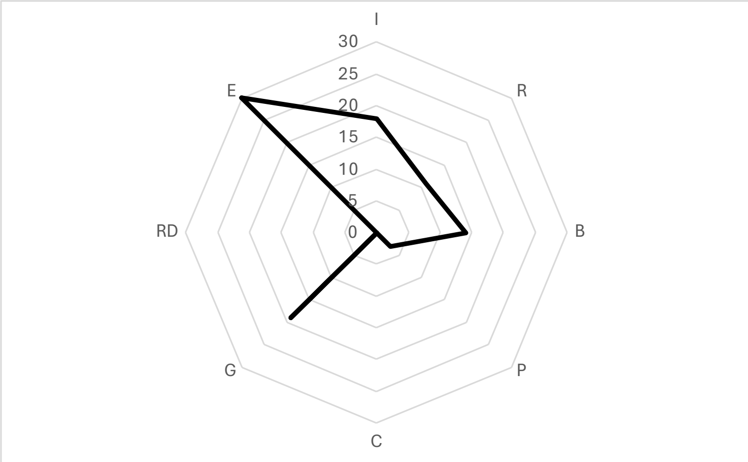
<u>Unit Focus</u>: In-your-own-words questions, Global questions
<u>Number of Communicative Acts</u>: 217
<u>Interaction Duration</u>: 28 min 43 sec

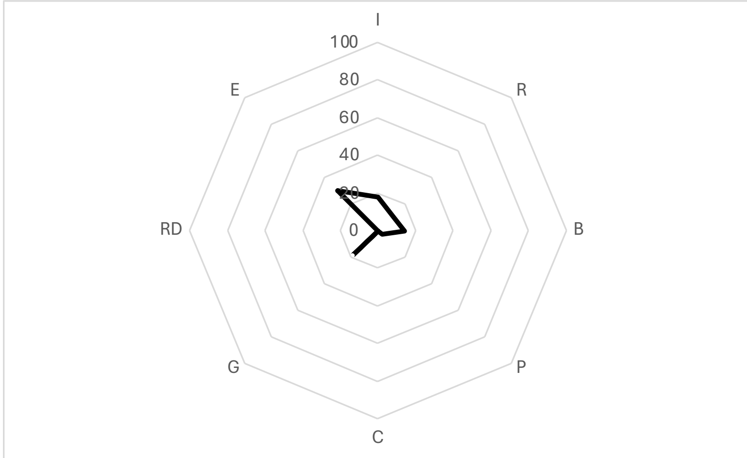




Lesson 6

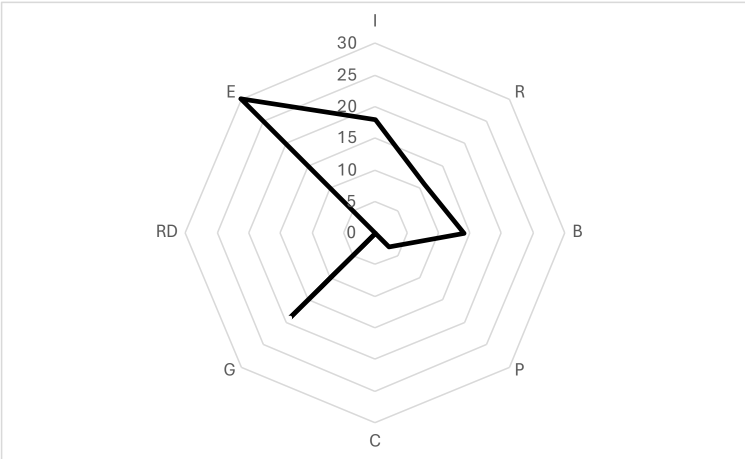
Unit Focus: In-your-own-words questions
Number of Communicative Acts: 95
Interaction Duration: 11 min 32 sec

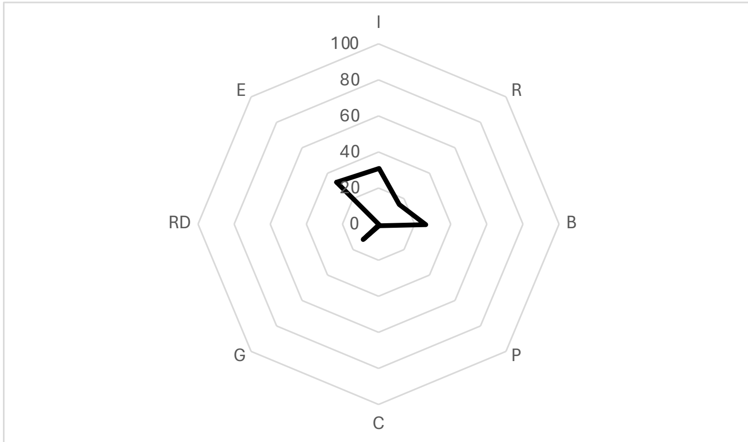




Lesson 7

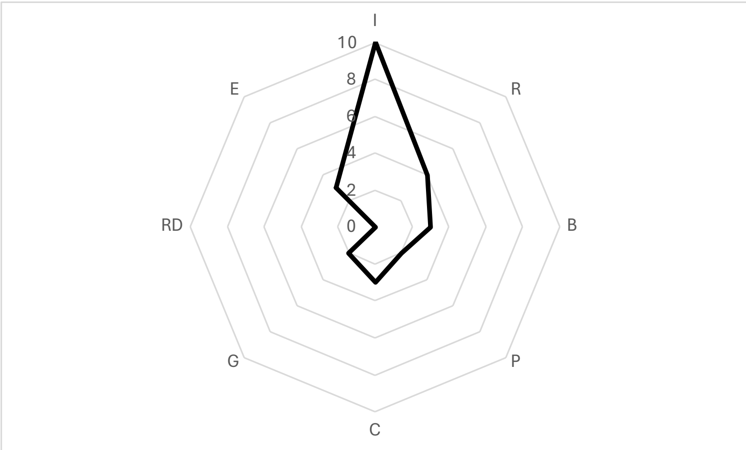
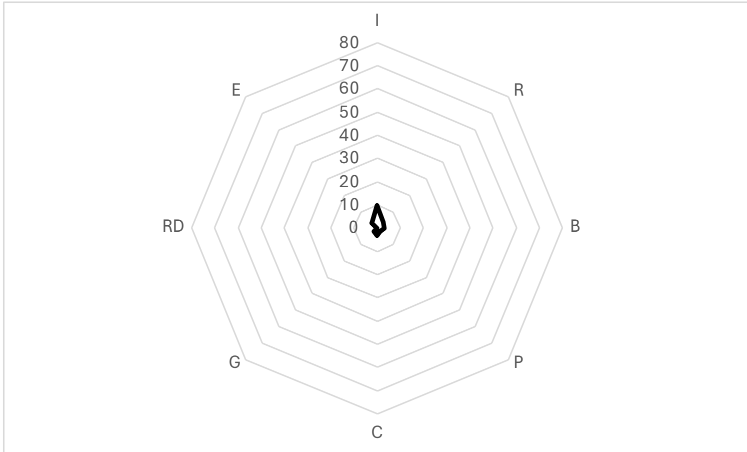
Unit Focus: Global questions
Number of Communicative Acts: 120
Interaction Duration: 16 min 08 sec





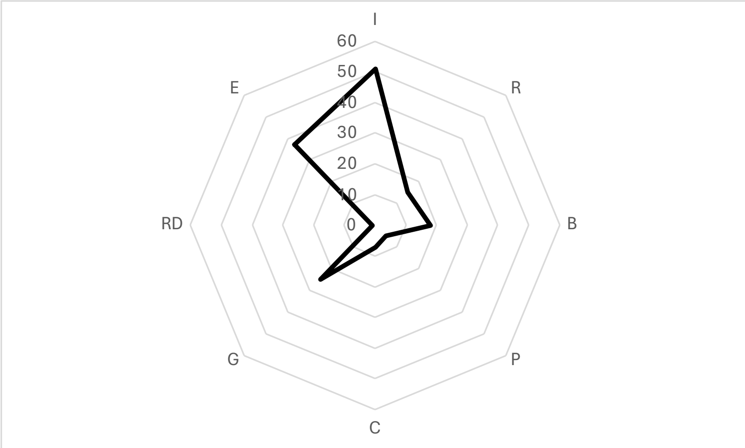
Appendix K

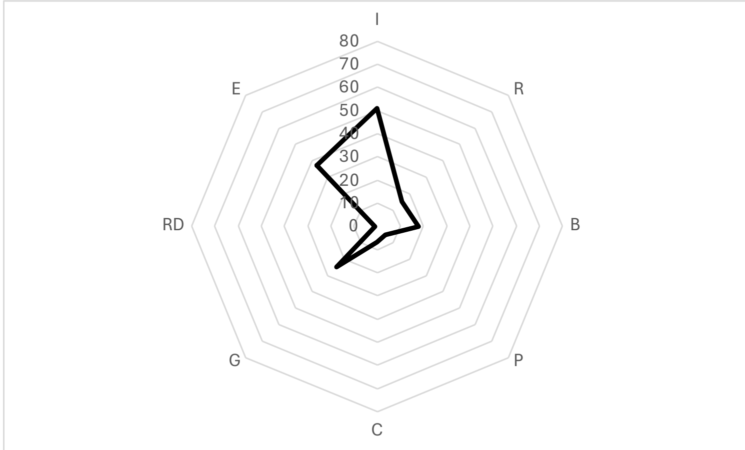
Distribution of Communicative Acts Observed in Ms Aliyah's Lessons

Lesson Information	Radar Chart (Raw Scale)	Radar Chart (Standardised Scale)
Lesson 1		
<u>Unit Focus</u>: Topical Discussion: Teenage Life <u>Number of Communicative Acts</u>: 27 <u>Interaction Duration</u>: 4 min 2 sec		

Lesson 2

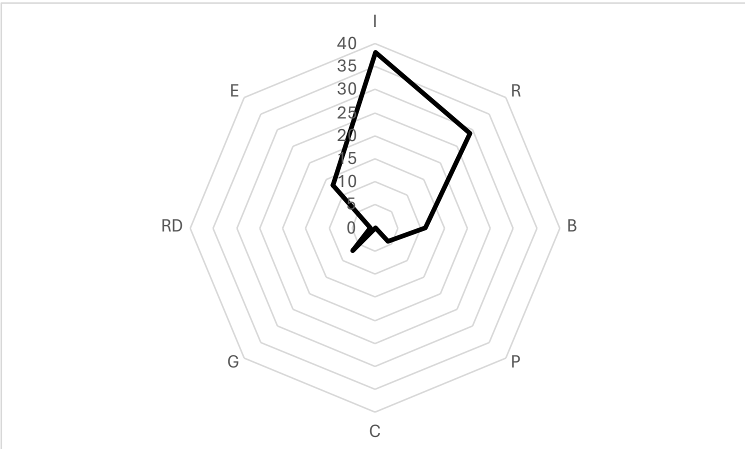
<u>Unit Focus</u>: Creating an Infographic
<u>Number of Communicative Acts</u>: 159
<u>Interaction Duration</u>: 21 min 16 sec

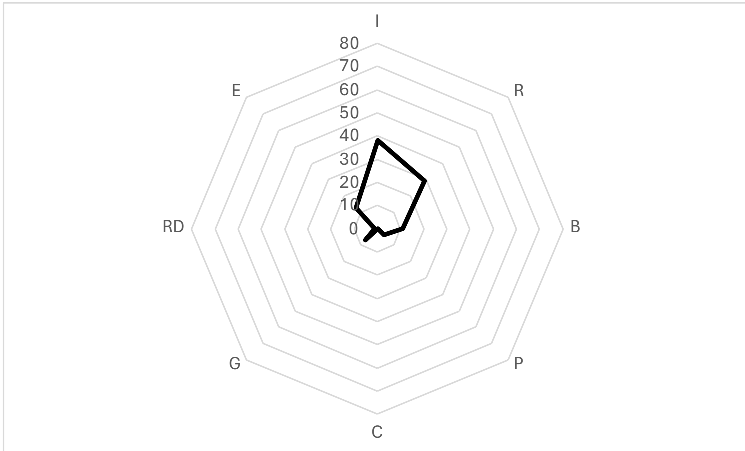




Lesson 3

<u>Unit Focus</u>: Creating an Infographic
<u>Number of Communicative Acts</u>: 103
<u>Interaction Duration</u>: 21 min 4 sec



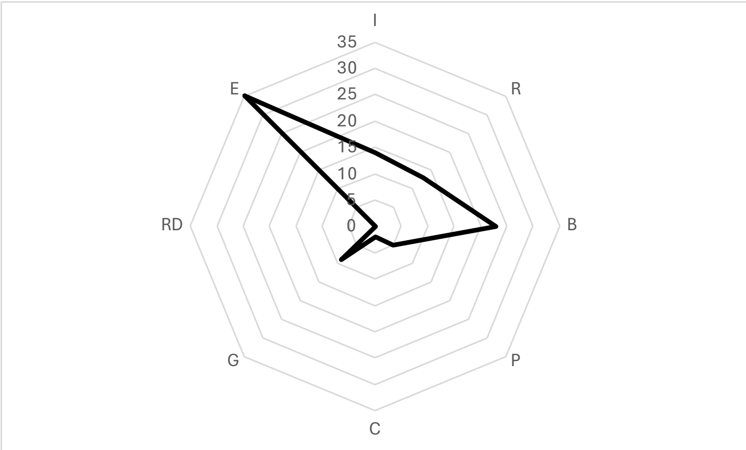


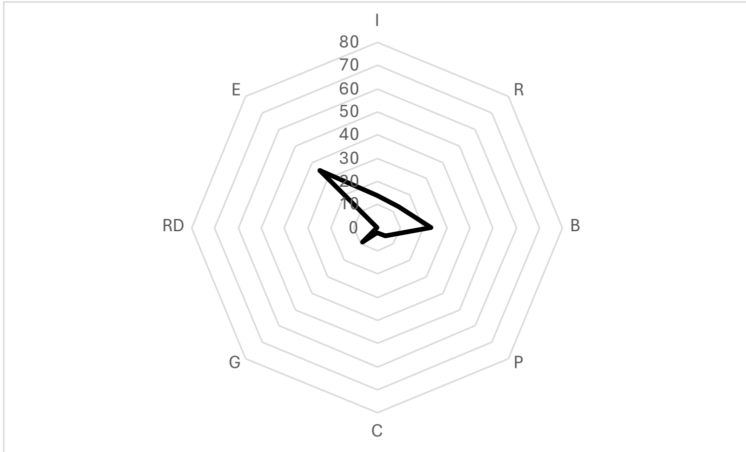
Lesson 4

Unit Focus: Discursive Writing Introduction; Writing Hooks

Number of Communicative Acts: 101

Interaction Duration: 16 min 44 sec



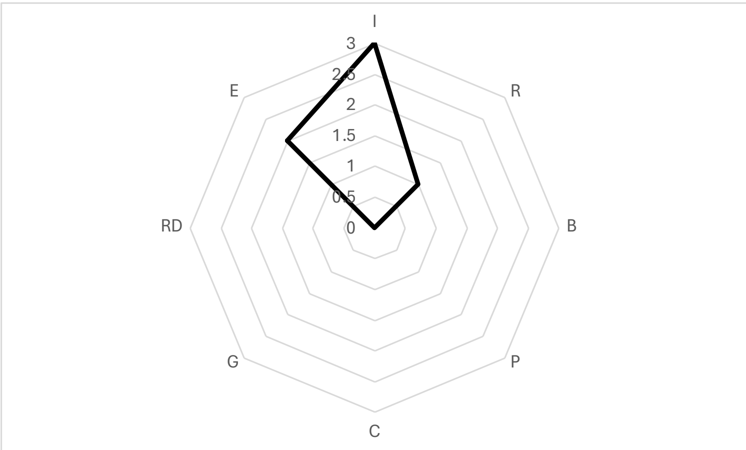


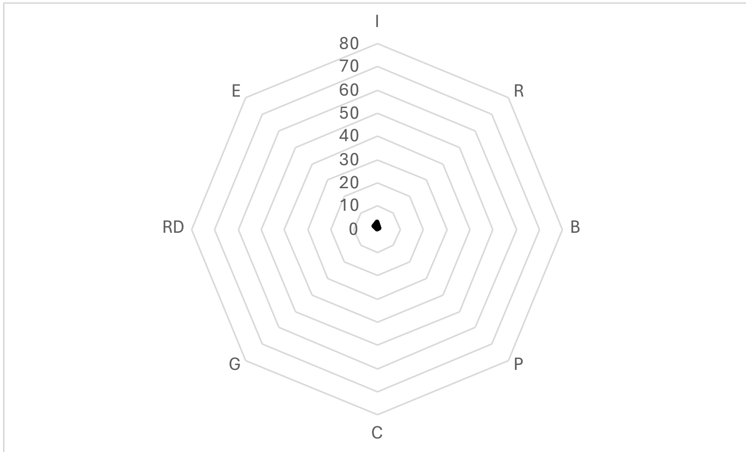
Lesson 5

Unit Focus: Writing Hooks

Number of Communicative Acts: 6

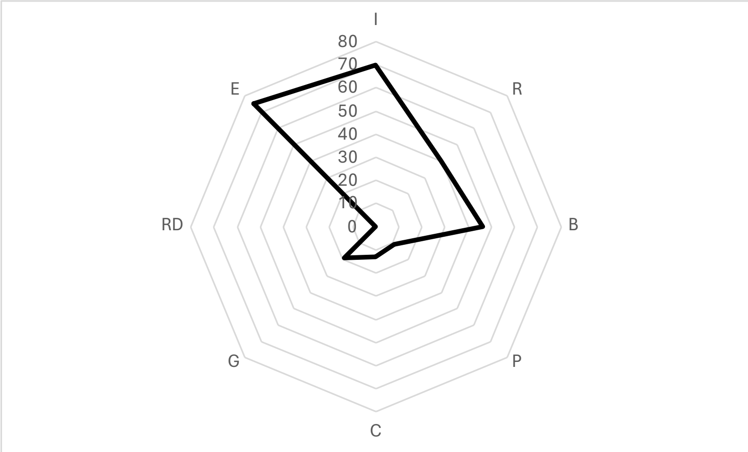
Interaction Duration: 3 min 20 sec

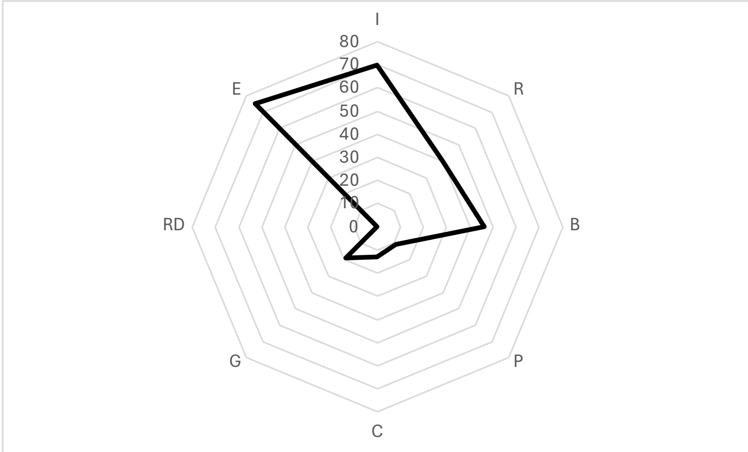




Lesson 6

Unit Focus: Writing Thesis Statements
Number of Communicative Acts: 274
Interaction Duration: 33 min 51 sec





Lesson 7

Unit Focus: Writing Body Paragraphs; Writing Conclusions
Number of Communicative Acts: 152
Interaction Duration: 37 min 22 sec