

Integrating data in a complex mixed-methods classroom interaction study

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Mixed-methods (MM) designs have gained increasing interest in educational research. Still, many studies collect quantitative and qualitative data but report these data separately and do not attempt to integrate them in practice. The aim of this article is to discuss the purposes and processes of integrating qualitative and quantitative data in an MM classroom interaction study. Issues regarding mixing and integration, including how to overcome integration barriers, are discussed. Based on this outline, the study then presents details about the various integration processes adopted in a recent MM study on classroom interaction in Norway. The possibilities and challenges of integration to produce new knowledge and a deeper understanding throughout the research process in classroom studies are illustrated with a specific focus on points of interface. A key issue is whether the new knowledge obtained in an MM study is more than the sum of the individual quantitative and qualitative parts. Using selected questions from the MM alphabet proved a helpful heuristic for guiding the iterative processes of integration and provided richer explanations and an enhanced understanding of the implementation and impact of a complex classroom intervention initiative. The study provides a new methodological contribution to the MM literature by examining the integration processes and challenges faced in a specific study.

Keywords: classroom interaction; integration; mixed methods

Introduction

Education, learning and development are complex. As a result, it has become increasingly common for educational researchers to use both quantitative and qualitative methods in a complementary manner. However, reviews of mixed-methods (MM) studies have found that many studies collect quantitative (quan) and qualitative (qual) data but report these data separately and do not attempt to integrate them in practice (Bryman, 2006; Guetterman *et al.*, 2015). Although the MM literature addressing integration has increased in the last few years (Bazeley, 2018; Plano Clark, 2019), discussions of why, when and *how* such data can be linked or integrated in complex classroom studies, and many other educational fields, are still limited. Uprichard and Dawney (2019) argue that there is a discrepancy in the literature's recommendations for researchers on combining methods in terms of theory and actual practice, and few studies describe and discuss processes of integration in detail. A

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main aim of the article is to discuss the purposes and processes of the integration of qual and quan data in an MM classroom interaction study in Norway. In particular, the article elaborates on *how* integration may be achieved in complex classroom studies. The purposive combination of quan and qual data and research approaches can complement and extend one another and thus lead to better descriptions, clearer explanations and an enhanced understanding of phenomena, research aims and questions. However, the question of *how* integration is conducted in a study is rarely explicitly addressed; thus, the knowledge about approaches to integration is neither well developed nor practiced. This article illustrates how integration can be accomplished in classroom studies. First, the article discusses approaches to integration in MM research, including how to overcome the barriers of integration. This introduction sets the stage for a discussion on the integration processes in a specific MM study on classroom interaction, illustrating the possibilities and challenges of integration to produce new knowledge and a deeper understanding in classroom studies. The Classroom Interaction for Enhanced Student Learning (CIESL) study is a large-scale MM study on enhancing student learning by improving teachers' classroom interaction skills and is used as the exemplar in this article. The flexibility allowed by MM designs is particularly suited to the study of complex education topics such as teachers' classroom practices (Sammons and Davis, 2017).

The utility of a guide to MM research (see the 26 questions listed in Table S1) proposed by Sammons and Davis (2017) informed the MM approaches adopted in the CIESL study and is used for illustrative purposes. Preference is given to questions that are most relevant for data integration. Table 1 outlines the selected questions used to inform the data integration process highlighted in this article.

Approaches to integration in mixed-methods research

There seem to be no widely agreed upon definitions of either MM research or integration in MM research (Fetters and Molina-Azorin, 2017; Bazeley, 2018). In this

Table 1. Selected questions from the MM alphabet used to inform the data integration process

A. What was the overall purpose of this study (aims/objectives)?
D. How are the quantitative and qualitative questions linked?
G. What is the overall sampling frame and how are the qualitative and quantitative samples linked/related?
M. What are the 'points of interface' linking the qualitative and quantitative data analyses?
Q. What attempts were made to link or integrate the qualitative and quantitative components of the study?
R. How far do the quantitative and qualitative findings align? What efforts were made to reconcile/explain any differences in the findings of the qualitative and quantitative components of the study?
Y. Do the researchers make new knowledge claims that are based on the integration and synthesis of qualitative and quantitative data and findings?
Z. Is there evidence that the MM design has produced findings/added new knowledge that is more than the 'sum' of the quantitative or qualitative parts?

Source: Sammons and Davis (2017).

article, we consider MM research to be the *intentional* collection of both qual and quan data and the *combination* of the strengths of each to more completely address a study's research questions than could be achieved by reliance on data from one paradigm alone (Tashakkori and Teddlie, 2010; Cresswell and Plano Clark, 2018). Integration is defined as the explicit interrelation of the quan and qual components of an MM study (Kington *et al.*, 2014; Sammons and Davis, 2017; Plano Clark, 2019), and it is a critical and defining feature of MM that may occur at many levels of the research process. In integration, investigators intentionally integrate or combine qual and quan data to maximise the strengths and minimise the weaknesses of each (Fetters *et al.*, 2013; Sammons and Davis, 2017). The notion of 'mixing' is also associated with integration; Symonds and Gorard (2010) argue that 'mixing' truly occurs when the elements of the research process are used to construct, transform and influence one another (p. 13).

Design typologies have long been an important feature of MM research. There are numerous ways to integrate data, which is another potential strength and attraction of MM designs (Tashakkori and Teddlie, 2010). Generally, designs are categorised into types of design based on the level of integration (fully or partially mixed), the sequence of quan and qual components (convergent or sequential) and the emphasis of components (equal or dominant) (Tashakkori and Teddlie, 2010; Creswell and Plano Clark, 2018). Thus, three different logics for combining quan and qual study components can be identified as (a) convergent MM design, (b) explanatory sequential MM design and (c) exploratory sequential MM design. Strategies for integrating data are connected to the three basic designs and include (1) merging (convergent design), (2) explaining (explanatory sequential design) or (3) building (exploratory sequential design). 'Explaining' and 'building' are sometimes collectively considered to be 'connecting' strategies (Harrison *et al.*, 2020). Integration through *embedding* occurs when data collection and analysis are linked at multiple points, and it is especially important in advanced intervention designs. Embedding may involve any combination of the above-mentioned three approaches; however, it is essentially characterised by linking qual data collection to quan data collection at multiple time points, and is best suited to longitudinal designs. With respect to mixing quan and qual data, a distinction can be made between connecting, where the types of data are largely independent of one another, and merging, where the types of data are largely dependent on one another (Yin, 2006). Accordingly, data integration can be achieved in various ways and is dependent on typology, theoretical grounding or whether there is a balance (as opposed to differing priorities) between quan and qual data sets (Fetters *et al.*, 2013; Creswell and Plano Clark, 2018). Kington *et al.* (2011, 2014) are relevant examples of MM research in classroom studies.

Another way of viewing and describing MM research is based on the *point of interface* (Morse and Niehaus, 2009; Guest, 2013). The concept of 'point of interface' is defined as 'the position in which the core and supplement component meet during the conduct of the research' (Morse and Niehaus, 2009, p. 25). A point of interface can occur in any or all of the planning stages of research, data collection, during analysis or at the conclusion for interpretation. Strategies for integrating data can be connected to the three basic designs and include the three aspects addressed (Harrison *et al.*, 2020). That is, the point of interface is the point where deliberate 'mixing' occurs.

A main idea in Guest's (2013) perspective is a shift in focus from the entire study to the point of interface between two or more data sets of different types. Guest argues that this approach reduces the number of descriptive dimensions to two types: *timing* and *purpose*. Guest's views can be extended to any point in a study where two or more research components are mixed or connected in some way (Schoonenboom and Johnson, 2017). Although it may be highly useful in developing, conducting and describing strategies for data integration in MM studies, addressing the point of interface may not replace the need for or value of typologies, as Guest (2013) argues. Typologies, or core MM designs, remain useful in describing the main features of an MM design and display how different methods are combined. This particularly applies to complex studies in terms of providing an overview of the different elements of the study across time.

A new feature to emerge in MM is to consider beyond the insights that come from integrating 'core' designs into more complex procedures, such as experimental trials or evaluation procedures. In short, what has evolved in recent years is an understanding of the key characteristics of a well-designed MM study. This includes (1) collecting and analysing both quan and qual data, sometimes referred to as combining numbers or statistics and narratives or stories (Gorard and Smith, 2006); (2) rigorous procedures with both data sources (e.g. systematic sampling, adequate sample size); (3) combining the two data sources through systematic procedure(s) where the overall intent is to bring the databases together; (4) conducting the integration within one of the three broad types of MM design; and (5) framing the study within larger philosophical assumptions, beliefs or orientations (Creswell and Hirose, 2019).

Overcoming barriers to integration

It has been argued that it is often difficult to genuinely integrate findings in MM research due to several barriers—such as losing sight of the rationale for conducting MM research, lacking certainty about how to connect quan and qual data, and writing up the results separately for quan and qual components (Bryman, 2006). Fetters and Freshwater (2015) describe the integration challenge as the imperative to produce through integration a whole that is greater than the sum of the individual qual and quan parts. Sammons and Davis (2017) propose the MM alphabet, a list of 26 linked questions that can help critically appraise, interrogate, understand and plan MM designs. Although these questions address MM design in general, several are highly relevant for integration. For example, questions related to the aim (question A) and to quan and qual research questions and how they are linked (questions B–D) can provide guidance for data integration. Similarly, several questions address qual and quan data sources and the strategy for analysing them (questions E–K). Some questions relate specifically to the quantising and qualitisising of data, examining whether quan and qual results align—there is growing evidence that carefully constructed MM designs can produce findings/add new knowledge that is more than the 'sum' of the quan or qual parts (questions R–T). A few of the questions specifically address integration, particularly question M: *What are the 'points of interface' linking the quan and qual data analyses?* and question Q: *What attempts were made to link or integrate the quan and qual components of the study?* (Sammons and Davies, 2017, p. 499;

see Table S1). Fielding (2012) argues that integration should be at the heart of any MM research study because the purpose is to obtain information from multiple sources; therefore, bringing together the information provided by the different data sources is crucial. Recently, Uprichard and Dawney (2019) have questioned why, given its prime importance in MM research, integration has not received more attention. They argue that when authors do focus on integration, they often underscore the sheer challenge of integrating different methods. Drawing on the MM alphabet (Sammons and Davies, 2017) and the above integration outline, in the following sections the processes of integration of quan and qual data adopted in a recent large-scale MM project will be illustrated and discussed with regard to the decisions made and the approaches adopted in a study investigating classroom interaction in Norway.

The CIESL study

The CIESL study was a 4-year study funded by the Research Council of Norway. The project focused on two distinct fields of research: a focus on improvement in teachers' classroom interaction skills throughout a national initiative and the school organisational factors that facilitated or hindered teachers' implementation of the initiative. The main aim of the CIESL study was to add to the already extensive knowledge on classroom interaction (Pianta *et al.*, 2012) as part of the broader concept of classroom management (Evertson & Weinstein, 2006) in a Norwegian school context. A previous study indicated that teachers can improve their classroom interaction skills in terms of monitoring students and providing emotional and academic support when they were involved in a school-wide initiative on improving classroom management (Ertesvåg, 2009). However, little attention has been paid to understanding how teachers themselves perceive and understand classroom interaction, how they enact classroom interaction skills in the classroom and what they do when implementing new approaches to develop their classroom interaction skills. The previous research has been mainly based on either survey data (quan) or interview data (qual). Internationally, a few larger-scale studies have combined the two. However, larger-scale systematic classroom observation studies are scarce (Muijs *et al.*, 2012; Kington *et al.*, 2014), and there are even fewer in Norway. The few such studies that have been conducted have investigated only specific subjects such as language arts or mathematics (e.g. Klette *et al.*, 2017).

There is a need for research to more closely examine the links between teaching quality in individual classrooms, particularly since classroom-level effectiveness has been shown to influence practice more directly than school-level effectiveness (Kington *et al.*, 2012). The CIESL study exemplifies such a study. The outline of the project provides essential information about the study details; however, the focus of this article is on *how* quan and qual findings are integrated (integration strategies). For the purpose of illustrating integration, we draw on a sub-study elaborating on the first research aim of the main study, as follows:

Describe, analyse and explain the variation in lower secondary teachers' classroom interaction skills throughout the intervention period of the national initiative, Ungdomstrinn i Utvikling (UiU) [Developing Lower Secondary Schools].

The research questions (RQs) related to the first research aim were as follows:

1. How do teachers in lower secondary schools improve their classroom interaction skills throughout a national initiative aimed at improving classroom management in a lower secondary school? (Quan)
2. How do teachers enact and implement classroom interaction skills in their classrooms? (Quan and Qual)
3. How do lower secondary school teachers understand classroom interaction? (Qual)
4. How are teachers' perceptions of collaborative activities related to the improvement of their classroom interaction skills? (Quan and Qual)

Design decisions and integration

The decisions made in the planning of the study supported integration throughout the research process. The research questions were related to the aims of the study, addressing several aspects of the first broad research aim. The four specific research questions were developed. The MM approach was seen as the best design by which further evidence could be gathered on the complex interactions between teachers and students in the classroom. The MM alphabet points to the study's overall aim and its research questions (questions A–D) in the critical appraisal of MM studies (Sammons and Davis, 2017). The above research questions were identified as quan (RQ1), qual (RQ 3) or both (RQs 2 and 4) according to how they were addressed in the CIESL study, also indicating the links between the research questions. In line with Fetters' *et al.* (2013) suggestions concerning the design phase, a plan for the collection of both qual and quan data was developed in a way that allowed for and guided the later *merging* of the databases and integration of the results. The MM design for the overall

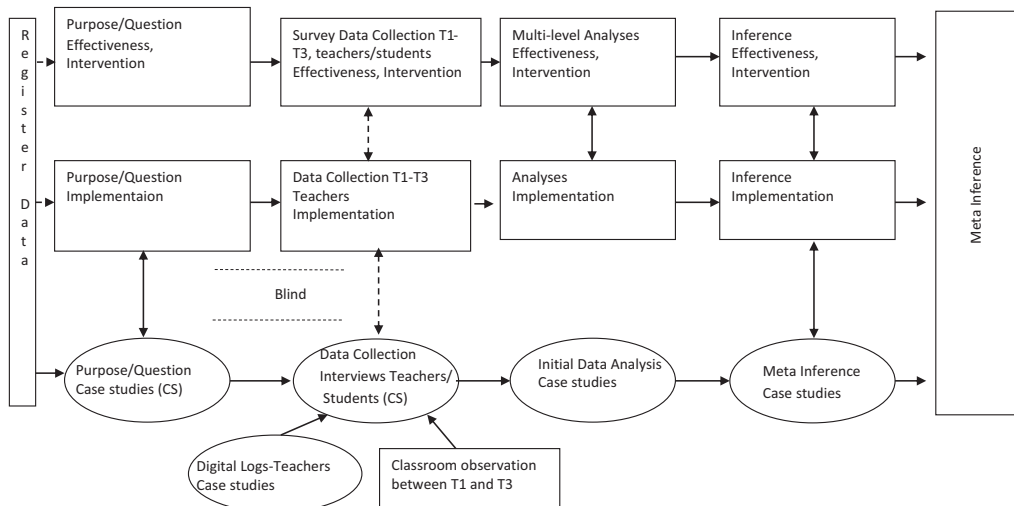


Figure 1. Research design in the Classroom Interaction for Enhanced Student Learning study

project is outlined in Figure 1. The qual and quan strands were given equal weight as a deliberate choice. Similar to the approach used by Tashakkori and Teddlie (2010), the rectangular blocks show the quan stages, and the ovals show the qual stages in the design and analysis processes. Here, the relationships between the quan (effectiveness and implementation study in rectangular blocks) and qual (case study in ovals) components of the study are summarised. The diagram illustrates the analytical process that was followed in combining these two methodological approaches and the three parallel aspects of analysis: the effectiveness study, the implementation study and the selected case studies. Two parallel quan phases of data collection were conducted to address the effectiveness of the initiative and the schools' implementation of the initiative. Moreover, a qual component was added to address the concept of classroom interaction in more depth via 54 case studies. By doing this, the research was able to answer a more complex set of research questions about the impact of the initiative on improving classroom interaction through a national initiative in Norway.

The effectiveness study (quan) was developed to investigate changes in teachers' classroom interactions throughout the initiative. The implementation (quan) study was developed to investigate the implementation quality of the initiative and organisational factors affecting the implementation (to investigate the third broad aim not discussed here). Both the effectiveness and the implementation study data were collected through surveys administered to teachers (effectiveness and implementation study) and students (effectiveness study). Furthermore, a case study group of a subsample of teachers and students in a class they were teaching was planned to investigate classroom interaction in more depth through interviews (qual), logs (qual) and observation (both qual/quant). Accordingly, there was *connecting* of quan survey and observation data sources, with qual interview, log and observation data sources.

The quan and qual data were collected concurrently, and the integration approach involved a number of points of interface to allow integration and merging at various stages, which also illustrates how integration was facilitated through *embedding*. Based on the research questions, the decision was made to videotape lessons to allow for both quan analysis and subsequent in-depth qual analysis of a subsample of classrooms. Moreover, the survey and interview guides were thematically organised. Accordingly, some integration occurred at the point of data collection. In general, the different data sources were collected separately but involved subsamples of participants invited to participate in the surveys.

Three main sources of evidence were addressed: teachers' questionnaire surveys, semi-structured group interviews and classroom observations (both quan and qual). Thus, the integration process began right at the point of developing the aims of the study and then informed the set of research questions. With the content of the scales in the survey in mind, the qual team developed the open-ended interview questions for the focus groups to parallel classroom interaction questions about teachers' understanding of the concept and how they were working to implement classroom interaction skills in the context of their particular school. By *intentionally* making this choice during the design, integration through later merging would be more naturally supported going forward.

Sampling, recruitment of participants, procedures and their implications for integration

The sample consisted of teachers and students at nine schools participating in a national initiative on developing lower secondary schools. The national initiative sought to address three aspects: improvement in students' basic skills (reading, writing and numeracy), teachers' classroom management and development of the school as an organisation. All schools intended to address the development of the school organisation, and they chose one or two of the other aspects as additional focus areas. The teachers and students were recruited from schools that had chosen classroom management as a focus area. The sampling procedure supported later integration of data. Three specific questions (E–G) in the MM alphabet guided how the qual and quan samples were selected and the links between them. All students and teachers at the schools were invited to participate in a survey three times: at the beginning of the initiative, which was at the start of the school year (T1); at the end of the same academic year (T2); and after the schools' participation in the initiative ended, after one and a half academic years (T3). The surveys from 230 teachers and 1,500 students were the data sources for the effectiveness study and implementation quality study (student reports were not related to the first aim of the overall study).

In addition to the survey samples consisting of all teachers and students at the schools, the case study sample of 4–9 teachers (54 in total) at each school and a class they taught were selected. In addition to participating in the surveys, the case study teachers:

- were observed in a classroom four times over the first school year of the initiative;
- were interviewed in groups at each school at the beginning and end of the initiative;
- wrote a log once each semester describing a learning experience they had within the previous 3–4 weeks.

For the case study group, the sampling procedure enabled the identification of possible changes in teachers' practice throughout the initiative, as well as in-depth analysis of classroom practices and teachers' perceptions of the implementation process. The case study group, being part of the larger survey sample, benefitted from the integration of results from the different quan and qual data sources.

Measurement

The teacher questionnaire contained measures of classroom interaction (understood as emotional support, classroom organisation and instructional support), as well as measures related to school organisation (e.g. level of collaboration, benefits from collaboration, innovation climate and support from colleagues). Classroom observations were scored using the secondary version of the Classroom Assessment Scoring System (CLASS-S) (Pianta *et al.*, 2012). The interview guide was thematically organised to address teachers' understanding of classroom management (a term more familiar to teachers in Norway than the term classroom interaction) and schools' and teachers' strategies and actions in implementing classroom management work in the initiative.

Data analysis and integration

Addressing the analytic strategy, the links and priorities between the different data sources shed light on the integration in the MM design (questions K–N). For the current study, the qual and quan data sources had equal priority. Figure 2 and Table S2 illustrate which data sources fed into the investigation of classroom interaction. As illustrated, there were data related to the classroom (teacher–student interaction, student behaviour and academic performance), to the school organisation (school organisational factors, implementation quality, teacher learning) and descriptive data. In the following subsections, the analytic approaches adopted for the different data sources are outlined.

Quantitative sources. Teacher questionnaire data. The data from each teacher questionnaire were analysed with Mplus and SPSS. Growth mixture models (GMM) (Muthén and Muthén, 1998–2017) were applied to investigate the trajectories of improvement in instructional support among the teachers. Additionally, the questionnaire collected data on aspects of the school organisation (e.g. collaboration and innovation climate) and descriptive data from the teachers (e.g. work experience, gender, years at the school). The scores for these factors and descriptive data for the teachers were then analysed by the subgroups identified through GMM analysis. For details on measurements and analyses, see Ertesvåg (2019) and Virtanen *et al.* (2019).

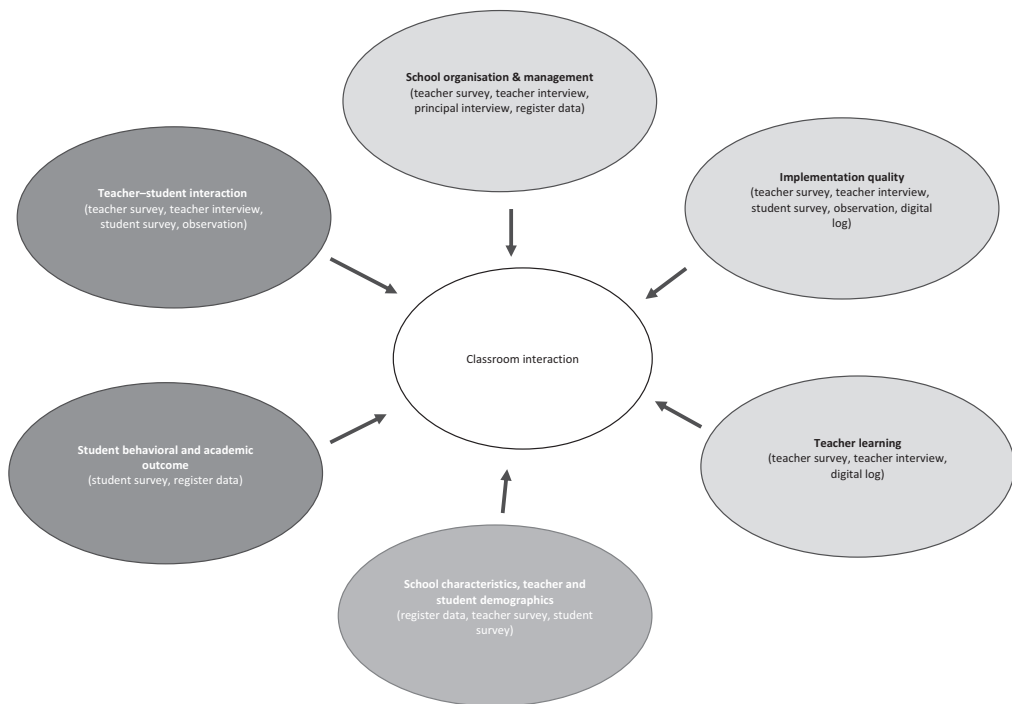


Figure 2. Data sources used in the mixed methods approach to investigation of classroom interaction in the Classroom Interaction for Enhanced Student Learning study

Qualitative sources. Interview data. Analysing qual data means designing the data collection and interpreting data as soon as the research questions are posed. Thus, the interview guide is an important tool for starting the analysis. The interview guide used in the teacher focus group interviews was structured by the following themes: (1) knowledge of classroom management; (2) practical experience with classroom management; (3) classroom management as a collaborative effort; (4) transforming theory into practice; and (5) the organisation's role in developing teachers' classroom management. The themes were developed to align with and extend information on classroom interaction and the role of the school as an organisation from the surveys. In this case, there was integration at the data collection level. The data from the interviews were then categorised according to the themes in the guide into a school case study report for each school, aimed at depicting the status of classroom interaction as well as the professional and organisational conditions for developing classroom interaction (Roland and Ertesvåg, 2020).

Mixed sources. Observation data. Videotaped lessons were scored with CLASS-S. The results for instructional support were compared to teachers' self-reports of instructional support, and a purposeful sample of teachers was selected for a qual in-depth analysis of lessons. Teachers were selected based on self-reported high instructional support and medium to high scores on instructional support on CLASS-S. Videotaped lessons from the five case study teachers were then analysed using qual content analysis approaches to identify patterns of deep learning, understood as '... the process through which an individual becomes capable of taking what was learned in one situation and applying it to new situations (i.e., transfer)' (Pellegrino and Hilton, 2012, p. 5). The aim was to explore the instructional teaching practices for deeper learning performed by highly skilled teachers teaching students in grades 5–10 (11–16 years) and to shed light on what teachers do to promote deeper learning in their classrooms (see Sølvik and Glenna, 2020 for details on approach and analysis).

So far, the outline and discussion of the CIESL study has focused on the integration of data and the implications for integration of decisions made relating to design, sampling, procedures and data analysis. Still, the most common type is integration of findings.

Integrating qualitative and quantitative findings

The research team conducted separate analyses for the quan and qual data in parallel. For the quan analysis, the team conducted a GMM analysis of teachers' reports of instructional support for the survey data and descriptive statistics for the observation data (Ertesvåg, 2019). For the qual data, the team used a theory-driven analysis based on Nicolini's (2013) definition of practice as a social, bodily, material and sense-making activity (Blossing *et al.*, 2019). Sense-making was understood as the process that shapes the conditions of practical work and shapes teachers' identities in relation to what being a teacher means and, in this study, what the teacher's role is in classroom interaction. Social, bodily and material activity were found to shed light on teachers' actions and how they constitute processes with other teachers and students at their

schools. Since these processes are situated at the local school, it was important to compile the analysis of the interviews in reports for each local school organisation.

Two key questions (M and Q) in the MM alphabet (Sammons and Davis, 2017) relating to integration explore the identification of points of interface linking qual and quan data analysis and what links are made to bring together or integrate the qual and quan components of the study. Figure 3 visualises the process of integrating specific qual and quan components, addressing the first aim of the CIESL study. The specific points of the interface are identified.

The analysis of quan survey data collected from teachers aimed to identify the trajectories of teachers' perceived improvement of instructional support. School case studies were used to analyse qual group interviews, and CLASS-S was used in the quan analysis and qual analysis of observations. The main emphasis was on the point of interface between the quan and quan data sources (e.g. when quan survey and observation scores were identified as high, medium and low and used to identify the subsample of teachers and classrooms for in-depth qual data). Moreover, the qualitying of survey data on organisational factors (e.g. collaboration) sheds further light on the qual interview findings about schools' collective work in the initiative.

Trajectories of improvement in instructional support

To address the first research question, teachers' improvement in instructional support was investigated through the analysis of survey data. A five-item scale for teachers' self-reports of instructional support was previously developed and validated in a study using the same sample of teachers (Ertesvåg, 2019). Mean scores for each teacher were calculated. GMM was used to investigate teachers' individual trajectories of instructional support throughout the initiative. Membership in these latent trajectory classes is initially unknown but subsequently inferred from the available data (Wickrama *et al.*, 2016). The GMM analysis of teachers' self-reported instructional support identified two distinct trajectories of teacher improvement, illustrated by the upper left rectangle in Figure 3 (see Ertesvåg, 2019 for details on procedure).

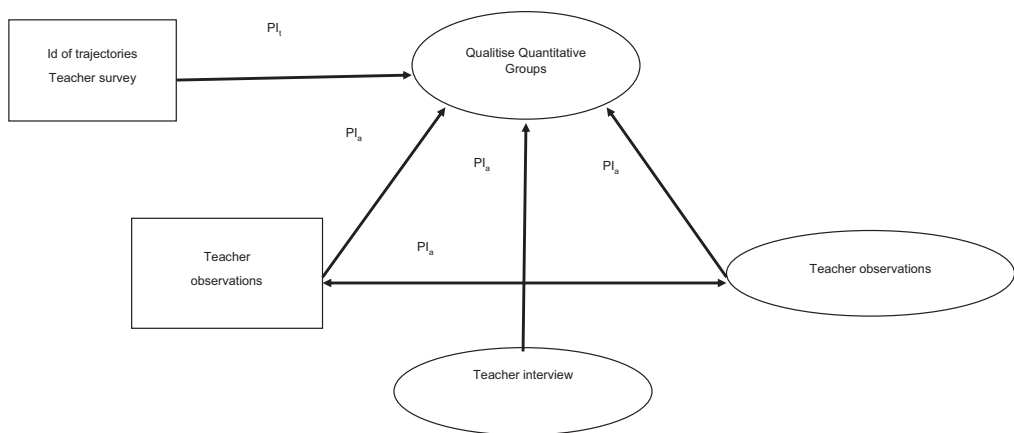


Figure 3. Strategy for integration of quantitative and qualitative components. Pi_t = point of interface in data transformation, Pi_a = point of interface in data analysis.

Point of interface

The point(s) of interface in the CIESL study were addressed in line with question M in the MM alphabet (Sammons and Davis, 2017). First, the data from the survey, the group interviews and the observations were analysed separately. Second, an analytical matrix was developed drawing on Miles *et al.* (2014) and the literature on joint display (Fetters *et al.*, 2013; Guetterman *et al.*, 2015). The matrix provides an overview of the findings from the different data sources, and is illustrated in Figure S1.

- Analysis of instructional support (Figure S1, columns 2, 4 and 5):
 - Based on the subgroups identified in the GMM, the improving group was selected for further analysis.
 - The individual teachers' instructional support scores on the survey were identified as three broad categories: improving, declining or non-changing.
 - The scores on the five dimensions for individual teachers on the CLASS-S observation were identified and classified as low, medium or high.
 - The teachers in the improving group identified in the GMM and with medium to high scores on the CLASS-S instructional support dimensions were then selected for further qual analysis of observations of what they did in the classroom.
- Analysis of teacher collaboration (Figure S1, columns 2 and 3):
 - The data on teachers' perceptions of collaboration from the 14 case study group teachers surveys' were qualitisd through the identification of the teachers as high, medium and low in terms of four aspects of collaboration: type of collaboration, how useful they perceived the collaboration to be, how they collaborated with colleagues and the support they felt from colleagues.
 - The data from the focus group interviews containing the 14 case study group teachers were content analysed to obtain a more in-depth understanding of the teachers' perceptions of collaboration related to the implementation of the initiative.
- Based on the analysis of instructional support and collaboration, a sample of five teachers who had high scores on self-reported instructional support and collaboration and medium to high scores on observations was identified for further qualitative analysis of observations. The teachers represented the subject areas of mathematics, English and science. Three were female. NVivo was used for the analysis of the qualitative data.

Following the definition (Morse and Niehaus, 2009; Schoonenboom and Johnson, 2017), there were points of interface related to both data transformation (a qualitisng of quan data) and data analysis, as illustrated in Figure 3.

Integration at the data transformation level (Pi_t in Figure 3) is illustrated by the qualitisng of survey data to identify profiles of teachers' perception of collaboration and instructional support for individual teachers. At the transformation level, integration occurs in two steps. First, one type of data is converted into the other type. Here, the scores on measures of instructional support and collaboration from the teacher

survey and quan analysis of the observations were converted into qual levels (i.e., qualitised) of the scores relative to the distribution in the overall sample of teachers. Second, the transformed data were integrated with other qual data from the interviews and observations that had not been transformed. This leads us to the integration and point of interface at the analysis level (Pi_a in Figure 3).

At the analysis level, the data for the teachers in the improving group were compared across the teachers based on the patterns found. Since the quan and qual data were organised in a format based on thematic relevance related to instructional support and collaboration to allow for merging, higher-order integration for fuller interpretation was required. Accordingly, the results from the quan and qual data were deliberately integrated in the matrix, as illustrated in Figure S1. The first column identifies a specific teacher, and the next three show the teacher's quantitative ratings of their instructional support scores from the survey and the observations. The last three columns provide illustrative qual data from the group interviews and the qual analysis of the observations. First, the teacher's perception of collective learning opportunities that may support their individual learning in relation to instructional support is reported. Second, the way in which they conceptualise classroom interaction is presented. Finally, observations of how they perform key aspects of instructional support in their classroom are considered.

It should be noted that the matrix in Figure S1 is shown for illustrative purposes only. A real display would typically contain many examples of each of the three topics in the columns containing qualitative data. The matrix may provide both confirming and contrasting data that provide a fuller picture of the phenomena in question. For example, in case I, the teacher provides evidence of collaboration that may have supported this individual teacher's learning. Moreover, the teacher sees managing a classroom as being like a coach who moves the students forward. In the classroom observations, there is evidence that the teacher performed as a coach, scaffolding learning among students.

The different sources of evidence may add to each other and confirm this finding. In contrast, the results from different sources may contradict each other or diverge, providing additional information and understanding regarding a single data source (Sammons *et al.*, 2007). The development of a matrix displaying the findings from the qual and quan data is seen as an ongoing, iterative and creative process. The multiple steps in developing the matrix described above contributed to a richer and deeper interpretation of the data and discussion among the research team regarding robust findings and plausible explanations and accounts.

Findings in brief

One of the two groups of trajectories identified through the GMM analysis reported that their instructional support improved (33% of teachers). Given that implementation of school-wide initiatives may take 3–5 years even if they are well implemented (Ertesvåg, 2009), it was not unexpected that all teachers did not improve. The teachers in the improving group were selected for further analysis.

Five case study group teachers in the improving group were identified for in-depth analysis of the observed lessons with the aim of investigating the instructional

qualities present in promoting deep learning among students. The interviews and observations provided an additional analytic lens through which integration enabled further exploration of the meaning of improvement in instructional support. Analyses of the observations of the five teachers' lessons indicated that their lessons were characterised by their support of students' learning. They helped the students to identify and focus on learning targets, key concepts and procedures during the lessons, and they focused dialogues and activities in accordance with these learning targets. In addition, they supported students' metacognition as they asked the students to explain their learning processes. This approach, which has been shown to be essential to students' learning, seemed to strengthen the students' engagement. Comparison of the scores on the dimensions of instructional support for the full observation sample indicated that this type of support was most likely not typical for all teachers.

The findings also indicated that the teachers perceived little collective effort among staff. Typically, they collaborated with only one other teacher, if any. Some of the teachers reported that their team collaborated well in improving classroom interaction; however, there was little collective effort at the school level. This was the case despite one of the aims of the initiative to develop the school as an organisation. Although there were initiatives at some schools to strengthen the collective approach to improve classroom interaction, these initiatives were not systematic enough to provide the intended improvement for all teachers. For further details of the CIESL findings, see for example Ertesvåg (2019), Virtanen *et al.* (2019), Roland and Ertesvåg (2020) and Sølvik and Glenna (2020).

Discussion

The discrepancy in terms of what the literature on combining methods encourages researchers to do in theory and what actually happens in practice (Uprichard and Dawney, 2019) indicates that there are still barriers to MM integration. Accordingly, taking the CIESL study as an example, the following subsections discuss integration throughout the research process with a main emphasis on data collection and data interpretation. The strengths of integration, the barriers found and possible ways to overcome the obstacles are illuminated.

Integration during data collection

Decisions made in the planning of the CIESL study were essentially related to integration. In line with questions A–D in the MM alphabet, the research questions were related to the aims of the study, addressing several aspects of the first broad research aim. The four specific research questions were identified as qual and/or quan, and the links between the research questions were identified in line with how they were addressed in the CIESL study. A concurrent MM approach allowed for the integration of data from the different sources. In line with the MM alphabet (questions E–L), the sample and analytical approaches for the survey, observations and interviews were carefully chosen to support integration. An example is that the samples for group interviews, logs and observations were all collected for the same subset of teachers. This case study group was chosen as a purposeful subsample of the larger survey

questionnaire sample that included all teachers at the participating schools. The sampling supported convergent validation (triangulation) and enabled analytic density (Fielding, 2012). In the CIESL study, the data collection provided the opportunity to add to the existing knowledge of classroom interaction by including observations, interviews and surveys. The sampling is, at least partly, an example of integration at the data collection stage. Accordingly, there was a point of interface (Morse and Niehaus, 2009) at the data collection stage. Moreover, the data were equally prioritised and given equal prominence in the analysis process (questions M–N).

The simultaneous collection of different data sources strengthened the study because it facilitated possibilities for later points of interface and integration based on temporal association. However, this approach is demanding because of the resources required and the need for a large research group highly skilled in the different types of data collection. Moreover, the design required some flexibility, especially because it was concurrent. Collecting several types of data also posed some challenges for integration as the results of analysing one data source were not known before collecting and analysing other data, especially at early time points. As an example, the number of subgroups in the GMM analysis could not be predicted although, theoretically, it was assumed that there would be more than one (Ertesvåg, 2019).

Integration during interpretation

Meta-inference. The CIESL study provided new knowledge and understanding beyond the potential of each of the different data sources. An example from the interviews is as follows. When asked to define the concept of classroom interaction (management), the teachers did not provide in-depth descriptions. In general, they hardly went beyond describing classroom interaction as building relationships with students and developing structures and routines in the classroom. On its own, this finding may indicate that the teachers do not have an in-depth understanding of the concept. Given that Norwegian schools have strongly emphasised the concept of classroom management for more than 20 years, this was unexpected. However, the analyses and findings from the survey and the observations (both qual and quan) shed further light on the teachers' knowledge of classroom interaction skills. Generally, the teachers' self-reported classroom interaction skill scores were medium to high, indicating their knowledge of these skills. Observation scores on the CLASS instrument varied but were generally lower than the teachers' self-reported scores, providing a more nuanced picture. Taken together, the comparison and integration of the findings indicate that although most teachers were not able to describe or define classroom interaction in depth in the interviews, at least some of the teachers (as shown by observations and high scores on self-reports) performed classroom interaction skills at a high level.

The somewhat contradictory results indicate that although teachers may not be able to describe/define classroom interaction (management) in detail, they are able to perform at a high level. There are at least two possible reasons for and implications of this finding. First, teachers may not be conscious of their skills and how they perform, beyond perceiving that they are doing fairly well (medium to high scores on self-reports). Another possibility is that the teachers are conscious of how they perform but

lack the professional language to articulate and describe their skills. Either way, the lack of such language may both hinder further development of skills and imply that teachers may not be well suited to face (new) challenges in the classroom as they may not be conscious of what, why, how and when to enact certain skills. This illustrates that different data sources may provide both contradictory and confirmatory findings that can provide a new understanding of classroom interaction. However, we cannot fully rule out a third possibility: some of the differences we identified might be related to the particular data collection processes used. This is a general problem in educational studies and not peculiar to MM research, although such differences may be more likely to be found if MM approaches are used.

The processes of MM integration: lessons learned

Bryman (2006) argued that a main challenge in MM research is to genuinely integrate findings. As discussed above, the challenge and complexity in data collection and the required skills may be one reason. The complexity of the data may be demanding in the analysis and interpretation of the results. In particular, this applies to concurrent MM designs as in the CIESL study, where several data sources were collected at the same time points. However, as discussed and illustrated, careful planning from the beginning, reference to typologies and guidance from the literature (e.g. in this case, the MM alphabet) can provide support and has the potential to strengthen an MM study. As a result, the CIESL study has been able to provide results that lead to new knowledge on classroom interaction in the context of a major national initiative in Norway. This article seeks to provide some illustration of the integration processes throughout the research process but cannot give a full account of the findings from the CIESL. One may argue that, in essence, this relates to the handicraft of conducting MM research, which in itself may imply challenges that must be resolved and are discussed in the research literature on MM design.

Apart from the need for a highly skilled research group, little is written about the human and practical challenges and barriers to successful MM design and analysis that intentionally promotes integration. This may be equally important to address. In the planning and data collection phases of the CIESL study, it involved planning a research group that included collaborative partners who were highly skilled in qual, quan and MM research. While each partner had their own expertise, an interest in other perspectives and a willingness to engage in MM study is more essential than the perspective that different traditions must be kept separate (or are incommensurate ways of seeing the world).

Another key challenge in MM research can be to ensure that all participants contribute, and that they do so at the same standard, even if their methodologies and data differ. In the CIESL project, this required some negotiation of roles and ample time to find a common framework for the research to obtain the right balance of contributions from the different fields and research disciplines. To facilitate successful teamwork in the interdisciplinary research group, a series of strategies to facilitate communication within the group were used. Examples are as follows:

- Frequent face-to-face meetings including five 2-day workshops with social events in the evening. These were especially important at the beginning of the project.
- Regular video conferencing to tackle the geographical distance between project members.
- Overcoming communication barriers by focusing on clarifying perspectives, positions and understandings of concepts among the research group members. Additionally, reading the literature from the contributing discipline and discussing different views on this in project meetings contributed to overcoming these barriers.
- Establishing a group to organise and lead day-to-day activities. The group consisted of the project leader and three researchers who were responsible for the different types of research approaches and data.
- Joint analysis of data in an iterative process, including qualitising quan data and quantitising qual data where appropriate, and discussing findings.
- Co-authoring papers. Writing together encouraged integration across disciplines.

MM research collaboration may be challenging due to cultural differences, research language and traditions (van Drie and Dekker, 2013; Sammons and Davis, 2017). Accordingly, the challenges in organising a successful MM study should not be underestimated. The detailed planning of a research infrastructure that outlined the collection, analysis and reporting of each data source, as well as the researchers' responsibilities, provided an overview, clarity and predictability for the research group members. The positive relationships in the group that were established through careful planning and organising of activities in the project were important when project-related challenges occurred and facilitated constructive research dialogue through the iterative analysis and integration phases. When challenges arose, as they will in any project, the project group members were already used to discussing different views and finding common ground for their work.

A practical challenge that must be solved within the broader research community is related to reporting. There seems to be a tendency among research journals to require shorter articles. Descriptions of complex MM designs and their findings very easily exceed the 7,000–8,000 word limit (with references, etc. included). This may be an important reason why relatively few studies address the integration of qual and quan data in any detail. Instead, researchers may report qual and quan findings separately, which sadly inhibits the documentation of MM integration processes. The illustration of meta-inferences on data, analysis and findings via points of interface in the CIESL study reveals that reporting findings separately may hinder the potential to generate new knowledge from various qual and quan data sources.

Similarly, techniques in MM research take time to learn, and funding for MM studies must take this into account. In addition to the often time-consuming work needed to overcome communication barriers in the research group, complex MM studies often require time for researchers to develop skills within MM techniques. Although it is not uncommon to learn new skills in research projects, the use of different research approaches and traditions may increase the challenge. In addition to funding, there is a need to carefully draw on the project groups members' existing

skills and experience in the field and carefully compose considered work groups in light of the different aspects of the research project.

The human and practical aspects addressed are also relevant for MM research in general. However, they may be essential to conducting integration successfully and fully exploiting the findings of any MM study. Despite these difficulties, the CIESL study reveals that the careful choice of an MM design with the intention of facilitating points of interface and integration processes can prove fruitful. Using selected questions from the MM alphabet (Sammons and Davis, 2017) proved to be a helpful heuristic to guide the iterative processes of identifying points of interface, conducting analyses of different sources of evidence and integrating the findings to provide richer explanations and enhanced understandings of the implementation and impact of a major classroom intervention initiative in Norway. This study also provides a new methodological contribution to the MM literature by explicitly focusing on and illustrating the integration processes and challenges faced in a specific study.

Ethical guidelines

The study adhered to the Norwegian national research ethics committees' guidelines for research ethics in the social sciences, humanities, law and theology, and was subject to ethical review by the national data protection services.

Conflict of interest

There is no conflict of interest to declare.

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Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

Figure S1. Data matrix template (illustration). Display of data from teacher survey (TSurvey), observation and interview.

Table S1. The MM alphabet.

Table S2. Research questions, data sources and analytical approaches.