How can motivation to learn science be improved?

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How can student motivation to learn science be improved?

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1. Introduction

As an incoming Head of Chemistry at a medium-sized, non-selective, coeducational independent school, one of the challenges I have been tasked with is to set strategies in place to help the lowest-achieving students improve their GCSE results. This is a single metric of success, but an important one: the school policy is to report 'progress' and 'attainment' for pupils throughout Years 10 and 11 based on their common assessment results in each subject and how closely their results match their 'target' grades. Common assessments are tests generally composed of past GCSE questions on the relevant topics. Target grades are based on YELLIS test results. YELLIS is a baseline assessment developed by the Centre for Evaluation and Monitoring at Durham University. It is designed to measure performance, potential and attitude of students in Years 10 and 11. The test is computer-based and self-adjusting to ensure the difficulty level of the questions matches the ability of the test-taker. YELLIS results include baseline scores which compare the test-taker to the national cohort, predictive GCSE (and iGCSE) scores and 'value-added' feedback which can be used by schools to measure progress over time. (Centre for Evaluation and Monitoring, 2016).

Pupils in my school are reported as 'academically successful' if they routinely demonstrate the ability to earn good results on GCSE-style tests, and that these results are equal to or higher than the results predicted by YELLIS. This is in line with the Ofsted definitions of *attainment* as results based on tests, such as GCSE or other formal Key Stage testing and *achievement* as the progress made by students considering their starting point (baseline data) and their attainment (Ofsted, 2011). In this way, even low-attaining pupils can be shown to make progress in achievement, if there is evidence of an upward trend in results. Although the school has asked me to

focus on attainment, I will also be monitoring pupil achievement, and helping students to recognise when progress is being made.

To understand the factors influencing student attainment and achievement at my school, I must first explore the implications of using high-stakes tests such as GCSEs as a measure of pupil attainment. This includes examining why these tests are used as a measure of pupil (and by extension, school) success, how pupils respond to the pressures of such tests and how interventions in the classroom can help students develop coping strategies for dealing with anxiety and academic set-backs, specifically looking at developing academic buoyancy. Finally, I will explore some of the factors that influence student attainment and achievement specifically in science, including understanding student attitudes towards learning science and factors affecting student motivation to learn science.

2. Literature review

The review begins in section 2.1 by considering the use of high-stakes testing and argues that exams such as GCSE, although accepted as the benchmark for pupil attainment in the UK, have unintended negative consequences on the children sitting the exams. One of these unintended consequences is that for some pupils, the pressure of the exam can have a deleterious effect, causing them to underperform on exams compared to their actual ability, as described in section 2.2. In section 2.3, I discuss the concept of *academic buoyancy* and the research that shows that pupils who are able to 'bounce back' from academic setbacks tend to perform better than those who internalise such setbacks. I also highlight the role of anxiety on student performance in high-stakes exams. In section 2.4, the link between academic buoyancy and growth mindset is investigated, and evidence is presented which

shows that not only can pupil mindset be shifted from ‘fixed’ to ‘growth’, and that growth mindset builds academic buoyancy. Section 2.5 outlines the history and development of theories on academic motivation from determinist theories to the development of growth mindset theory. Additionally, a review of pupil attitudes towards learning science and an exploration of the effect of ability setting on pupil self-esteem is presented. Finally, in section 2.6, I disentangle some of the concepts discussed in the literature review, and show that academic buoyancy, mindset, and attitudes towards science are all factors affecting pupil motivation to learn science.

2.1 Using high-stakes tests as a measure of success

High-stakes testing is common practice around the world. In the United States, the passage of the No Child Left Behind act in 2001 led to a dramatic increase in state-wide external examinations in an effort to produce data for which school administrators, teachers and students could be held accountable. In the United Kingdom, this high-stakes testing comes in the form of GCSE and GCE examinations, with school performance and league table position based on pupil results. Increasingly, these results are linked to school administrator and teacher pay and school funding. This system of accountability for pupil learning has led to a vast amount of educational research into the effectiveness of high-stakes testing. The body of literature arising from this research detailing the detrimental and unintended effects of such testing is vast and largely undisputed (Amrein and Berliner, 2002; Yeh, S.S., 2005; Guisbond and Neill, 2004; Nichols, S.L., Glass, G.V. and Berliner, D.C. 2006). Some of the arguments against the usefulness of high-stakes testing are:

- There is little evidence to support the idea that such tests increase pupil achievement (Nichols, Glass and Berliner, 2006)
- Using improvement on such tests as a measure of pupil progress is problematic, as this could simply be the result of increased practice or 'teaching to the test' rather than actual learning (Nichols, Glass and Berliner, 2006)
- Test scores are not necessarily indicators of progress when they rise or deterioration when they fall (Guisbond and Neill, 2004)
- Many tests have results based on a normal distribution, which means that a certain proportion of test takers will 'fail' (Haney, 2002)
- Tests often do not measure the objectives deemed most important by educators, therefore students 'taught to the test' access only a narrow curriculum (Rothman et al 2002), increasing the risk that particular topics or skills not emphasised on the tests are less likely to be taught (McNeil and Valenzuela, 2000)
- Teachers may spend inordinate class time on exam strategies and exam 'drills' that have very little values outside of the exam hall (Yeh, 2005).

Despite the widely accepted criticisms, high-stakes testing has its supporters who believe that:

- Testing holds teachers accountable, and motivates them to teach better
- Students work harder and learn more when their knowledge is examined in high-stakes tests (Raymond and Hanushek, 2003)
- High-stakes test motivates students to perform well, and if they do not perform well, it motivates them to increase their efforts in the classroom
- High-stakes tests are good measures of the curricula being taught

- Nationalised exams provide a baseline by which to judge pupils from different schools and backgrounds
- Tests are a good measure of pupil performance, and are show few effects from differences in motivation, language and socioeconomic status (Amrein and Berliner, 2002).

The bulk of research into high-stakes testing suggesting that at best, these regimes benefit some groups of pupils (but not all), and at worst have a detrimental effect on both pupils and teachers. Regardless of whether or not tests such as the GCSE are a reasonable measure of student learning and achievement, the fact remains that these external exam results are the primary data used to judge school, teacher and pupil performance. As a teacher and Head of Department, my responsibility is to make sure students are adequately prepared to sit these exams.

2.2 How do students respond to the pressure of high-stakes exams?

Students respond in a number of ways to the pressure of high-stakes tests. For some, the pressure is a positive motivating factor, whilst for others it has a deleterious effect on their performance (van der Embse and Hasson, 2012). Furthermore, test pressure can hamper the performance of high- and low-ability pupils in different ways, depending on the nature of the task. Lower ability students are likely to 'choke' on easier tasks than their higher-ability peers (Wang and Shah, 2013). This suggests that improving GCSE outcomes for my low-ability students may rest on finding strategies to help students reduce or eliminate test pressure and anxiety. In effect, I will need to help my students develop academic buoyancy.

2.3 Developing academic buoyancy

Whilst it is important to understand why students may underperform in high-stakes situations when developing strategies for improving achievement, it is equally important to understand how students make progress in everyday academic settings, for example during lessons and through homework and lower-stakes tests and quizzes. Martin and Marsh (2008, p 54) define *academic buoyancy* as

> students' ability to successfully deal with academic setbacks and challenges that are typical of the ordinary course of school life (e.g., poor grades, competing deadlines, exam pressure, difficult schoolwork).

Martin and Marsh (2008) compared the academic buoyancy of nearly 600 Australian Comprehensive High School students to self-reported data on self-efficacy, anxiety, uncertain control, teacher-student relationship, engagement, gender and age gathered through surveys. The measure of academic buoyancy was made using data such as homework completion, absenteeism, literacy, numeracy, academic achievement, persistence in the face of difficulty, disengagement and student participation in class. In this study, the authors found that anxiety, self-efficacy and academic engagement were the most important factors affecting academic buoyancy, with anxiety (a negative effect) contributing the most variance. Although the study is based on student self-reporting, and the data is correlational rather than causal, the survey was given to the participants on two occasions, six months apart, and there was very strong agreement between to two data sets. Furthermore, with such a large sample size (n=598), with statistically significant relationships between factors, it is unlikely that 'rogue data' from student surveys will have had any appreciable impact. The major finding, that anxiety is a major factor in academic

buoyancy, is also supported by other research (for example, Zeidner, 1992, 1994; Lazarus and Folkman, 1984; Kohn et al., 1991).

Passer (1983) found that individuals with high anxiety demonstrated significantly more of a 'fear of failure' disposition than less anxious individuals. This fear of failure manifests itself in a number of ways, including frequent worrying about making mistakes, worry about poor performance, and an expectation of negative feedback after failing a task. Martin (1998) also found that high levels of anxiety can lead students to employ counter-productive strategies to deal with this fear of failure. These strategies include defensive pessimism and self-handicapping, which are normal fight-or-flight responses to the negative emotion of anxiety, according to the 'broaden and build' theory of positive psychology. This theory, outlined by Barbara Fredrickson (2001), suggests that just as negative emotions can trigger immediate survival actions (like the fight-or-flight responses mentioned above) when a person feels threatened, positive emotions can trigger alternative thought-action repertoires which also have adaptive benefits for long-term survival. In fact, this positive 'broadened mindset' can build a reserve of skills and strategies for managing future adversity. Martin (2008) suggests interventions which help students reduce anxiety and fear of failure as a first step in developing positive academic buoyancy. Such interventions include development of effective relaxation techniques, preparing them both academically and psychologically for 'pressure situations', promoting a cooperative classroom environment with a culture of self-improvement and personal bests, and helping students to understand that success should be regarded in terms of personal progress and achievement rather than outperforming others. These intervention strategies are grounded in cognitive-behavioural, need achievement, and self-worth motivation theories (Atkinson, 1957; Beck, 1976; Covington, 1992; McClelland, 1965).

2.4 Growth as a key factor in buoyancy

There is a serious concern amongst educational researchers that current assessment systems exclude pupils from access to academic success and prevents them from feeling that they've made progress. In particular, pupils may be learning and progressing relative to their own baseline, but do not experience 'success' because the metrics of success are exam results. Conversely, other students may be labelled as 'successful' based on exam results, despite the fact that they are under-achieving relative to their own academic potential. (Nichols and Berliner, 2007; Anderman et al, 2010). The key issue in both of these examples is *progress relative to baseline*. In the first instance, pupils may not be aware of their own academic growth, even if they've come quite a long way given their starting point, if the 'end point' – the exam result – is a low grade. In the second example, students may believe they are making progress, when in fact they are performing at or below their baseline because the exam is not a challenge for them. In both cases, students could be motivated by the progress they've made or motivated to learn above and beyond the confines of the exam syllabus if they are aware of their starting point and end point, rather than just an exam result. The understanding that intelligence is flexible, and even if exam targets are never met, a student can be shown to have increased their understanding and ability may help motivate students to engage with their learning. This is the central premise of Mindset Theory.

'Mindsets' are people's inherent beliefs about the nature of human attributes, such as intelligence. There are 'fixed mindsets', in which people believe that these attributes are simply intrinsic traits. Those with a fixed mindset believe, for instance, that each person has a fixed amount of intelligence and this cannot be changed. Alternatively,

people with a ‘growth mindset’ believe that these traits are not fixed, and can be improved incrementally over time (Dweck, 2012).

When students hold a fixed mindset about their own intelligence, they tend to avoid challenges for fear of failure and show less academic buoyancy in the face of setbacks, attributing each setback to a lack of ability and therefore becoming defensive or discouraged (Blackwell, Trzesniewski and Dweck, 2007; Robins and Pals, 2002; Nussbaum and Dweck, 2008). However, students with a growth mindset actively seek out academic challenges and show greater buoyancy in the face of setbacks, viewing failure as an integral part of learning. Teaching a growth mindset to students also improves their motivation and achievement during particularly stressful academic periods, for example during high-stakes testing (Aronson, Fried and Good, 2002; Blackwell, Trzesniewski and Dweck, 2007; Good, Aronson and Inzlicht, 2003).

2.4.1 Evidence of the effectiveness of growth mindset interventions

A number of early studies in implicit theories showed that individual theories of intelligence can be manipulated by simply reading passages presenting either entity theory (fixed mindset) or incremental theory (growth mindset) (Dweck and Leggett, 1988; Bergen, 1991, cited in Chiu, Hong and Dweck 1997; and Chiu, Hong and Dweck, 1997). Since then, other researchers have shown that implicit theories of intelligence held by schoolchildren can also be manipulated: growth mindset can be taught.

Blackwell, Trzesniewski and Dweck (2007) completed one such medium-scale longitudinal study following four consecutive groups of students entering the seventh-

grade (UK Year 8) over a period of five years to investigate the link between their implicit theories and other achievement-related beliefs at the start of junior high school and achievement outcomes throughout the seventh and eighth grades. This study established that students with a growth mindset

- affirmed learning goals more strongly,
- were more likely to feel that hard work was a key factor in achievement,
- were less likely to attribute a potential failure to lack of ability,
- were more likely to try again and possibly employ a new strategy when faced with an academic setback

than their peers who believed that intelligence is a fixed quantity which cannot be improved upon.

Blackwell et al (2007) followed this study up with a short-term intervention on a different group of pupils. In this second study, 99 American pupils (aged 12-13) were divided into experimental and control groups. Both groups participated in eight 25-minute sessions, one per week, in the spring term of their seventh grade year. The sessions were similar, with both groups being taught the physiology of the brain, study skills, and antisterotypic thinking. The experimental group were taught that intelligence is malleable and can be developed during sessions when the control group were taught about memory and discussed other academic issues. The results showed that not only can pupils' implicit theories be altered – those pupils in the experimental group developed a growth mindset – but that students who were offered a growth mindset intervention showed a significant reversal in their declining grade trajectory, where the pupils in the control group continued to show a decline in grades.

More recently, Aditomo's (2015) medium-scale study of first year university students in Indonesia (n=123) found that whilst growth mindset about academic ability did not have a direct effect on academic achievement, it seems likely that it has an indirect effect on achievement, as it acts as a buffer against de-motivation due to academic setbacks: growth mindset builds academic buoyancy.

2.5 Motivation and Attitudes towards science

My action research is focused on increasing motivation to learn science through developing pupil growth mindset, and in this section, I will explore the development of theories on general academic motivation leading to Dweck's theory of growth mindset, followed by a more specific examination of pupil attitudes towards learning science.

2.5.1 Motivation

Some early ideas about student motivation distinguished between the concepts of 'drive' and 'learning'. Hull (1943) explained that learning shaped the direction of pupil behaviour (for example completing a particular assignment during a lesson) whereas drive was the factor responsible for the duration and intensity of the behaviour. A pupil who worked diligently on a maths assignment until it was completed to a high standard would have a high level of drive shaping his learning in maths. According to Hull's theory on drive and learning, the teacher's role is limited to the realm of learning, as motivation (drive) is an internal factor specific to each child, and therefore much more difficult to impact. Teachers can influence the learning of their

students by creating an appropriate learning environment and employing engaging techniques and approaches to teaching and learning; however, their level of internal drive will determine the extent to which their pupils respond.

Hull's concept is a useful starting place, but it has its limitations. According to his theory, motivated pupils will respond well to teaching and unmotivated pupils will not. In this sense, a good teacher will make the most of motivated pupils' energies and the pupils will make excellent progress in their learning, whereas there is little hope of reaching the unmotivated pupil, no matter how good the teaching is (Galloway et al, 2004). Others theories however, suppose that motivation and learning are not separate elements, but rather view motivation as a fundamental part of learning, with both components sensitive to the quality of teaching. Behaviourism and achievement motivation are two such theories.

Behaviourists suggest that all motivation comes from basic human drives, instincts or emotions (Galloway et al, 2004). Teachers can therefore plan lessons that are fun, interesting, or have some element of competition in them to increase pupil engagement in each activity - as engagement, or 'on task' behaviour, is the observable measurement of pupil motivation - regardless of whether or not the pupils have an interest in the subject that's being taught (Galloway et al, 2004). Teachers can increase student motivation through appropriate reinforcement, and there are many models of teaching practice which are aimed at increasing 'on task' behaviour, such as 'chunking' lessons into a series of small activities and teaching through game play. The risk here is that the emphasis is placed on rewards such as teacher praise, winning a game, or completion of a task (Condry and Chambers, 1978). Psychologists call this motivation to behave in a certain way or engage in an activity to earn a reward (or avoid a punishment) as *extrinsic* or *external motivation.* This is opposed to *intrinsic* or *internal motivation*, which is motivation based on personal

satisfaction rather than an external reward. For example, a pupil who completes an English assignment because they want a good grade is externally motivated, whereas the pupil who completes the assignment because they enjoy creative writing is internally motived.

Other writers have stated that it is easy for teachers to focus on external motivation through teaching practice (Cameron and Pierce, 1994), and although there is evidence that pupils who are motivated by external rewards have a more superficial approach to learning (Condry and Chambers, 1978), there is also evidence supporting the motivational benefits of such rewards (Cameron and Pierce, 1994).

Atkinson (1964) proposed a less deterministic, more qualitative concept of motivation with his theory of achievement motivation. He proposed that pupils are motivated both by the prospect of success and the fear of failure, and that individuals are *predisposed* to place higher or lower importance on success or failure as outcomes. In practice, Atkinson advocated that teachers must consider both the likelihood of success on tasks and the risks associated with failure on tasks when planning their teaching. Atkinson predicted that pupils will preferentially choose tasks of intermediate difficulty, where succeeding offers a valuable reward, but the likelihood of failure is not immense (Galloway et al, 2004).

However, one of Atkinson's PhD students, Bernard Weiner, found that evidence failed to support Atkinson's theory about intermediate task preference (1986, 1992). Weiner discovered that pupils with high motivation to succeed will tend to choose tasks of intermediate difficulty, while those pupils with high motivation to avoid failure tend to prefer either very easy or very difficult tasks. These findings led to Weiner's attributional theory of motivation: the factors which pupils attribute to their success and failure have a profound affect on their motivation. For example, Weiner's theory

sugguests that a pupil may attribute failure on a task to either low ability or low effort. If they feel that their failure is due to the fact that they are *not able* to complete such tasks, they are likely to avoid similar tasks in the future, as they will perceive a high likelihood of a similar outcome. However, if the pupil feels that their lack of effort contributed to the failure, they are more likely to attempt similar tasks in the future, as the outcome could change with additional effort. Weiner refers to 'stable causes', such as ability and 'unstable causes', such as effort. When pupils attribute success or failure to a stable cause, they are highly likely to expect similar outcomes in the future. However, students attributing success or failure to unstable causes are much less likely to assume a similar outcome in the future. Carol Dweck expanded on Weiner's attributional theory with her theory of growth mindset, with the main tenet being that pupils can be taught that ability and intelligence are not fixed (Dweck and Leggett, 1988).

2.5.2 Attitudes to learning science

The understanding of pupils' attitudes towards learning science has been the focus of much educational research over the past 30 years (see for example, Assessment of Performance Unit, 1988; Sundberg, Dini and Li, 1994, and the Organisation for Economic Co-operation and Development, 2006). 'Attitude' here refers to self-reported level of interest in and perceived value of learning science. The overall picture is daunting: there has been a decades-long trend in declining interest in students choosing to pursue careers in Science, Technology, Engineering and Mathematics (STEM subjects) and an increase in widespread scientific ignorance in the general population (European Commission, 2004; Organisation for Economic Co-operation and Development, 2006; Department for Education 1994). This trend global, and is actually more pronounced as nations become more advanced: 2005

research shows that there is a significant negative correlation between the level of development of a nation and the interest shown by its students in studying science (Sjøberg and Schreiner).

Interestingly, It has been repeatedly shown that whilst young people often have positive attitudes towards science in general, for example, they think that science is valuable and interesting, they find science lessons to be boring (Ebenezer and Zoller, 1993; Assessment of Performance Unit, 1988; The Research Business, 1994; and Sundberg, Dini, and Li, 1994). There must, therefore, be factors affecting how pupils feel about school science that give rise to this contradiction. Osborne, Simon and Collins (2003) in their major review of attitudes towards science outline a number of factors contributing to pupils' attitudes towards studying science, including:

- Environmental factors, such as the attitudes of peers and friends towards learning science. The relationship between peer attitudes and individual attitudes peaks around Year 10 (age 14), and will be an important consideration for my students (Simpson and Oliver, 1985).
- Classroom and teacher factors. The most positive pupil attitudes towards learning science are associated with teachers who provide a high level of personal support, promote a positive classroom atmosphere, and employ varied and exciting teaching strategies (Myers and Fouts, 1992).
- The perception of science as difficult to learn. In a large-scale study including nearly 42,000 students, Cheng, Payne and Witherspoon found that grades earned in GCSE science and mathematics were the most significant factors influencing uptake of science at A Level (1995). Thus, only the most able students tend to pursue non-compulsory science education beyond GCSE. Extending this, I wonder if my students, particularly those who are low-

achieving, already see themselves as *unable* to learn science, and have therefore written off the chance of success?

2.6 Ability setting and motivation

During the 2000s, the USA and the UK began to diverge in the national approach to ability setting in schools. In the UK, the introduction of the National Curriculum as part of the Education Reform Act 1988 and the subsequent formation of the Office for Standards in Education (Ofsted) under the Education (Schools) Act 1992 were part of a major overhaul and centralisation of the British education system. The introduction of the National Curriculum led to extensive testing in schools and to the publication of league tables. Ofsted was responsible for holding schools to account for their pupil's progress through the National Curriculum. This emphasis on standards led to an increase in the amount of ability grouping in UK schools (Ireson, Hallam and Hurley, 2005).

Conversely, in the United States, concerns about the effectiveness and fairness of ability setting led to an increased level of heterogeneous ability groups in schools (Ireson, Hallam and Hurley, 2005).

Setting is a hot topic, both in my school and nationally. In their 2007 Education Policy Green Paper, the Conservatives say, 'each pupil should be given the opportunity to learn in accordance with their particular aptitude and ability, so that the brightest pupils continue to be stretched at the same time as pupils who might be struggling are given extra support. We believe that setting by ability is the only solution to achieving this ambition' (Conservative Party, 2007, p 32). In 2012, Sir Michael Wilshaw, then the Chief Inspector of Ofsted, said that 'bright teenagers fail to achieve

top grades in some comprehensives because teachers insist on mixed-ability classes and concentrate on weaker students. Able children are being held back in some schools that do not tailor teaching, tasks and resources to stretch their best pupils' (quoted in Wintour, 2014). David Cameron said in 2006, 'I want to see setting in every single school. Parents know it works. Teachers know it works.' (quoted in The Guardian, 2006).

But does it work? The research evidence is not conclusive. In their review of ability grouping in UK secondary schools, Ireson et al (1999) report that

> Overall, there are small effects of ability grouping on pupil attainment. Effect sizes differ from one curriculum subject to another and pupils attaining higher levels on entry to secondary school make greater progress in school adopting setting in mathematics, but not in English or science. There are also small effects of school type on measures of self-concept, with pupils in the schools that adopt more mixed ability groupings having higher academic subject self concepts (1999).

In her review 1997 review of the theoretical and historical developments surrounding pupil ability setting, Boaler claims that 'there is little, if any, evidence, anywhere in the world, that supports this notion [that setting advances achievement, particularly for high ability students]' (p 576). Many large-scale studies in a variety of countries and educational settings show instead that ability setting, is most likely to have a sizeable negative effect on lower-ability pupils and very little effect on the attainment of higher-ability pupils. For example, four Israeli longitudinal studies looking at the link between attainment in mathematics and ability setting found that, in general, ability had either no effect or a very small negative effect on attainment (Linchevski, 1995). Furthermore, Linchevski found that pupils assigned to higher 'sets' attained more

than pupils of similar ability assigned to lower 'sets'. Furthermore, high-ability pupils in 'ability sets' achieved slightly (but not significantly) higher results than similar-ability pupils in heterogeneous classes; however, lower-ability pupils in 'sets' achieved significantly lower results than similar-ability pupils in mixed classes. Similar results were found by Slavin (1990), whose review of 29 studies (25 in the USA and 4 in Britain) showed no differences in achievement between pupils taught in mixed-ability or set classes.

Although ability setting may not have a strong influence on attainment, there is a growing body of research suggesting that such setting has an adverse impact pupils' self-esteem, self-concept, and their attitudes towards school and schoolwork (Gamoran and Berends, 1987; Lacey, 1974; Oakes, 1985; Kulik and Kulik, 1992; Ireson and Hallam, 1999). In particular, pupils risk linking their set to their own identity as a student, a phenomenon known as stereotype threat.

Steele and Aronson (1995) define *stereotype threat* as 'being at risk of confirming, as self-characteristic, a negative stereotype about one's group' (p 797). Often, stereotype threat is discussed in psychological and educational research into factors underlying race and gender gaps. But this definition could just as easily be used to describe 'bottom-set' students. Inzlicht and Ben-Zeev have shown that being evaluated in a stereotyped situation (for example, completing an academic test in a 'set' group), triggers responses such as decreased enjoyment of the educational process, increased stress and anxiety and underperformance (2000).

2.7 The relationship between academic buoyancy, motivation, pupil attitudes and growth mindset.

This literature review has examined four related concepts: academic buoyancy, motivation, attitude, and growth mindset. The aim of this section is to disentangle these concepts and show how they relate to, and differ from, each other.

I use the term *motivation* to describe the force that prompts a person's direction to behaviour or causes a person to want to repeat a behaviour and vice versa (Elliot and Covington, 2001). In the context of my research, *motivation to learn science* includes all of the factors influencing the behaviours that enable pupils to increase their achievement (progress from baseline) and attainment (results, such as grades) in their science classes.

Academic buoyancy, described by Martin and Marsh (2008) in section 2.3 as "students' ability to successfully deal with academic setbacks and challenges that are typical of the ordinary course of school life (e.g., poor grades, competing deadlines, exam pressure, difficult schoolwork)", is one such factor affecting motivation to learn science. An academically buoyant pupil would not, for example, develop a perception of low ability in science based on exam results, and therefore would not necessarily become less motivated to learn science based on these results.

Growth mindset is another factor affecting motivation to learn science. Pupils with growth mindsets are less likely to be de-motivated to learn science based on feelings of inability, as they believe that ability is not fixed, and that they are able to increase their understanding of a topic with practice and effort.

Attitudes towards learning science in this context refers to the extent to which pupils favour or disfavour science in an educational setting. Roughly, it describes how much pupils like their science lessons and how relevant they feel science lessons are to their lives. This is also a factor in pupil motivation to learn science, as pupils who

enjoy science lessons will be more motivated to behave in a way which could lead to improved attainment and achievement. Likewise, pupils who think that learning science is important and relevant to their lives currently or in the future (for example, in their chosen career) are also more likely to reach high levels of attainment and achievement.

3. Overview of research plan

The overall purpose of my research is to develop and deliver interventions that will ultimately help my Year 10 students improve their achievement in chemistry. Using an action research cycle model, I began by investigating the pupils' attitudes towards learning science and the major factors affecting their motivation to learn science, leading to two separate interventions aimed at improving their motivation to learn science through developing growth mindsets and minimising stereotype threat. This action research cycle is shown in Figure 1.

In order to gain a fuller picture of my students' achievement (progress from baseline) and attainment (grades, such as GCSE) in science, I collaborated with the Head of Physics at my school, who happens to teach the same two Year 10 science sets that I teach. One class is set 2 of 4, consisting of 24 students who mostly have target GCSE grades of A* to B. Despite these relatively high target grades, the pupils in this set have a wide range of YELLIS scores (which are used as a baseline measure of 'ability') and there is a small core of pupils (boys and girls) who often display disruptive behaviour. These students tend to be the lowest-achieving students in the set. The other class is set 4 of 4, most of whom have target GCSE grades of C. For many of the 20 students in this set, a C is an aspirational target, as they normally

earn grades of D or below. This set has more boys than girls (16 boys and 4 girls), and disruptive behaviour is frequent and persistent in the class.

The research took place in three phases, study 1, study 2 and study 3 each building on issues raised from the previous study.

Each of these studies employed common action research methodologies (questionnaires and interviews) and broadly follow the overview of action research in education provided by McNiff (2002) in *Action Research: Principles and Practice*:

- Review current practice
- Identify an aspect for improvement
- Imagine a way forward (develop an intervention)
- Employ the intervention
- Gather results of the intervention
- Modify the plan or intervention based on the results
- Continue with the modified intervention or plan
- Monitor the intervention
- Evaluate the modified action
- Continue in this manner until satisfied with the aspect that was identified as in need of improvement.

This process sets up the action research cycle of 'planning, acting, monitoring and reviewing' as described in Edwards and Talbot (1997). The review of study 1 led to planning and implementing a new intervention in study 2, the review of which led to planning and implementing yet another intervention in study 3. The result of the three studies was an increased understanding of the factors affecting our students

attainment and achievement in science, as well as identifying ways in which we can support pupils to overcome some of the barriers to success.

Study 1 (section 3.1) reports on a baseline study investigating these year 10 pupils' motivations to learn science using a questionnaire developed and widely used by American educational researchers. This study and its follow up indicated that the pupils' strongest motivating factor was grades, and pointed to negative mindsets amongst the pupils.

In response to these conclusions, study 2 (section 3.2) introduced an educational intervention aimed at improving student mindsets. Although this study and its follow up showed that the intervention was successful to some extent, there remained some evidence that the pupils retained a fixed notion of ability linked to the school's setting system.

Study 3 (section 3.3) therefore introduced an intervention aimed at continuing the growth mindsets work, and strengthen it through using attributional techniques to tackle the stereotype threat of ability-based groupings.

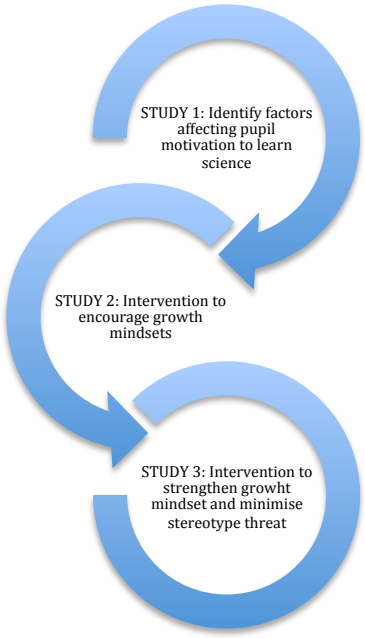


Figure 1: Overview of action research cycle

3.1 Study 1: Motivation

3.1.1 Background

Through our own teaching experiences, we found that many of our lowest-achieving students seemed very disengaged during lessons. We felt that these students were not motivated to learn science, and wanted to establish some baseline data regarding their motivation in science.

There is evidence that using individual and group interventions, science teachers can help students become more motivated to learn science. In fact, Druger argues that one of the most important functions of a teacher is to help their students become

motivated self-learners (2006). Motivating our students to want to learn science is a crucial part of our research plan as our end goal is improved academic achievement and motivation has been shown to be a significant mediating factor for academic performance (Vansteenkiste et al, 2005; Kusurkar et al, 2013; and Goodman et al, 2011).

Before intervention strategies to improve motivation can be designed, teachers must be able to identify *which* students lack motivation to learn science, and *why* they lack this motivation. With these questions in mind, the Science Motivation Questionnaire II (SMQ-II) was developed by American researchers to assess motivation levels in students across four domains: intrinsic motivation, which involves the inherent satisfaction in learning science for its own sake; self-determination, which relates to how much control pupils perceive they have over learning science; self-efficacy, the belief that pupils have in their ability to achieve well in science and extrinsic motivation, which involves learning science as a means to reaching a goal. In the SMQ-II, extrinsic motivation is divided into grade motivation, the desire learn science in order to earn good grades, and career motivation, the desire to learn science in order to access a desired career (Glynn et al, 2011).

3.1.2 Research question and method

The first research question we set out to answer was:

How motivated are our Year 10 students to learn science?

In order to answer this question and establish baseline motivational data on the two science classes, we chose to use the SMQ-II. This questionnaire has been established as a valid and efficient instrument for assessing components of pupils'

motivation to learn science. Furthermore, the components measured in this assessment are important indicators of academic performance in science, as students with high levels of self-efficacy, self-determination, intrinsic and extrinsic motivation perform better (according to grades earned) than students with lower levels of motivation (Glynn et al, 2011).

We chose to use the SMQ-II test because it is an accepted instrument for measuring motivation in science students and because it is easy to administer and analyse. We chose to deliver the questionnaire in the form of a Socrative Quiz. Socrative is a quiz app that we often use with our students, so the format is familiar to them. There were clear instructions at the start of the quiz, which were also read aloud to the class before beginning. The instructions stated:

> In order to better understand what you think and how you feel about your science courses, please respond to each of the following statements from the perspective of "When I am in my science class…"

The questionnaire itself consists of 25 statements, and pupils respond to each statement by choosing from a 5-point Likert-type scale (never, rarely, sometimes, often, always). The questionnaire items are shown in Table 1 below. Each of the statments corresponds to one of the 5 components: intrinsic motivation (IM), self-efficacy (SE), self-determination (SD), grade motivation (GM) and career motivation (CM).

In the context of this research, *self-efficacy* is defined as the extent to which a pupil believes in their own ability to complete tasks and reach goals. *Self-determination* is defined as the extent to which a pupil believes they have control over their academic life. For example, a pupil with strong feelings of self-determination feel strongly that

they are in control of their course choices and future prospects, whereas a pupil with low feelings of self-determination feel that they have little say in which classes they take or how these classes will impact on their future.

Table 1: SMQ-II items

Item	Statement	Component
01	The science I learn is relevant to my life.	IM
02	I like to do better than other students on science tests.	GM
03	Learning Science is interesting.	IM
04	Getting a good science grade is important to me.	GM
05	I put enough effort into learning science.	SD
06	I use strategies to learn science well.	SD
07	Learning science will help me get a good job.	CM
08	It is important that I get an “A” in science.	GM
09	I am confident I will do well on science tests.	SE
10	Knowing science will give me a career advantage.	CM
11	I spend a lot of time learning science.	SD
12	Learning science makes my life more meaningful.	IM
13	Understanding science will benefit me in my career.	CM
14	I am confident I will do well on science experiments and projects.	SE
15	I believe I can master science knowledge and skills.	SE
16	I prepare well for science tests and experiments.	SD

17	I am curious about discoveries in science.	IM
18	I believe I can earn a grade of “A” in science.	SE
19	I enjoy learning science.	IM
20	I think about the grade I will get in science.	GM
21	I am sure I can understand science.	SE
22	I study hard to learn science.	SD
23	My career will involve science.	CM
24	Scoring high on science tests and experiments matters to me.	GM
25	I will use science problem-solving skills in my career.	CM

We explained to the students that the SMQ-II was a tool for investigating their motivation to learn science, and that we would use the results to analyse the factors that drive them to succeed in science. Students were told that they would be given a copy of their responses, and we would discuss the outcomes of the questionnaires as a group after all participants had completed the survey. Students were given the opportunity to opt-out of the activity, although none chose to do so. Students completed the questionnaire at their own pace, using their iPads. Two students with special educational needs completed the questionnaire with the assistance of a reader, in line with their normal mode of working. We obtained permission from the Headmaster of the school to engage in this research as required by the University of Oxford’s ethical clearance procedures (CUREC).

All 24 students in Set 2 completed the questionnaire, and 17 of the 20 students in Set 4 completed the questionnaire (3 students were absent on the day of the questionnaire).

3.1.3 Results and discussion

One of the strengths of the SMQ-II is that it can be used to look at the motivation of whole classes or of individual students. The results for the classes are shown in Figures 2 (Set 2) and 3 (Set 4).The mean cannot be used as a measure of central tendency with Likert scale data, as it is meaningless; for example, it does not make sense to take the average of 'sometimes' and 'rarely'. Instead, it is helpful to look at the most frequent response for each item, which is why Figures 2 and 3 are bar charts showing the distribution of responses, with the statements grouped to show the motivational components they measure.

There is a marked difference between the two sets, with Set 2 showing higher motivation in each of the five components. Both groups are most motivated by grades. Set 2 also demonstrate relatively high self-determination and intrinsic motivation, and moderate career motivation. Set 4, however, show low career motivation, self-efficacy and self-determination. Although intrinsic motivation is a mixed picture for Set 4, there was an overwhelmingly negative response to item 12: "Learning science makes my life more meaningful".

We chose to use the data collected through the SMQ-II qualitatively rather than quantitatively, as there are several distortions common to Likert scale instruments. For example, respondents may avoid choosing extreme response categories (such as *never* and *always*), causing a central tendency bias. This may account for the frequency of 'sometimes' in our data – it is the central response. Students in

particular often seek to please their teachers, and may try to agree with the statements, causing an acquiescence bias. Similarly, the students may respond in such a way as to portray themselves in a favourable way, causing a social desirability bias. There may be some evidence of this, particularly in Set 4, where the responses for intrinsic self-determination in particular do not fit with our observations of student behaviour in lessons (University of St Andrews, 2016).

3.1.4 Follow-up work

In the lesson following the SMQ-II survey, students were provided with individual copies of their results. We discussed the five components of motivation that were measured in the questionnaire, and talked about the difference between *intrinsic* and *extrinsic* motivation. We discussed the fact that whilst there is evidence that both intrinsic and extrinsic motivation can lean students to improved academic performance, although there is evidence that intrinsic motivation leads to 'deep learning', where the pupil actively searches for meaning in new information and attempts to relate this meaning to prior knowledge and experience. Deep learning leads to better comprehension of material, better long-term retention of knowledge and skills as well as the ability to apply these knowledge and skills to new situations (Oost, De Vries and van der Schee, 2011, Deci, 1975; Cameron and Pierce, 1994).

Figure 2: Results of the SMQ-II for Set 2

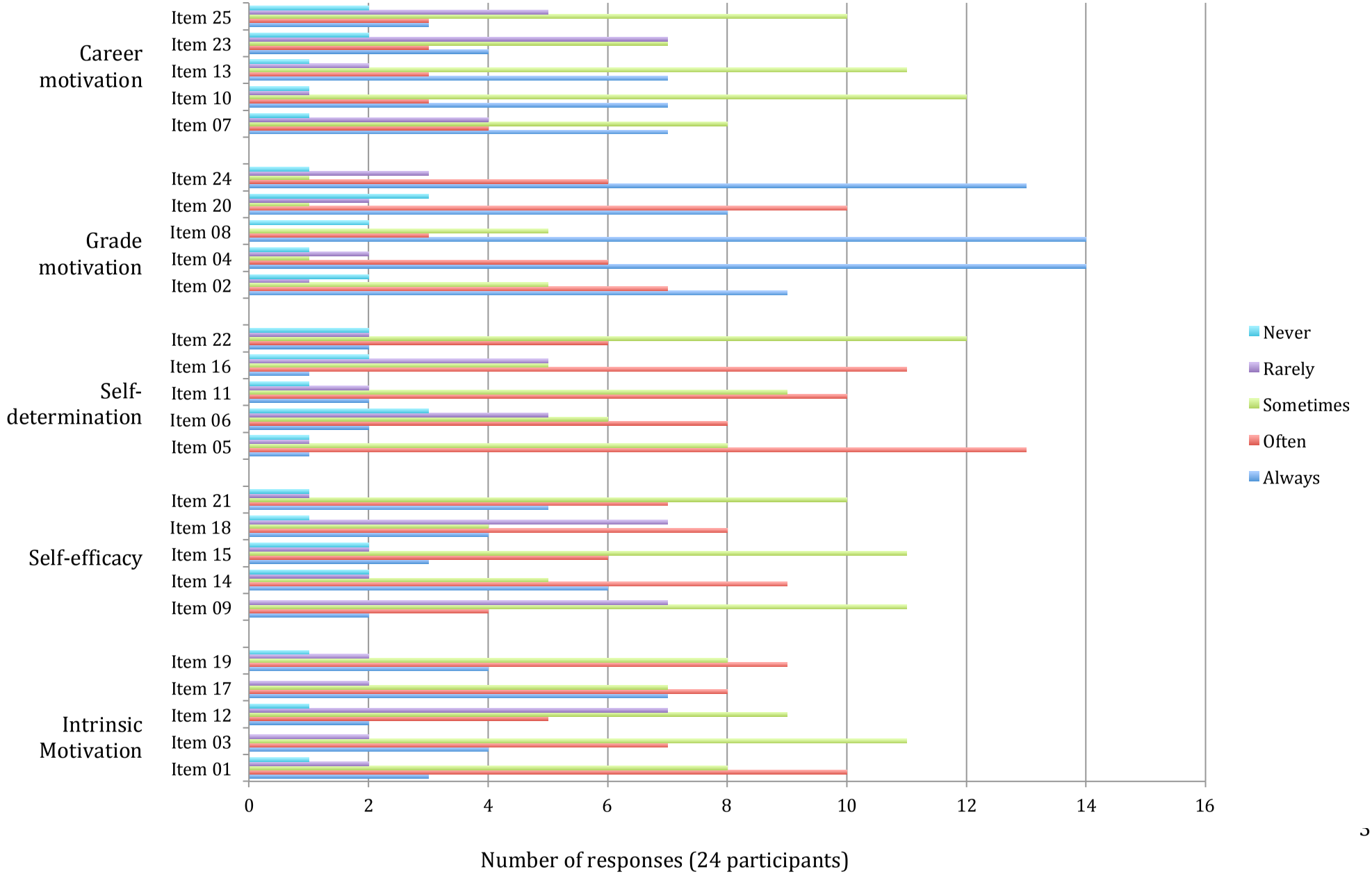
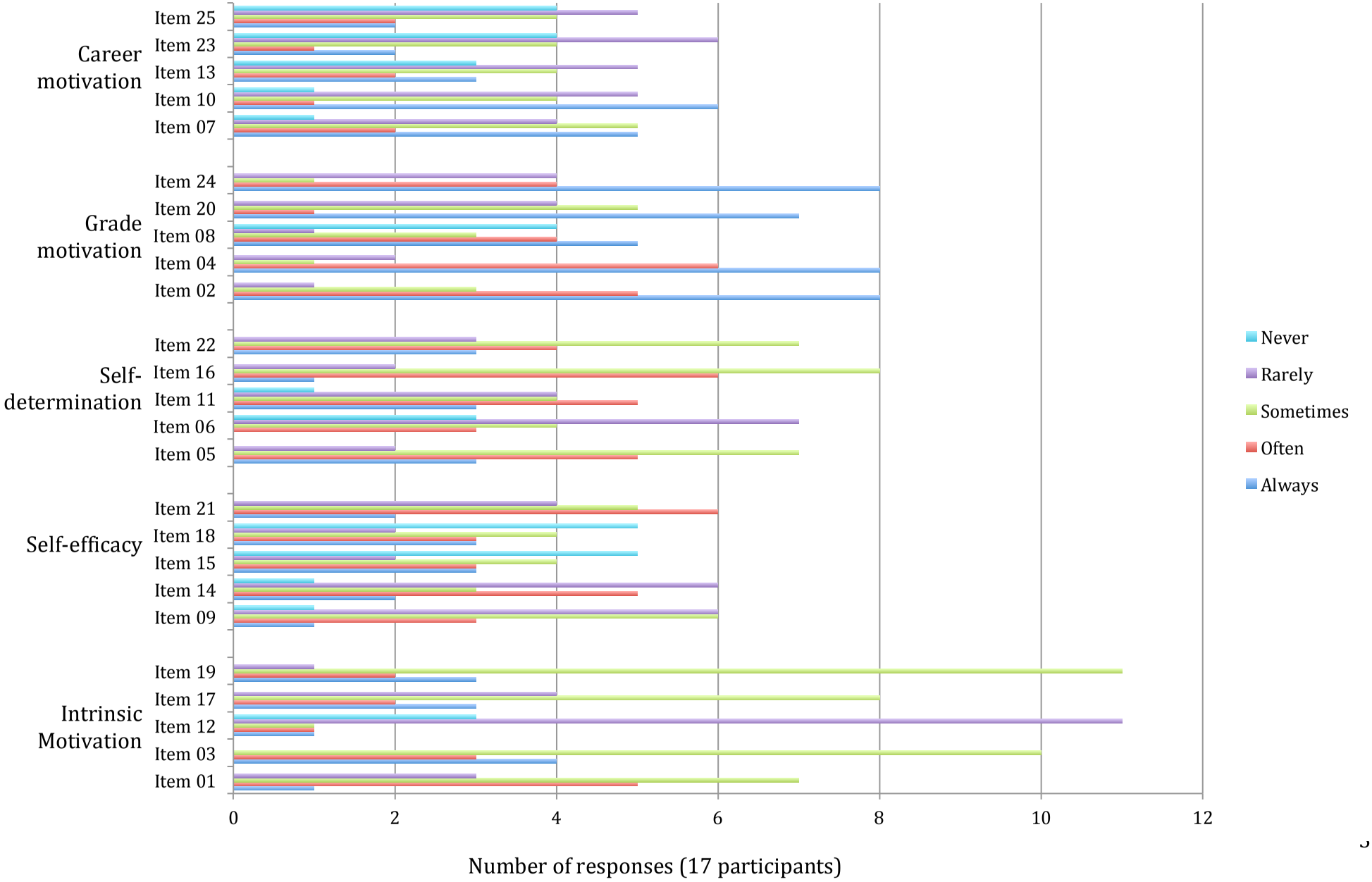


Figure 3: Results of the SMQ-II for Set 4



One of the reasons that students may have low feelings of self-efficacy and low intrinsic motivation to learn science is that studying science is perceived as a risk. It is likely that my pupils already perceive science as a difficult subject, where success can only be achieved by the very able (Osborne, Simon and Collins, 2003). In fact, studying science is often perceived as a risk. Kahneman and Tversky report in their 1984 study that the risk of failure is a more important factor in choosing a course than the potential reward. For example, although completing a course in science will potentially lead to high financial gain, many school students will choose a low-risk option, such as an arts-based course, despite the fact that financial rewards may be less. In our initial discussions of our Set 4 students, we used the expression 'risk-averse' to describe many of their learning behaviours. Therefore there is a chance that students are struggling with their compulsory science lessons, as they feel that they have little chance of success.

In our discussions with the classes, rather than leading conversations focusing on the opportunities available if one has a background in science, we instead encouraged the pupils to imagine careers and opportunities that are *unavailable* to people with no science qualifications. This shifts the emphasis away from the benefits (which are overshadowed by the inherent risk of failure) and instead focuses on *lost opportunities* – which could be perceived as a greater risk than the risk of failure. This is in line with suggestions by Simpson and Oliver in their study of influences on adolescent attitudes to science (1990).

In addition to devoting an entire lesson in Physics (for Set 2) and Chemistry (for Set 4) to helping the pupils understand their individual results of the SMQ-II survey, we also conducted three interviews, with pairs of students from both classes. The pairs were chosen based on their academic ability and achievement (similar YELLIS scores and similar grades). Furthermore, each pair of students are friends, and

indicated that they'd be happy to talk candidly about their grades and attitudes in each other's presence. Pair A consisted of a high-achieving, high ability boy and girl from the Set 2, Pair B consisted of two low-achieving, moderate ability boys and Pair C consisted of a low-achieving, low-ability boy and girl from Set 4.

Each interview was conducted by both teachers (myself and the Head of Physics) during the pupils' extended form time during the course of the normal school day. The interviews lasted approximately 10 minutes each. These interviews were voluntary, and students had the option to end the interview at any time. The interviews were audio recorded (with permission from students) for later transcription. The interviews were not scripted. Each pupil had a copy of their SMQ-II results, and we used the results and the component categories to discuss the students' personal motivations to learn science. Of particular interest to us were our interviews with the two low-achieving pairs, Pair B (Joe and Mike) and Pair C (Anna and Ed). Note: these are not the pupils' actual names.

Responses to the SMQ-II for each pair of students are shown in Figures 4 and 5. Both boys in Pair B show relatively high intrinsic motivation and self-efficacy, but Mike has very low career motivation, grade motivation and self-determination, whereas Joe shows high motivation across all five domains. We found it interesting that Mike had very low self-determination yet high self-efficacy. We asked him about this:

Interviewer: *You answered positively to the questions about self-efficacy: you seem quite confident in your ability to understand science and do well on tests.*

Mike: *Yeah, I've always been good at science. I understand everything in class, mostly, if I pay attention. I don't pay attention all the time.*

Interviewer: *Do your grades reflect this?*

Mike: *My grades show that I don't pay attention.*

Interviewer: *Do your grades show how much science you know?*

Mike: *No. My grades are bad because I don't remember the right words, and can't be arsed with long answers.*

Interviewer: *You said you've 'always been good at science'. How do you know this? Especially if your grades don't reflect it?*

Mike: *I don't know. I just know I'm good at science. It's interesting. I like science shows on TV like Myth Busters and nature programmes. My grades are bad in all subjects. I don't like to write long answers.*

Interviewer: *Do you think your grades can improve?*

Mike: *Not really. I'm always getting Ds and Fs or whatever. I'm below target on all of my reports. But I don't mind because it's just I don't care about tests. I get the stuff. My parents know that, too. They don't care about grades, either.*

As illustrated in the above excerpt, Mike is defensive about his low grades, and repeatedly makes the excuse that he can't be bothered, rather than possibly admit to the fact that he finds the schoolwork difficult. He has a strong belief in his own ability to understand science, despite the lack of any concrete evidence of his understanding. He knows that grades are a standard measure of understanding, but rather than appear unintelligent, he explains the discrepancy between his self-described high level of understanding and low grades by stating that he doesn't put in the effort to earn grades (implying that if he *did* put in the effort, his grades would reflect his understanding more). This is a form of challenge avoidance typical of pupils with fixed mindsets. Additionally, these pupils consider academic setbacks (such as a low grade on a test) as evidence of lack of ability, and become discouraged or defensive, as Mike has done (Dweck, 2012).

Joe demonstrated more of a growth mindset, which may account for his higher motivation to learn science. Although his grades have been low to date, when asked about whether or not his grades could improve, he answered in the affirmative. He went on to say that his 'grades were not great, but I know I can do better later on. I think I will get a B on the end-of year test.' When pressed, Joe could not explain what he could do to improve, but he seemed very confident in his capacity to improve.

Pair C includes two students who both consistently earn failing grades in Chemistry and Physics. They both have low YELLIS scores and have aspirational predictions of C grades in Science. They will both sit the exams for Science and Additional science (the 'dual award') GCSEs rather than three separate sciences (the 'triple award), as this allows them to work at a slower pace, because they are only responsible for two-thirds of the course content as the triple award, but have the same amount of time to cover the material.

Figure 4: Results for Pair B (low-achieving, moderate ability boys in Set 2)

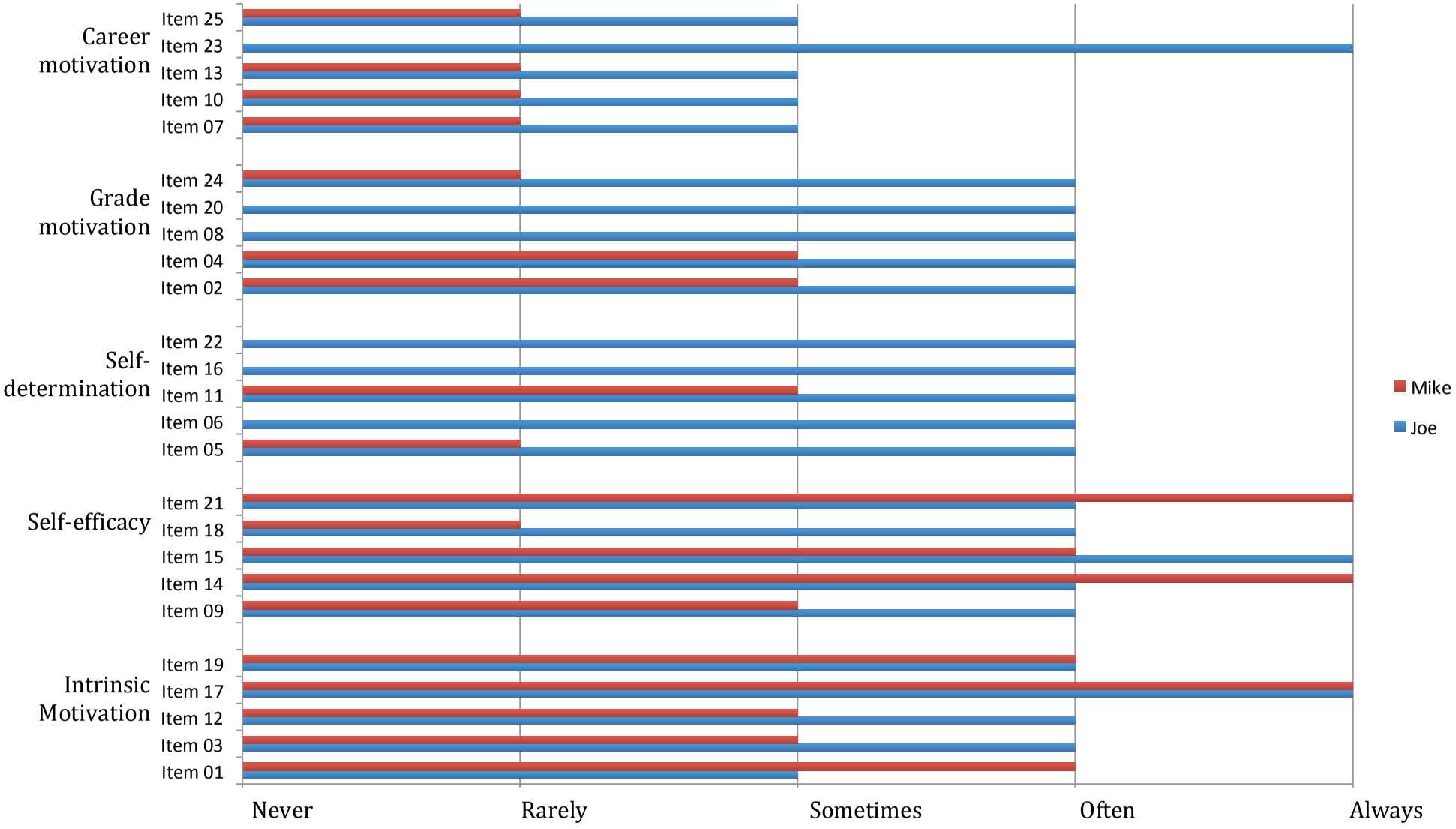
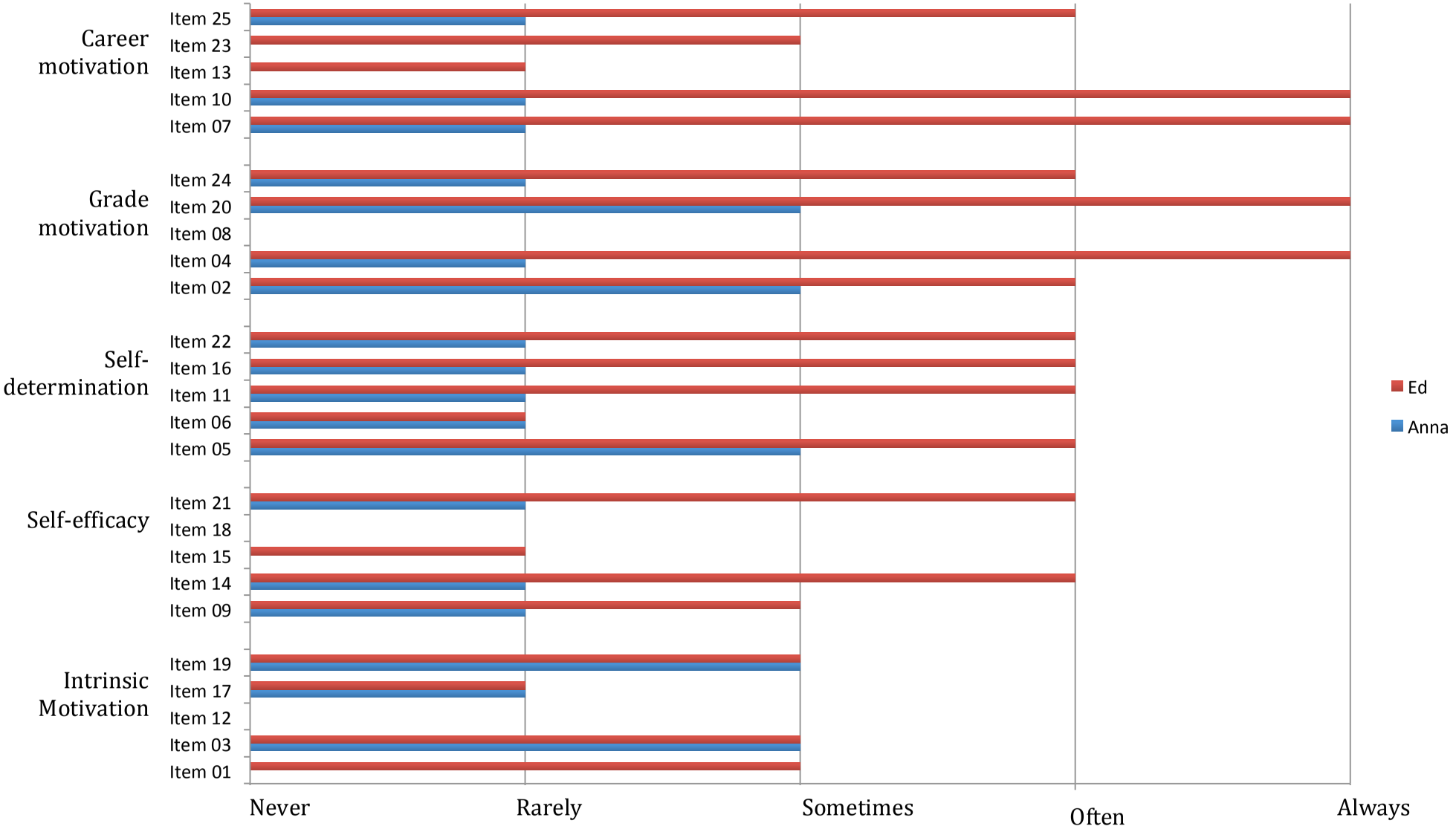


Figure 5: Results for Pair C (low-achieving, low-ability boy and girl in Set 4)



As shown in Figure 5, Ed's motivation is similar to that of Joe in Set 2. Anna, however, demonstrates very low motivation across all five domains, especially in self-efficacy and self-determination. In our discussion before interviewing Pair C, the Head of Physics and I noted that both students display a high level of 'learned helplessness' in Chemistry and Physics lessons, in that they stop working whenever their task becomes difficult, relying instead on the teacher to answer their questions. They are both reluctant to 'have a go' at answering questions, and both resist writing answers until they have confirmed with the teacher that it is 'right'. This learned helplessness is, according to Galloway et al, the best-known maladaptive motivational style. It arises from a fixed mindset: learned helpless pupils attribute failure to lack of ability, and lack of ability is seen by these pupils as beyond their control – a fixed quantity (2004). Some of the statements made by Anna and Ed that demonstrate their fear of failure and the belief that ability is fixed are shown below.

Interviewer: *Can you tell me a bit about how you deal with difficult problems in your classwork?*

Ed: *I try my best, but sometimes it's really hard to get it.*

Interviewer: *What do you do as you are 'trying your best'?*

Ed: *I think about it and try to remember what was said in class.*

Interviewer: *Do you consult your friends or the textbook?*

Ed: *Not really. They [the others in class] don't know what they're doing. It's hard to find the right stuff in the textbook. It's easier*

to ask you [the teacher] for help. Then I know it's right and I can carry on.

Interviewer: *How do you feel when you are faced with a difficult problem in your science work?*

Anna: *Rubbish. Science and maths make me feel so thick! I see a question and I think 'We just talked about this' or 'We did this last lesson' but I never remember anything. Even when I revise for tests, I see a question and think 'I revised this!' but then I can't remember what I revised. It's frustrating. I hate that we are forced to do science, no offence, because lots of us won't ever need it for jobs or whatever. I want to work in business. I don't need this stuff, it's a waste of time and I could be doing subjects that I'm good at instead – stuff that will actually help me in the future.*

Interviewer: *Do you think you can get better at science?*

Anna: *No. I've never been good at science, even at primary school! I'm not going to suddenly get it. It's OK, though, because I'm good at history and art and things.*

Worryingly for us as teachers, learned helplessness, which is a common behaviour in Set 4, is a very difficult pattern to break. However, changing pupil intrinsic theories (i.e., developing growth mindsets) has been somewhat successful in breaking the cycle of learned helplessness (Craske, 1988).

3.1.5 Conclusions

Our research question asked '*How motivated are our Year 10 students to learn science?'* Based on the results of the SMQ-II surveys and the small sample of follow-up interviews, we concluded that although motivation is a mixed picture across the two sets, the pupils' biggest motivational driver is an extrinsic factor: grades. Furthermore, within each class, there is a full spectrum of intrinsic theories from absolute fixed mindset to full growth mindset. Some pupils have conflicting beliefs, such as a belief that they are incapable of achieving 'A' grades in science, yet are fully capable of understanding the science taught in lessons. Some pupils indicated that earning a good science grade is very important to them, however they feel that they will never be able to earn a grade of 'A'. Wanting to be able to demonstrate the ability to do well in science, but feeling that they don't have (or can't develop) that ability leads to frustration, defensiveness, avoidance, and behaviour problems – particularly in Set 4.

The results from this small study highlighted to us the extent to which our pupils have fixed mindsets. In the interviews, we were struck by the fact that students seemed to believe that some pupils were 'good' at Physics and Chemistry and would earn good grades, whilst others were 'bad' at Physics and Chemistry and could not earn good grades. Although motivation to learn science is high amongst many of the pupils in our Year 10 sets, we wonder if helping them to develop growth mindsets can improve their motivation to learn science, particularly by improving feelings of self-efficacy, self-determination, and intrinsic motivation. Therefore, as a result of this first study and its findings the educational innovation we next implemented involved developing a growth mindset in Year 10 pupils.

3.2 Study 2: Developing growth mindset

3.2.1 Background

Year 10 can be a difficult time for students. The transition from primary school to secondary school is a particularly difficult time, marked by decreasing self-esteem, school engagement and grades. This decline continues through the middle years of secondary education, accompanied by a normative increase in anti-social behaviour. (Wigfield, Byrnes and Eccles, 2006; Entwisle, 1990; Eccles, et al, 1993). This is not to say that all teenagers suffer these declines, but rather that there is evidence of a general trend from primary through secondary school. This decline could be attributed to environmental factors. Eccles et al (1993) found that the secondary school environment is one in which an emphasis is placed on competition, social comparison and self-assessment of ability. This is a time of contradictions for young people: it is

> …associated with a decrease in decision making and choice at a time when the desire for control is growing; and it disrupts social networks and support when they are most needed. Together, these changes point to a mismatch between the adolescent's needs and the environment they are thrown into – one common result of which is disengagement from school (Blackwell, Trzesniewski and Dweck, 2007, p 246).

Whilst some students suffer from setbacks as described above, others thrive during this tumultuous time. Understanding the nature of those resilient, academically buoyant pupils has been the subject of significant amount of research over the past three decades, and Dweck's model of implicit theories of intelligence has been developed to explain the psychology of pupils who flourish under challenge when

their equally able peers do not (Dweck and Leggett, 1988; Dweck, 1999; Dweck, 2006; Dweck, 2012).

3.2.2 Research Question and Method

Through our post-SMQ-II interviews, we identified some pupils who display the attitudes consistent with fixed mindsets, and by extension we assume that a number of other pupils in Year 10 also hold fixed views of ability and intelligence. We wanted to develop and deliver a series of lessons on the brain and intelligence, in the hopes that some of our pupils shift from fixed mindsets to growth mindsets. The ultimate goal is to increase feelings of self-efficacy, self-determination and intrinsic motivation amongst our science pupils. Our research question became:

Can our Year 10 pupils shift from fixed mindsets to growth mindsets by being taught about the physiology and psychology of learning?

Pupils' theories of intelligence are not subject-specific. Therefore, we decided to include mindset training as part of our school's PSHE offering. We formed a small working group within consisting of me, the Head of Physics, the Head of Psychology and the Head of Middle School to explore ways of teaching growth mindset to Year 10 pupils. We decided to use extended form time and PSHE lessons to deliver a programme of intelligence theory to the students. There are 86 students in Year 10, in eight tutor groups. We paired tutor groups to create four 'sets' of students for the purpose of this programme. Each member of staff in the working group delivered the programme to one set of students, with form tutors present to participate and assist. The programme itself was based on the incremental theory intervention described by Blackwell, Trzesniewski and Dweck (2007), and consisted of eight sessions of either 30 minutes or 50 minutes (depending on whether the session was held in extended

tutor time or during PSHE lessons), over the course of six weeks. The Head of Psychology is particularly interested in mindset research, and volunteered to prepare the detailed lesson plans and materials for the programme. An outline of the sessions is provided in Table 2 below.

The Blackwell, Trzesniewski and Dweck programme was chosen because it has been demonstrated by the authors to be an effective intervention in helping students develop growth mindsets, and the authors provide a detailed appendix in their paper which clearly describes the contents of the 8 session programme, making it quite easy to develop and deliver to our students.

The students were told about this programme in a Year 10 assembly at the start of second half of Lent Term. During the assembly, pupils completed the see Mindset Assessment Profile Tool (Mindset Works, 2012), which was handed in and scored by group leaders. See Appendix A for a full version of the assessment and information on interpreting the scores. We chose to use the Mindset Assessment Profile Tool as it was developed by Blackwell and Dweck, and is available at no cost from the website of their company Mindset Works. It includes detailed instructions on scoring and interpreting the results, and although it can be used by people of any age, it was specifically designed for use with pupils in Years 6 through 10. The Mindset Assessment Profile Tool provided us with baseline data on our pupils' intrinsic theories of intelligence.

Parents were informed of the programme via the weekly parent mailing, and were sent an electronic of the Mindset Assessment Profile Tool and scoring instructions in the hopes that some of the parents will investigate their own Mindset Assessment Profile group and discuss with their child.

Table 2: Outline of incremental theory intervention programme

Session	Lesson Title and Content
Introduction	A Year 10 assembly was held to introduce the Incremental theory intervention programme that the students would be participating in over the next several weeks. As part of the assembly, students completed the Mindset Assessment Profile Tool, which was handed in and scored by group leaders.
1	'How does the brain work?' Part 1 The session began with students receiving their scored Mindset Assessment Profile Tool and information sheet. Results of the assessment were briefly discussed. Students were taught about the basic anatomy of the brain using models and a slide show, including the fact that the brain is divided into regions responsible for different functions such as sensory and motor, higher cognition and memory, and that the brain is divided into two hemispheres connected by the corpus callosum. We looked at the structure and function of the neuron.

2	‘How does the brain work?’ Part 2 Students investigated neuron communication and learned about how information is passed throughout the nervous system. We completed a ‘connect the neuron’ activity and timed the ‘synapse’ response time. We then discussed the parasympathetic nervous system.
3	‘You can grow your intelligence’ Part 1 Students were shown a presentation based on Blackwell’s article for students, ‘You can grow your intelligence’ (Blackwell, 2014). Students each prepared a brief summary of the information on their iPads. (The presentation was made available to students electronically for review).
4	‘You can grow your intelligence’ Part 2 Students read their summaries from Session 3, and the group leader briefly recapped the ideas from ‘You can grow your intelligence’. Emphasis was placed on the metaphor of the brain as a muscle. A discussion was held in which students were asked to think of things they had

	learned to do well, and to also think about the practice and time they put into mastering these skills. The group talked about how the pupils' brains had physically changed as a result of mastering skills, linking to the first 2 sessions on the structure and function of the brain.
5	Stereotype Challenge Students participated in a stereotype workshop as described for Session 5 in Appendix A of Blackwell, Trzesniewski and Dweck (2007).
6	Study Skills Students participated in a study skills workshop as described for Session 6 in Appendix A of Blackwell, Trzesniewski and Dweck (2007).
7	Discussion Session Part 1 Students again reviewed the results of the Mindset Assessment Profile Tool, and this began the discussion that proceeded as described for Session 7 in Appendix A of Blackwell, Trzesniewski and Dweck (2007).

8	Discussion Session Part 2 Group leaders led a discussion on harmful stereotyping as described for Session 8 in Appendix A of Blackwell, Trzesniewski and Dweck (2007). Students were then asked to think about how their feelings on innate ability and theories of intelligence have changed during the course of the programme. Students were given a new copy of the Mindset Assessment Profile Tool and instructions on how to score the assessment (see Appendix A), and were given 35 minutes to complete and score the questionnaire to see if and how their Mindset Assessment Profile group had changed from the start of the programme. Students were also given electronic copies of the assessment tool and scoring instructions for future use.

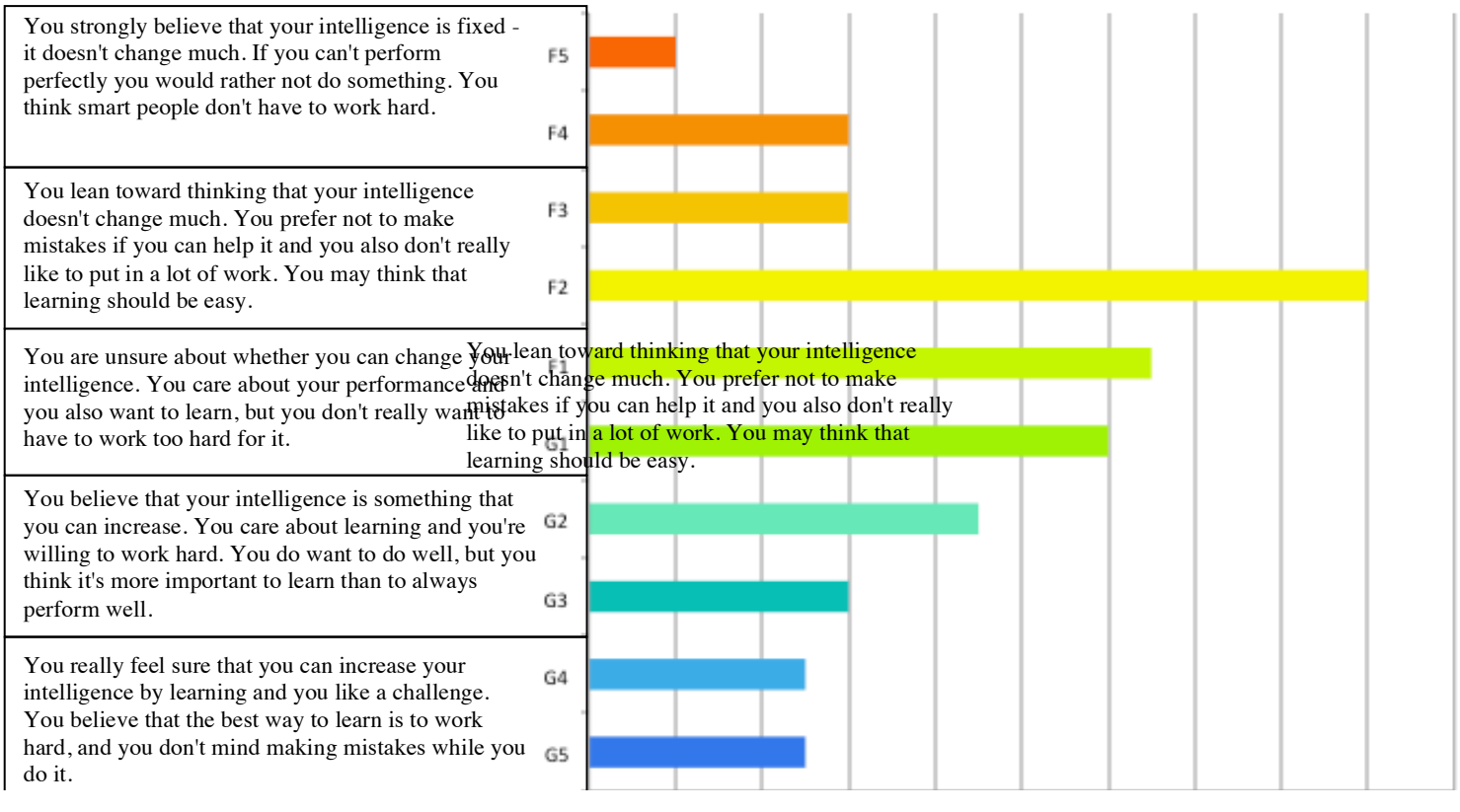
3.2.3 Results and Discussion

82 students in total completed the initial Mindset Assessment Profile Tool during the introductory assembly. These were collected and scored by group leaders. The final score is used to place the respondent in a Mindset Assessment Profile group ranging from F5 (strongest fixed mindset) to G5 (strongest growth mindset). Figure 6 shows the distribution of pupils into the ten Mindset Assessment Profile groups based on

the scores from this initial assessment. This data can only be read as a snapshot of pupil mindset at the time that the questionnaire was completed, rather than a definitive label for each student. The responses on this assessment are given on a Likert scale, thus there is a possibility of central tendency bias, acquiescence bias and social desirability bias as described in study 1, and the data must be considered qualitatively.

There is a marked difference between the two sets, with Set 2 showing higher motivation in each of the five components. Both groups are most motivated by grades. Set 2 also demonstrate relatively high self-determination and intrinsic motivation, and moderate career motivation. Set 4, however, show low career motivation, self-efficacy and self-determination. Although intrinsic motivation is a mixed picture for Set 4, there was an overwhelmingly negative response to item 12: “Learning science makes my life more meaningful”.

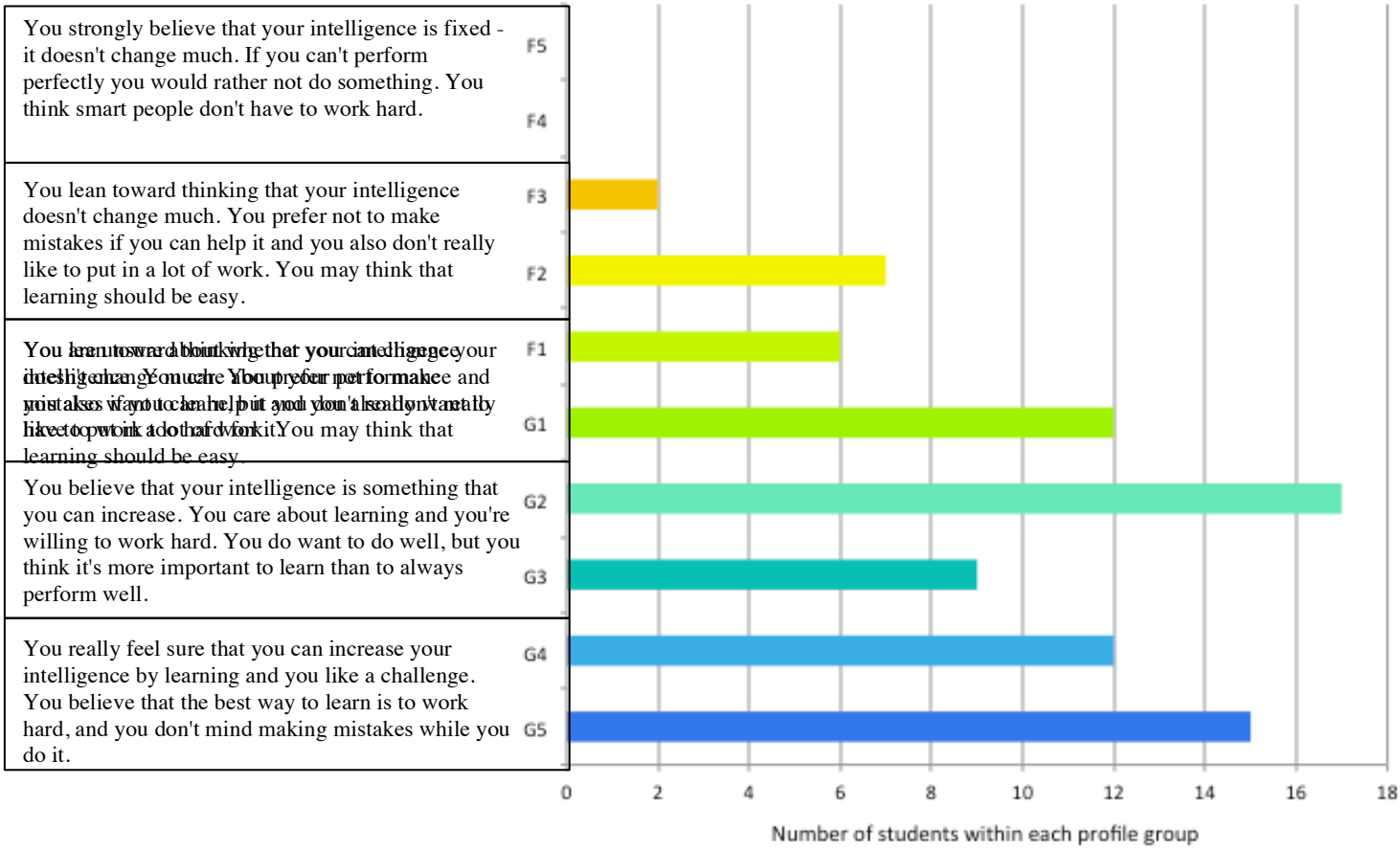
Figure 6: Initial distribution of pupils into Mindset Assessment Profile groups



The eight sessions were delivered to schedule, and the group leaders and form tutors reported that pupils responded quite positively to the programme, and seemed to genuinely enjoy themselves. During informal discussions throughout the programme, tutors reported that they found the eight consecutive, themed sessions more meaningful and interesting than the stand-alone sessions that make up the majority of the PSHE curriculum followed by the school.

81 pupils were present during Session 8 and completed a second, post-intervention Mindset Assessment Profile tool. The Mindset Assessment Profile groups were recorded, and the results are presented in Figure 7. Whilst several pupils remain in the fixed mindset groups, there is a notable shift in groupings. After completing the intervention programme, more pupils have been identified as having more of a growth mindset. On a purely qualitative basis, it seems that the eight-week programme was successful in achieving the goal of helping pupils develop growth mindsets.

Figure 7: Post-intervention distribution of pupils into Mindset Assessment Profile groups



3.2.4 Follow up

We were still concerned by the number of pupils in the F3 to G2 categories, as we had hoped to see most of the students in categories G3 and above. We selected a group of 5 pupils from Set 2 who agreed to discuss their experience of the intervention programme with us. Each of the five students (3 girls and 2 boys) participated fully in all eight sessions and the introductory assembly. The discussion was informal and unscripted, and lasted approximately 15 minutes. The session was audio recorded, with student permission, for later transcription.

During the interview, it became apparent that the pupils found the intervention programme interesting and meaningful. There were a number of positive comments such as, 'I thought it was really good – the best PSHE we've had', and 'I thought it was useful. We've learned about the brain before, but I didn't know that practicing something would make your brain grow [neural connections].'

However, it also emerged that whilst the students had certainly taken onboard the fundamental principles of growth mindset, namely that with continued practice and challenge, it is possible to increase one's intelligence; the pupils also still hold conflicting, deep-rooted beliefs about innate intelligence. This is illustrated in the excerpt from the interview shown below.

Interviewer: *So, you think some people are naturally 'smarter' than others?*

Girl 1: *Yeah, of course. There are top sets, middle sets and bottom sets, and you get put in the set that you belong in.*

Girl 2: *But you might be in bottom set science and top set English. Some people are science-y and some people are English and Art or whatever. Some people are good at some subjects and not good at other subjects.*

Boy 1: *Yeah and some people are terrible at everything or amazing at everything.*

Interviewer: *Is it possible to get better? For example, to improve enough to move from bottom set to top set?*

Girl 1: *Yeah, maybe. Well, probably not bottom set to top set, but from bottom set to middle set or middle set to top set probably.*

Boy 2: *Yeah, it'd be too hard to go from bottom set to top set, especially in, like, chemistry or maths.*

Girl 1: *Sometimes you're put in the wrong set because teachers don't know you or whatever, and you get moved when they realise you were in the wrong set. I got moved in maths last year because I was new to the school and I was in set 4 to begin with but now I'm in set 2 [of five].*

Interviewer: *What do the students who are in top sets do to get there? Do you think they work hard to be there?*

Boy 2: *Some do. Some people always work hard. But they're also naturally clever or whatever, and if you work hard and are already clever, you'll of course be in top set and do well.*

As the interview progressed, it became more apparent that students only had a superficial growth mindset, but still held deep-seated ideas about fixed ability and intelligence. Students seemed to believe that they could work towards understanding discreet topics, for example, one of the pupils in the interview explained that 'I've found the salt making stuff we've been doing lately quite difficult. But I think I'll be able to learn it; I'm going to work through those questions you gave us to practice'.

However, it also seems that although the pupils know that they can improve on these discreet topics, they don't equate this improvement with increased ability in the subject. For example, Girl 3 said, 'It took me ages to figure out how to do transformations on graphs [in maths]. I had to do a million practice problems and go to maths clinic at lunch. I finally sorted it, but I'm just not good at maths. I wish I was actually in a lower set.'

Through the interviews an interesting picture developed: the set that a pupil is placed in plays a fundamental part of their self-assessment as a student; it forms a large part of their academic identity. Furthermore, pupils felt that set placement is mostly beyond their control: it is something that teachers do. While there was acknowledgement of movement between sets, it was experienced infrequently and was explained in terms of being 'misplaced' in the first instance rather than movement based on changing ability and achievement.

3.2.5 Conclusions

In study 2, we set up an educational intervention to determine whether our Year 10 pupils could shift from fixed mindsets to growth mindsets by being taught about the physiology and psychology of learning. A comparison of the initial and final results of the Mindset Assessment Profile Tool, reveals that after participating in an eight-session programme in mindset training, more students demonstrated attitudes implying growth mindset than before participating in the programme.

However, the follow-up interviews showed that whilst students seemed to understand that intelligence and ability can be improved, they continued to believe that some people are 'naturally' smarter than others and don't need to work as hard to achieve success. Furthermore, they identified strongly with the academic set they are placed in for their maths, science and English studies. There was evidence that achievement was limited by the set a pupil is placed in; someone in a bottom set could never achieve the same as a pupil in a top set.

This contradiction made us question the reliability of the post-intervention Mindset Assessment Profile results. Did the pupils we interviewed say all the 'right things' because they had been taught about growth mindset, even though their beliefs

contradicted their statements? Was this an example of acquiescence bias, with the pupils simply telling us what they believed we wanted to hear? Did they choose the 'right' answers on the Mindset Assessment Profile questionnaire because they knew that the growth mindset profile groups were more desirable? Possibly. However, regardless of whether or not the students answered honestly on their assessment, the fact remains that they had learned about how the brain works and how intelligence is developed. They learned that ability is not a fixed quantity, but is malleable through practice. Based on this alone, we felt that the intervention was a success and laid the foundations for future work in the school developing growth mindset in pupils. The Head of Psychology at the school is particularly interested in this, and is moving forward with developing a school-wide growth mindset training programme to be delivered in PSHE classes across all year groups. This will be put in place for the 2016-17 school year.

3.3 Study 3: Tackling 'stereotype threat' of setting

3.3.1 Background

One of the outcomes of Study 2 served to highlight the fact that students identified strongly with the academic set they are placed in for maths, science and English classes. Pupils in the top set were spoken of with respect, whilst those in bottom sets were dismissed as something of a lost cause for that particular subject. This is concerning because there is a threat that pupils in low sets could underperform as the expectations for bottom sets are lower than for top sets; lower set pupils could be happy with mediocre performance if it is seen to be appropriate for the set as a whole. Furthermore, self-determination is a motivating factor for students, and this may be a negative influence on our pupils' motivation to learn science (Glynn et al

2011; Galloway et al 2004). As long as students are placed in homogenous sets, where movement between sets rarely occurs, it will be difficult for them to build positive feelings of self-determination.

As shown in the literature review (section 2), the effectiveness of ability setting in improving student outcomes is questionable. Within my school, there is serious disagreement between the Heads of Chemistry, Physics, Biology and Maths as to whether or not students should be set at all, and if they are to be set, should it happen as early as Year 7? How often should sets be re-evaluated and pupils shifted from one set to another? The current practice at our school is to set for maths and science from Year 7 and English from Year 9. There is no setting in other subjects.

Regardless of whether or not ability setting is appropriate or beneficial, this is the model we have to work with. We have no recourse to re-setting into mixed-ability groups to explore possible changes in self concept and mindset. Instead, we must think about ways to work within the system we have to challenge the stereotype of a 'top-set student' or a 'bottom-set student'.

Pupils in any set group may experience stereotype threat. The 'top-set' pupil may feel increased anxiety and pressure to attain high grades, the 'middle-set' pupil may feel side-lined academically, unable to access the academic recognition associated with being placed in a top set. It is, however, the 'bottom-set' pupils that we turned our attention to, as they tend to have lower levels of motivation, particularly self-determination, than other pupils (see Study 1). Additionally, several negative references to 'bottom sets' were made by pupils in our interview in Study 2, evidence that this negative stereotype in entrenched.

We decided to develop an intervention for our pupils in science Set 4, to reinforce the growth mindset training described in Study 2 and to use 'attributional techniques' such as those described in Wilson and Linville (1985) to shift the perception that poor academic performance is the result of pejorative attributions (such as lack of ability or intelligence).

3.3.2 Research Question and Method

Our research question for this study is:

Can growth mindset training and attributional techniques improve Year 10 pupils' attitudes towards learning science?

The intervention was two-fold. First, we continued reinforcing the growth mindset message instilled through the intervention described in Study 2. Second, we taught pupils that low attainment can be attributed to a number of temporary, external factors, and is not the result of low intelligence or lack of ability.

To reinforce the growth mindset training, we developed a series of growth mindset and learning skills 'starter' activities that were delivered in physics and chemistry lessons over the course of the last four weeks of the first half of the summer term. After half-term, the students would return to school for a week of internal end-of-year examinations in all subjects. We chose this time frame as students were beginning to express some feelings of anxiety about their upcoming examinations, and were particularly open to interventions that they believed could help improve their grade outcomes.

The starter activities included:

- viewing Eduardo Briceno's TEDx video on the power of belief (Briceno, 2012) and holding a brief class discussion;
- re-writing statements from fixed mindset to growth mindset. For example, the class was shown the statement 'I'm not good at this' and decided instead to write 'I haven't got my head around this yet';
- developing a list of 'dos and don'ts' for exam revision, such as 'don't compare yourself to your friends' and 'do revise in short yet productive sessions';
- each student prepared an individual revision timetable for the half-term holiday;
- students made postcards to themselves including an illustration and brief description of a skill they have mastered through tenacity and hard work. Examples included working up to the first team in cricket, learning the viola, performing in the school musical and learning French.

Furthermore, we provided time at the start of appropriate lessons where students could reflect on homework feedback. When marking during this period, we did not correct student work or provide 'grades', but instead wrote brief statements praising effort, or specific statements about why the piece of work is good (or needs improvement) and emphasised progress made by the student (Murtagh, 2014). In the 'feedback review' sessions, students were expected to correct or edit their work and/or provide a written response to the feedback (for example, stating which resources they used to help them answer questions successfully, and how these resources proved helpful or a statement about how they approached the task differently in correcting their work).

The second part of this intervention aimed to teach students to reattribute academic difficulties to non-pejorative attributions. This was done through showing the pupils a set of results across topic tests of previous Year 10 pupils showing that, on average, test grades improve throughout Years 10 and 11. This is evidence that much of the poor performance experienced by the pupils to date can be attributed to the difficulty of starting a new course (GCSE Science) and understanding the new associated demands and expectations. We also invited a current Year 13 Chemistry pupil to speak to the group about how he went from Set 5 in Year 10 to Set 3 in Year 11 to earning a B at AS chemistry and being predicted an A for A-Level chemistry.

3.3.3 Results and discussion

The first part of this intervention, which involved growth mindset starter activities, was delivered during the first half of the summer term, whist the second part (the talk by the A Level student) was delivered in the first week of the second half term. Unfortunately for this study, I left the school over the summer half-term, and therefore the second half of the intervention and the analysis of effectiveness was done in my absence.

The Head of Physics interviewed six of the 20 pupils in Set 4 within a week of the second part of the intervention, in two groups of three pupils. Interviews were chosen over other methodologies (for example, questionnaires) as the teacher felt that an interview would allow for unprompted insight into the students' answers. These interviews were not recorded, although notes were taken. The interviews revealed a degree of 'growth mindset fatigue' amongst the students. For example:

> *Interviewer*: Do you think the starter activities we did last half term helped re-inforce your growth mindset?

Student 1: No. Or maybe. I am really sick of growth mindset!

Student 2: Me too! We get it! We can grow our smartness!

Interviewer: Do you think the starter activities were useful at all?

Student 2: Sort of. The thing about grades was good, made me feel hopeful.

Interviewer: The day when we showed how Year 8, 9, 10 and 11 grades map to GCSE results?

Student 2: Yes. That was good. I told my mum about it!

Interviewer: Do you think the increase in results is linked to growth mindset?

Student 2: I don't know. I'm so bored of growth mindset stuff!

Over the course of the interviews, the other students also reported responding positively to both the presentation about the increasing trend in end-of-year exam results and the talk from the Sixth Form student. Ironically, even though many reported being tired of growth mindset-based activities, when asked about the Sixth Former, several pupils talked about how much effort he put in to improve his outcomes, and that they identified with his strong desire to 'get out of the bottom set'. Two pupils specifically mentioned wanted to work harder so they could perhaps follow in his footsteps, a suggestion that these students believe that hard work, rather than ability or other pejorative attribute, will lead to success. This kind of

interventional challenging how pupils attribute success and failure may lead to an increase in attainment, as described in Wilson and Linville (1985).

3.3.5 Conclusion

Although the analysis of the effectiveness of this intervention was weak, as it was limited only to three short interviews with pairs of students, there were encouraging signs that providing pupils with evidence of the impact of growth mindsets (showing exam data over time and providing a talk by a Sixth Form pupil who improved his attainment significantly over the course of three years) did have some impact on them. If we had the time and personnel, a more robust analysis of the intervention would have been carried out, including perhaps another SMQII test at the end of the intervention that could be compared with the baseline data collected in study 1.

4. Implications for future practice

In study 1, found that all of the Year 10 science students we worked with exhibited at least some level of fixed mindset with respect to their science education. In particular, ideas about fixed ability in physics and chemistry were prevalent. We also discovered that grades were the single largest motivating factor for our pupils to learn science. This suggests that, according to Dweck's (2006) model of growth mindset, these students demonstrate fixed mindset and the tendency towards extrinsic motivational factors. Students driven by such external motivational factors tend to do less well than those students who are driven by internal motivational factors such as interest in the subject or implications for future careers (Atkinson, 1957 and 1964; Covington, 1992; McClelland, 1965; Cameron and Pierce, 1994). It was therefore important to us that we challenge both the fixed mindset and the tendency toward extrinsic motivation in our students.

In Study 2, we showed that an eight-week programme of growth mindset training was successful in raising student awareness of growth mindset, and perhaps in increasing growth mindset of pupils. This second claim is more difficult to substantiate, as there is a strong possibility of acquiescence bias in the instrument we used. Nevertheless, our results are similar to those shown by Blackwell, Trzesniewski and Dweck (2007), after a similar intervention. Despite the increase in growth mindset of the students, our follow-up interviews highlighted a correlation between the ability set the pupils were placed in and feelings of self-efficacy. For example, pupils in the 'bottom set' reported the lowest levels of self-efficacy. This link between feelings of low self-efficacy and being identified as 'bottom set' is also described by Boaler et al (2000), Boaler (1997), Hallam and Ireson, (2007) and Ireson, Hallam, and Plewis (2001) as detrimental to student self-worth and attainment.

Study 3 sought to further growth mindset training for our year 10 pupils, as well as tackle stereotype threat by providing different forms of evidence that pupils in 'bottom sets' were able to improve their attainment and achievement over time. Students reported feeling more positive about their chances of improved results after this intervention.

The initial findings reported in these small studies have had an impact on practice at the school. For example, the Head of Psychology is preparing a progressive growth mindset training programme that will be delivered over the course of next year to each year group (7 through 13). Several teachers have been sent on growth mindset courses as part of their continuing professional development (CPD), and the school has made a commitment to support pupil and teacher training in growth mindset in the coming years. Furthermore, a dialog has begun regarding setting in mathematics and science, with an argument against setting from year 7. Next year, science will

not set based on ability in Year 7, and there is a chance of keeping heterogeneous groupings in science until through Year 9.

Since starting this research, I have become a Deputy Head in another co-educational independent day school. I have added a growth mindset module into our Key Stage 3 PSHEE programme, and have initiated heterogeneous groups for Science and English at Key Stage 3 based on the results of this research. Moving forward, I hope to encourage a group of teachers to attend growth mindset training as part of their CPD.

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