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How can developing teacher feedback and encouraging a growth mindset with post-16 GCSE maths re-sit students enable them to justify their answers in the classroom?

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About CfEM

Centres for Excellence in Maths (CfEM) is a five-year national improvement programme aimed at delivering sustained improvements in maths outcomes for 16–19-year-olds, up to Level 2, in post-16 settings.

Funded by the Department for Education and delivered by the Education and Training Foundation, the programme is exploring what works for teachers and students, embedding related CPD and good practice, and building networks of maths professionals in colleges.

Summary

The purpose of this action research was to explore how the structure of a GCSE re-sit maths lesson can be adapted to allow time for students to work on resources which have a heavy focus on Assessment Objective 3 (AO3) questions. For students to meet the AO3 criteria they are required to explain and justify their answers and make connections between different topics in maths. It is essential that students are able to complete AO3 questions as they make up around 25% of the questions in their GCSE maths exam. However, a vast majority of students do not feel confident when answering AO3 questions and some do not even attempt them. Therefore, it is important to look at strategies to build learner confidence and resilience when attempting AO3 questions.

The report describes three cycles of action research, which allowed AO3 resources to be planned, observed and refined throughout. To initially plan the action research, an online student questionnaire was used. Following the findings from the questionnaire, a new lesson structure including AO3 resources was created and delivered to the students by re-sit maths teachers at the college; the effectiveness of the resources was then discussed in a teacher focus group. Student observations were then used to gather data about how strategies encouraging a growth mindset can help build learner confidence when answering AO3 style questions. For the third and final cycle, students were given feedback on assessments without a grade and used the feedback to create a personalised revision plan. The students then participated in interviews to offer their thoughts on the final cycle and suggestions to improve revision sessions for future students.

When the data from the initial student questionnaire was coded and analysed, it became apparent that students at the college lack confidence when answering AO3 questions and do not believe they have enough practice on them during their lessons. Once students had been using the new resources over a four-week period, the teacher focus group indicated that students struggled to break AO3 questions down, but that if the students engaged in group work effectively, they can help build each other's confidence when completing the new resources. Three peer work strategies were then planned and created for the second cycle of action research to encourage a growth mindset. The student observations conducted during this cycle showed that students can become demotivated when they receive a bad grade on assessments, which prevents them from reading the feedback they have been provided by their teacher to enable progress, this key finding early on informed future cycles. Therefore, the third cycle of action research looked at how feedback can be adapted so that students have time to read and act on the comments their teacher has provided before they receive their grade in an assessment.

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Background

Introduction

The college leading this project, Tameside College is situated in the East of Greater Manchester. From the 141 areas in Tameside, eight of these fall within the most deprived 5% nationally and a further 16 fall within the most deprived 10% nationally. In total, 13.4% of Tameside residents live in income deprived households with a 4.7% unemployment rate and around 9000 children across Tameside are eligible for income-based free school meals (Tameside Council, 2022). Tameside College is one of the 21 colleges across the country to carry out action research as part of the Centres for Excellence in Maths (CfEM) programme and is working with other Further Education (FE) providers within its network to expand upon that research.

In order to best understand and therefore inform and narrow the focus of the research proposal, it was necessary to examine and evaluate the changing landscape and challenges faced in teaching a maths resit within FE. Traditionally maths teachers within FE face the cognitive dissonance between covering the maths content and taking the time to develop understanding (Swan, 2006). This discord has become even more pronounced since the advent of the reformed 9-1 GCSE examinations where the increased subject content directly contradicts the published criteria i.e. to not overload the syllabus (Roy, 2019). It is no wonder then that the majority of GCSE Maths teaching has focussed heavily on the memorisation of rules and procedures and rote learning, reaffirming learners' attitudes and beliefs about maths and furthering disaffection (Dickinson et al., 2010; Boaler et al., 2000; Dalby, 2013).

College Goals and Learners

Improving employment prospects remain a key part of the college's goal to 'transform lives by offering first class education and training in order to improve employability' (Tameside College, 2022). The focus for the action research must consider how it will add value to developing strategies to ensure that all young people are given opportunity to achieve highly valued qualifications in maths, which, in turn, improves employment opportunities.

The curriculum supports both Greater Manchester and local authority priority areas and continues to be developed in response to employer skills needs and local/regional business development. The curriculum adequately addresses the priority Greater Manchester industries, fundamental to the future regional economic wellbeing. The specialist Advanced Technology Centre supports recruitment and learner progression into careers within engineering, advanced materials and manufacturing industries and the Health & Social Care Department are supporting careers in health innovation alongside the successful health cadet programme in conjunction with Tameside & Glossop NHS Foundation Trust. Strong links and partnerships within creative and digital media industries, such as Manchester Digital, have enabled the college to develop a robust offer which supports progression into employment and higher education which addresses Greater Manchester's local industry strategy (Tameside College, 2022).

Research Focus

As GCSE exams were cancelled again last year due to the pandemic, students were graded based on meeting a series of assessment objectives. During this grading process, it became apparent that students struggled to answer Assessment Objective 3 (AO3) style questions, which require learners to explain or justify their answers to a mathematical problem and to

make connections between different parts of mathematics (Edexcel, 2021). As some of the GCSE re-sit learners were unable to meet this assessment objective, it prevented them from achieving their target grade. Upon reflection, these students may not have had enough practice with AO3 style questions during lessons, which as a result, hindered them from progressing towards their target grade. Although exams went ahead in 2022, it is still important that students are able to meet AO3 criteria, as this makes up around 25% of the questions in the GCSE exam (Edexcel, 2021). Therefore, by giving students additional practice with AO3 style questions, the learners were more prepared for their exams, which could potentially help them to receive a higher grade.

In the next section I have addressed literature in relation to the research focus.

Literature Review

Introduction

This literature review focuses on six key sections; Assessment Objective 3 (AO3) criteria, self-determination theory, andragogy, working with peers, developing a growth mindset and teacher feedback. As AO3 questions are the focus of the action research it is important to research our examination board's (Edexcel) criteria and identify any issues within current literature which could affect the delivery of the action research intervention. It is also important to review literature around self-determination theory, as student motivation is an area of concern with GCSE re-sit maths students. The teaching philosophy andragogy is explored to find the relevance of the teaching paradigm with 16-19-year-old students within the Further Education (FE) sector and how it relates to literature on working with peers. Research around learner mindset will also be analysed to help plan strategies for encouraging a growth mindset with the learners. Literature surrounding the language used in teacher feedback will also be reviewed to evaluate the effectiveness of teacher feedback on enabling student progress. These six sections were selected as when combined together they will address how best students can be supported to answer AO3 questions.

AO3 Criteria

The Edexcel exam specification recognises the importance of AO3 style questions, as they make up around 25% of the questions in the GCSE maths exam (Edexcel, 2021). Part of the AO3 criteria is for students to make connections between different parts of maths, for example linking different topics such as fractions with ratio. Literature around this area suggests that students struggle to make these connections from a young age and it is common for primary school students to make false connections in maths. However, if these misconceptions are addressed and rectified, learners will extend and broaden their understanding, knowledge and use of mathematics (McCullouch & Turner, 2005). Rather than teaching students to learn through memory, an effective teacher would work with students to develop an understanding of mathematical concepts, which would enable students to see the connections between those different mathematical ideas (Johnston-Wilder et al., 2017). Another section of the AO3 criteria is to translate problems in non-mathematical contexts into a mathematical process or a series of mathematical processes (Edexcel, 2021). Studies have found that students who are taught using questions that are framed in non-mathematical contexts tend to be more accurate and more confident with their methods when solving problems, compared to students who are taught using traditional algorithms, as students taught using algorithms do not always recognise the number relationships they are dealing with in a context (Anghileri et al., 2002).

Self-Determination Theory

Self-determination theory (SDT) is a key theory of motivation which suggests people are motivated to grow and change by three innate psychological needs; autonomy, competence and relatedness (Ryan & Deci, 2017). Autonomy would require students to feel in control of their learning and their goals, competence focuses on learners gaining mastery of the skills needed for success and relatedness is the need for students to feel a sense of belonging (Cherry, 2021). SDT suggests that motivation cannot simply be categorised as either intrinsic or extrinsic, as there are several levels of both intrinsic and extrinsic motivation, so it is more useful to think of motivation on a continuum ranging from non-self-determined to self-determined. This continuum can be split into two main categories; controlled motivation and autonomous motivation (Ackerman, 2021), the latter related to the values and priorities of the learners.

Controlled motivation is where students feel obliged to engage in behaviours because of external factors, such as to avoid punishment or to impress others and individuals who are control-motivated are less likely to be self-determined. In contrast, autonomous motivation is where students engage in behaviours as they feel a sense of choice, for example if they value the activity or feel satisfaction for learning a new skill and students are more likely to be self-determined (Hagger et al., 2014). Studies have found if teachers support students' autonomy instead of trying to control their behaviour, students tend to have a higher academic achievement and greater conceptual understanding. To promote autonomous motivation, teachers should acknowledge signs of improvement and mastery of topics whist also encouraging students' effort and putting maths in contexts which learners see the value of (Reeve & Jang, 2006). However, although it is important for teachers to support autonomous motivation, studies have found that students prefer approaching their academic peers for support as opposed to their teachers, so peers can also contribute to the learner's growth and development, for example by explaining a particularly difficult concept to the learner (Shin & Johnson, 2021).

Andragogy

The term andragogy is a philosophy of teaching focused on adult learners, where learning is student-centred, as opposed to pedagogy where learning tends to be subject or teacher-centred. According to Fornaciari & Lund Dean (2014), andragogy is based on six key principles:

1. The students need to know why they are learning something
2. The students need to be responsible for their own learning

3. The students have prior learning experiences
4. Learning needs to be relevant to the students' lives
5. Learning should be based on problem solving rather than memorising content
6. The students learn better with intrinsic rather than external motivators

The andragogical teaching paradigm uses and builds on the learner's prior knowledge and experiences to help the learning process, whereas with a pedagogical approach, students are assumed to know little and the teachers will provide them with the information they need to learn (Forrest & Peterson, 2006). Although there is a gap in current literature surrounding andragogy within the FE sector, as GCSE maths re-sit students already have prior knowledge of the GCSE maths curriculum, as they have all already sat the exam at least once, it would seem appropriate to build on their prior knowledge through an andragogical teaching approach. However, the theory of andragogy focuses on the differences between teaching adults compared to children, treating the child-adult relationship as a series of oppositions rather than a progression from child to adult (Hartree, 1984), which may prove an issue within FE as the majority of learners are 16-19 year olds, still in some ways progressing from child to adult and still need some support in taking responsibility for their own learning.

An andragogical teaching practice would allow learners to analyse the material given to them to make connections between the material and their own life experiences. In contrast, with a pedagogical approach the students would take for granted what is being said to them by the teacher and they would learn it word for word to receive positive feedback, but may not necessarily make connections between what they have learnt (McGrath, 2009). Therefore, student motivation may be undermined when pedagogical methods are applied in situations which require andragogical dynamics, so although external motivators are easy to control, in order to intrinsically motivate learners, a learning environment should be created where learners can focus on what motivates them (Pew, 2007).

Working with Peers

Encouraging peer learning can facilitate an andragogical teaching approach, as to deliver effective group work, the teacher should give away the power to the group as much as possible, so the students become responsible for their individual learning (Pollio & Macgowan, 2010). This section will focus on two group learning methodologies; cooperative learning and collaborative learning. Collaborative learning emphasises the use of student-to-student interaction in the learning process, whereas cooperative learning is where students

work in small groups but under the guidance of their teacher (Roberts, 2004). Cooperative learning, which is where students work together to achieve a shared learning goal, can help improve learner motivation when implemented in a well-structured cooperative learning environment, as the students help each other as it is in their own interests to do so and therefore their effort increases (Hänze & Berger, 2007). The Education Endowment Foundation (EEF) has found that both collaborative and cooperative group work have a consistently positive impact on learning, however, the group work needs to have a structured approach with well-designed tasks for it to be effective, otherwise lower-attaining students may struggle to participate (EEF, 2021). Literature suggests that teachers may not value collaborative learning, as the group work they have observed is often of low quality with increased disruption and off-task behaviour, therefore it is important for both students and teachers to be trained in how to work collaboratively and the skills needed for group work, such as teachers taking a step back and learning becoming student led, should be embedded into the curriculum throughout the year (Durrington Research School, 2019).

Developing a Growth Mindset

Research supports that everyone has a core belief about how they learn, those with a fixed mindset believe that although you can learn new things, you cannot change your basic level of intelligence and those with a growth mindset believe smartness increases with hard work (Boaler & Dweck, 2016). Some students have a fixed mindset in maths classes and they have a negative emotional response when attempting to solve maths problems (Samuel & Warner, 2021). This may be because they believe they are not good at mathematics and never will be. As they do not feel competent, it seems pointless for them to try in their maths classes (Johnston-Wilder et al., 2021). A learner may have a fixed mindset because they believe it is socially acceptable to have a low maths ability. They may have repeatedly heard family members say, ‘I cannot do maths,’ so the student believes they have inherited the same low mathematical ability, but if teachers show students that they can grow their mathematical capabilities and the learners develop a growth mindset, they will start to respond to a mathematical challenge by saying, ‘I cannot do this yet’ (Johnston-Wilder et al., 2017).

However, reports have found that encouraging a growth mindset alone does not necessarily enable learners to make progress in maths. For example, simply telling students they cannot add fractions ‘yet’ does not help them to add fractions, so although the concept of a growth mindset is helpful, it would be more effective to promote and develop metacognitive discussion in the classroom (Sherrington, 2019). Metacognitive discussions are vital in the classroom if learners are to become problem solvers or critical thinkers, as metacognition

helps promote autonomy and resilience, whilst making students more likely to embrace a growth mindset and learn from mistakes (Spencer, 2018).

Teacher Feedback

When external factors, such as feedback, are used in controlling ways, there can be a negative impact on autonomous motivation of learners. However, when the contexts support autonomy, competence and relatedness, such as by providing positive and supportive feedback, intrinsic motivation is enhanced (Ryan & Deci, 2017). Experiments carried out by Grolnick & Ryan (1987) show that when students are told the assessments they complete will be graded based on their performance, they score lower and show less of an interest in the material than students who complete assessments believing the assessment is just to see what they have learnt and they will not be graded on it. This suggests that including grades in teacher feedback has a negative effect on student engagement.

Feedback can be divided into two categories; evaluative feedback, which focuses on grades or written praise/criticism and descriptive feedback which focuses on providing information on how students can become more competent, with descriptive feedback enhancing student performance when compared to evaluative feedback (Schinske & Tanner, 2014). It is argued that grading assessments has many benefits, including being a way of comparing performance between students and as an intrinsic motivator for student performance (Behling et al., 2017). However, it is important to note that grades may only enhance student motivation as students are too embarrassed to receive bad grades, not because they have any interest or enjoyment in the assessments and the pressure of being graded sparks anxiety and stress (Pulfrey et al., 2011), this would be an example of controlled motivation.

In contrast, Feldmesser (1971) argues that although grades can be a source of anxiety, they can help students become better learners as bad grades can become an opportunity for achievement in the future as it can help a student decide whether to continue in certain subject areas, rather than being a negative obstacle. In contrast, studies have found that when providing students with a grade along with comments to help the learners make progress, the learners will not read the comments, as the students who scored high grades felt that they did not need to read the comments and the students with low grades did not want to read them (Wiliam, 2018). When providing feedback, a recommendation from the EEF is for teachers to implement strategies which encourage learners to welcome feedback and opportunities should be given for the students to use the feedback in order to close the feedback loop and enable the learners to make progress (Collin & Quigley, 2021).

Conclusion

In summary, this literature suggests that it is vital that re-sit GCSE maths classes have a focus on AO3 style questions, as they make up a significant portion of the GCSE exam. Therefore, students should be encouraged to develop an understanding of mathematical concepts from a young age, as this would allow students to make connections between different parts of maths. Self-determination theory seems to be an appropriate theory of motivation and effective teachers should encourage autonomous motivation with their students as opposed to trying to control them. Although there is a gap in literature surrounding andragogy within the FE sector, it is important that teachers recognise the negative effect that pedagogical teaching methods may have on learner motivation, so it seems it would be useful to consider both teaching philosophies when planning and delivering FE lessons. Whilst helping learners to understand that intelligence can increase with hard work is useful, it would be beneficial for the learners to be encouraged to participate in metacognitive discussions, which would, in turn, help to promote a growth mindset. When providing students with feedback, it seems appropriate to provide students with descriptive feedback rather than grades, to avoid controlled motivation and to develop autonomy. However, it is important that learners are given the time to use the feedback to close the loop and enable progression.

Methods

Aim and Objectives

Conducting the literature review further highlighted the importance of Assessment Objective 3 (AO3) questions within GCSE maths and how learner mindset and teacher feedback can impact on student motivation. This allowed the action research group to arrive at the initial aim:

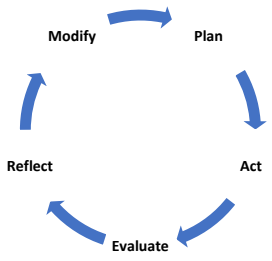
How can developing teacher feedback and encouraging a growth mindset with post-16 GCSE maths re-sit students enable them to justify their answers in the classroom?

This initial aim has been broken down into three objectives, which we aim to answer over three cycles of action research:

1. How can the structure of a GCSE re-sit maths lesson be adapted to allow learners time to focus on AO3 style questions, which require learners to explain and justify their answers and make connections between different parts of mathematics?
2. What strategies can be put in place to allow learners to move from a fixed to a growth mindset so they can be more confident in answering AO3 style questions?
3. How can teacher feedback be improved to motivate learners to answer AO3 style questions effectively?

Research Design

Educational action research supports curriculum and professional development through identifying and implementing strategies of planned action, which are submitted to observation, reflection and change (McIntosh, 2010); these stages of action research have influenced the following action research cycle to be drawn from the literature:



Data Collection Methods

Initially, a questionnaire was sent out to all students. The questionnaire followed a mixed methods research approach, collecting both quantitative and qualitative data. Mixed

methods research can reduce bias in research and increase the trustworthiness and reliability of data through triangulation (Denscombe, 2010). Following this, there were three cycles of action research in this project and a further three data collection methods were used: a teacher focus group, student observations and student interviews, collecting mainly qualitative data. Research indicates that the optimum number of participants in a focus group is between six or seven; too many participants has a negative effect on the quality of the conversation; too few participants can make it awkward for participants to speak up and share their deeper insights (Silverman, 2017). As a result, when planning the focus group 6 members of the action research group were invited to participate. Regrettably, due to the current pandemic only 4 participants were able to attend at the scheduled time and date.

Data Collection Method	Number of Participants
Initial Student Survey	446 Students
Teacher Focus Group	4 Maths Teachers
Student Observations	4 Students
Student Interviews	5 Students

Covid Impact

Due to either staff or student absences as a result of Covid, not all invited participants could take part in the research at the same time, for example the teacher focus group had to be split to allow participants to be socially distanced.

Ethical Considerations

The research followed British Educational Research Association (BERA) Guidelines (2018). The right to withdraw, informed consent, expectations, confidentiality and anonymity were explained to the participants in the project. However, participant consent also made clear that any safeguarding issues which came to light during the research would not remain confidential and any concerns would be shared with the college safeguarding officer. To ensure participants were aware that these ethical guidelines were being followed, they were provided with a consent form and participant information sheet, which also included an overview of the research and why the participant had been selected.

A researcher's positionality is determined by where they stand in relation to their participants, either as an insider or an outsider. An insider is usually someone who is a serving practitioner within their own field who has access to insider knowledge (Barnes, 2021). As the researcher will be conducting the focus group with fellow maths teachers, they

will be classed as an insider for this project. Although being an insider may impair a researcher's ability to remain objective, it is easier to gain acceptance, trust and cooperation from participants (Kelly, 2014). Consequently, it is crucial that the researcher seeks to avoid assumptions or interpretations from the findings of the focus group, so that the data collected does not become unduly biased.

Results and Discussion

Initial Student Questionnaire

446 of the GCSE re-sit maths students at the college completed the questionnaire on the online platform Survey Monkey. Each of the participants was given the participant information sheet prior to completion and all participants consented to take part in the study in writing. The questions in the survey were based around the structure of GCSE maths re-sit lessons, students' opinions on AO3 style questions and the students' mindset towards maths (see appendix 1). When given the choice between answering question A (a simple 1-mark maths question), or question B (a 1-mark maths question which requires learners to explain their answer), around 66% of those who responded would prefer to answer the simple maths question. The participants then had to give a reason why they preferred the question they had selected and their responses were coded during the data analysis process. Coding data is the process of turning raw qualitative data into a communicative and trustworthy account, enabling the researcher to draw conclusions whilst remaining loyal to the data (Skjott-Linneberg & Korsgaard, 2019). However, Rogers (2018) argues that for the data analysis to be trustworthy, it is important to look for patterns when coding data, which will also enhance the validity of the data, as recognising patterns can improve the quality of the researcher's interpretations. When coding the data, the qualitative responses were grouped into the following themes:

1. Question A is easier
2. Question B is easier
3. Question A is quicker to complete
4. Words make questions complicated
5. Question A is clear and simple
6. The student did not know why they chose A or B
7. The student misinterpreted the question and answered the maths question instead

A significant majority of students chose question A because they believed it is easier than questions which require an explanation. This result was expected, as students at the college have struggled to explain and justify their answers in the past, so it became apparent that the students needed more practice at AO3 questions.

Analysis of the quantitative data within the questionnaire showed the following:

- Fewer than 20% of those surveyed feel confident when answering maths questions which require them to explain their answers

- Approximately 25% of respondents would skip a maths question in an assessment or exam that requires them to give a reason for their answer
- Around 35% of respondents believe they have little to no practice in their maths classes on questions which require them to explain or justify their answers
- Well over 70% of 443 learners agreed that the structure of their maths lesson needed to be changed to allow them more time to practice AO3 style questions

With these figures in mind, resources were created which allowed students more practice within their maths lessons at questions which required them to explain and justify their answers, which would help to answer research sub-objective 1, “How can the structure of a GCSE re-sit maths lesson be adapted to allow learners time to focus on AO3 style questions, which require learners to explain and justify their answers and make connections between different parts of mathematics?” The new lesson structure, including the AO3 resources, were then delivered to students across the college during their GCSE re-sit maths lessons.

Cycle 1: AO3 Resources

Maths classes at Tameside College are over a two-hour period; to allow time for the students to work on the new resources. The structure of the lesson was adapted. The students spent one hour working on the resources and one hour working on new learning. The resources created were booklets which had a heavy focus on AO3 style questions; the questions were all relevant to the same maths topic, for example ratio, which the students would have learnt about in the previous lesson in the new learning hour.

Teacher Focus Group

After the resources had been delivered over a four-week period, a focus group was held with teachers who had been using the resources to allow them to share their feedback.

The 4 participants have been anonymised as Teacher A, Teacher B, Teacher C and Teacher D. Before the focus group started, lunch was provided for the participants to allow relaxed informal conversation; the focus group lasted for one hour as planned. All participants were given a participant information sheet and consent form at the beginning of the focus group; all participants gave written permission for the focus group to be recorded to help with the data analysis process. Fortunately, none of the participants seemed to be shy; in-depth discussions took place, with each of the participants taking the opportunity to share their own opinions and experiences. The focus group asked a series of questions based on the new resources and how the students responded to them (see appendix 2).

Data collected from the focus group was then transcribed and coded into the following themes (see appendix 3):

- Effects of the pandemic
- Challenges with the resources
- Student motivation
- Group work
- Recommendations for the resources

The effects of the pandemic emerged as an unexpected theme.

Effects of the Pandemic

The focus group did not ask questions specifically around the effects of the Coronavirus (Covid-19) pandemic, however, the respondents brought it into conversation fairly often. When asked about any issues faced with the resources, the respondents were all in agreement that because the learners have many gaps in knowledge due to disruption to learning as a result of Covid-19, they are working at a much lower level than their target grade. For example, a student may have a target grade of a 4 (a GCSE pass grade equivalent to a C) but they are only working at a grade 1 (equivalent to an F), so the booklets are pitched too high for the learner to access at the time. This finding is related to that of Onyema et al. (2020) who reported that online education was hindered during the pandemic, due to factors such as; network issues, poor digital skills and digital poverty, which all had an effect on students accessing their online lessons, resulting in poor academic progress.

Another issue the respondents found when delivering the resources to the students, was because the students were given a narrowed curriculum to manage the effects of the pandemic, they might complete the resource really quickly on a week where it is based on something they had focused heavily on at school, whereas other weeks they struggled to complete the resource as it is not a topic they are familiar with. Interestingly, Teacher A found that because the students had such disruption to learning when their lessons were online due to school or college closures, since returning to face-to-face learning, the students are more vocal in asking for help when they are struggling with the resources. Teacher A thought this was because the students could not receive as much support when learning online. However, this view contradicts Alabdulaziz's (2021) findings, which suggested that the pandemic was a gateway to digital learning in mathematics education; the use of videos and online platforms offered extra support for learners, so the students were excited and motivated to learn online.

Challenges with the Resources

As mentioned previously, the lesson structure of the GCSE maths lesson was adapted when the new resources were introduced; the first hour was spent on the resources, which were based on a topic they had been taught in the second hour, new learning section, of their lesson the previous week. The structure was designed that way, as being able to actively recall information whilst studying increases long-term retention of that information (Bae et al., 2019). Teacher B shared that the biggest challenge with the resources was if a learner was absent for the previous lesson, as they would miss the new learning section, which is the topic the resources are based on, so the students could not complete them without lots of scaffolding and 1:1 support from their teacher. The other three respondents agreed that this was the biggest challenge. Teacher D shared that this was particularly challenging when teaching larger groups, as they were having to provide extra support for those who were absent in the previous lesson, which reduced the amount of support they could give to the rest of the class. Teacher A suggested that including more scaffolding within the resources would help resolve this issue.

Another issue which came to light during the focus group, was not based on the resources themselves, but the new learning section of the new lesson structure. Teacher C voiced the following concerns:

> *The new learning section does not always reflect what is in the resources as they are planned by different people. There is not always enough substance in the new learning section to provide the students with the skills needed to complete the resources the following week so the students are unsure of how to approach the questions (Teacher C lines 20-23)*

The final challenge raised was about the format of the resources. All respondents felt that because the booklets were quite large, the students found them overwhelming as they would stop working and become disruptive and often mistook the resource for an assessment because of the heavy focus on exam questions within them. The resources also did not state whether the past exam questions included were calculator or non-calculator, so students were constantly asking the respondents if they could use a calculator. Teacher B also found the resources challenging to mark, as no mark scheme was provided so they were unsure of how many marks to award for each of the questions the learners had completed.

We went on to think about solutions to these challenges during the focus group which are discussed later.

Student motivation

When the participants were asked how they knew something in the resource was too challenging for the students, Teacher C explained that the students became demotivated and closed the booklets; if students struggled with one of the questions, they assumed that the resource would increase with difficulty, so they would not be able to complete the rest of the booklet. However, Teacher D found that instead of closing the booklets, the student appeared to be motivated because they skipped through the resource completing only the questions they knew how to do, but as soon as the remaining questions were out of the learner's comfort zone they would give up and become disruptive. Only practicing questions which a student already knows how to do may be a habit they have developed as a result of maths anxiety, as the students do not feel safe enough to leave their comfort zone. Barker (2019) suggests that when a student is suffering from maths anxiety, a teacher's nurturing instincts result in them giving the students questions they know they can solve easily. This could be detrimental for a student's achievement, as if they are only practicing questions they are already good at, the students will not be making any progress. Therefore, students need to be encouraged by their teachers to attempt questions they find challenging. Teacher B also added that the students soon gave up when they could not recall what they had learnt in the previous weeks' new learning section, as they cannot remember what they had been taught so struggled to complete the booklet.

Group work

Teacher A made the following comments when asked about how much time the students spent working with peers:

> *The resources work well when completed in pairs or small groups with an engaged class, but when you encourage group work with challenging groups they easily become distracted and off-task. Some students also just tell their peers their answers to the questions rather than explaining how to complete it (Teacher A lines 32-35)*

Teacher A's statement relates to research conducted by Durrington Research School (2019) which suggests some teachers do not value peer work if they observe an increase in disruption and off-task behaviour. However, Pollio & Macgowan (2010) point out that if a teacher encourages peer learning as much as possible, it is beneficial for the students as they would become more responsible for their own learning, so the students should be educated to engage in effective group work. The other respondents agreed with Teacher A that an issue with group work is higher attaining students sometimes just give their peers

their answers, but all 4 respondents believed if a student can successfully explain why they have done something to their peers, it shows they have a full understanding of the question.

Recommendations for the resources

The final focus group question asked the respondents to provide recommendations for the resources, so that the resources could be refined for the second cycle of action research. However, the respondents had already offered recommendations throughout the full hour of the focus group. When discussing the effects of the pandemic, a recommendation was made to include more scaffolding within the resources, which would help learners who are working at a lower level than their target grade and would also be useful for those learners that were absent for the new learning section in the previous week.

Teacher C believed that by delivering a recap at the beginning of the lesson and by providing key facts written in student friendly language within the resources, with some questions being broken down into stages, the amount of 1:1 time the teacher needed to spend with each individual student would reduce, to give the teacher the opportunity to support all learners. Another recommendation was to break the resources down into smaller booklets, so that the students were not overwhelmed by the size of them. Teacher A suggested the resources could be split into two booklets; calculator and non-calculator, which would also resolve the issue of the students not knowing when they could or could not use a calculator. By changing the format to several smaller booklets instead of one large one, the resources might also look less like an assessment.

Teacher A had shared that some of the students would just tell their peers the answers to questions instead of helping them break the questions down; the recommendation was made that the learners should be encouraged to work in groups for the next cycle of action research. Therefore, two group work strategies were created. The first was a group card sorting activity where the students would sort cards into statements around either having a fixed or a growth mindset. The second strategy of peer coaching was created so that the students had time in the lesson to explain how they had broken down an AO3 question in a previous assessment, without giving their peers the answer to the question. This would help to answer research sub-objective 2, “What strategies can be put in place to allow learners to move from a fixed to a growth mindset through peer work, so they can be more confident in answering AO3 style questions?” Also, as the new learning section of the lesson does not always provide the skills needed to complete the resources the following week, Teacher B suggested that the teachers planning the new learning section might plan around what is included in the booklets. They believed the section should focus on exam techniques and how to break AO3 exam questions down, to prepare the learners to complete AO3 exam

questions in the resources the following week. Therefore, a third strategy was created where the learners would colour code an exam paper and identify AO3 questions which they were not sure how to complete but were keen to learn how to, so that the students could tackle these questions in groups, so that they felt more confident completing them.

Cycle 2: Peer Work Strategies

Student Observations

Three peer work strategies were implemented in Cycle 2 of the action research and to analyse the effectiveness of the strategies, student observations were carried out whilst the students completed each of the 3 activities. The observations were with 4 female students who are completing a Level 3 Health & Social Care course at the college, whilst also re-sitting their GCSE maths. Each of the participants hope to pass their maths GCSE this year, so they can progress to university after completion of their course. The students selected were between the ages of 17-19 years old and their names have been anonymised to; Student A, Student B, Student C and Student D. All 4 of the participants consented to being observed and were happy for the researcher to audio record each of the observations, which meant the observations could then be transcribed to assist data analysis.

Strategy 1

The first strategy involved the students being given a card sorting activity, where they had to sort 15 phrases into 2 columns; a column for fixed mindset phrases and a column for growth mindset phrases. Unfortunately, Student D was poorly so only 3 students completed strategy 1. When the students were initially given the card sorting activity Student A made the following comments:

> *I did mindset stuff to death at school, I have a fixed mindset because I am sick of doing maths. Looking at fixed and growth mindset stuff did not help me pass in school so it is not going to help me now (Student A lines 1-2)*

Student A's comments support Sherrington's (2019) view that encouraging a growth mindset does not necessarily enable learners to make progress in maths, as encouraging a growth mindset through providing examples of positive phrases does not help a student solve a mathematical problem. This suggests that Student A may have just focused on growth mindset phrases alone at school and had not looked at other elements which help a student to thrive in the growth zone, such as promoting autonomous motivation by putting maths in contexts which learners see the value of (Reeve & Jang, 2006) and learning to recruit support.

Whilst completing the card sorting activity, Student C noticed that there were 15 cards for the activity which were to be sorted into two columns, so not every fixed mindset phrase would match up to a growth mindset phrase. This was done purposefully to see how the students would react to there being an odd number of cards. This provoked a discussion amongst the three participants and Student B suggested that if the activity was to be used again, each fixed mindset phrase should match to a growth mindset phrase to prevent confusion.

Strategy 2

The second strategy involved using peer coaching to help break down AO3 exam questions. Unfortunately, due to a Covid-19 outbreak, only two of the four students invited for the student observations could participate. The two learners (Student B and Student D) were given a blank copy of an AO3 exam question they had scored full marks on and an AO3 exam question they had scored badly on in their most recent assessment. The students then had to explain how they had broken down their exam question that they scored well in, without giving their peer the answer. The activity was designed so that the question which Student B had scored well in, was a question which Student D had not scored so well in and vice versa. This strategy aimed to promote metacognitive discussions, as the learners had to explain their thought processes when answering the questions to each other. Student B had to explain how they had completed a question which involved multiplying without a calculator and made the following comments:

> *I cannot actually remember how I answered this question in the assessment. Certain methods I just know how to do but do not know how to explain what I have done. It is easier to just complete the question rather than explain it (Student B lines 11-13)*

Student B's comments support the findings from the initial questionnaire that the majority of participants would prefer to answer a simple maths question rather than a question that requires them to explain their answer. After Student B made the above comments, a teacher helped Student B to explain how they had answered the question, which supports literature from Durrington Research School (2019) stating that students need to be educated in how to work collaboratively so that they can explain their reasoning behind answering questions, rather than just giving their peers the answer.

Once the students had completed both questions, the students were given their most recent assessment back so they could see where they could improve in the question they had scored badly on. Both assessments had been marked with a score and grade provided on the front cover, feedback was also provided throughout the assessment. Student D had scored well in the assessment and achieved a grade 4 (a GCSE pass grade) and Student B

achieved a grade 3 (equivalent to a grade D), which was a grade below their target grade 4. When the assessments were given back to the students, Student B was demoralised by the score and grade and picked up their mobile phone rather than looking through the feedback they had been given. Student B's reaction to the grade supports Wiliam's (2018) understanding that learners do not read the feedback they have been given if they already know what grade they received. However, Student D picked up the assessment and read through the teacher comments they had received, which interestingly contradicts Wiliam's (2018) view that students who receive high grades do not feel the need to read their feedback.

Strategy 3

The final strategy involved the students being given a past exam paper. As the students have already had access to previous Edexcel exam past papers and mark schemes, we decided to give the students a past paper from a different exam board (AQA), so that the questions were completely new to the participants. The participants had to look through and colour code each AO3 question in the past paper as either red, yellow or green. Red questions were questions which made the students feel anxious and they had no understanding of what the question was asking. The yellow questions were questions which were in the learners' growth zone, so the students were not quite sure how to complete them but were keen to learn how. The green questions were in the students' comfort zone, where the students would be happy to complete the questions as they knew how to do them. The students then had to work in a group through the questions they had labelled as in their growth zone. All four of the invited participants were present for the observation of this strategy. Whilst colour coding the questions, Student A shared that normally in an exam they would only attempt questions they had put as in their comfort zone. This finding suggests that Student A suffers from maths anxiety, as literature from Barker (2019) highlights that students only practice questions they know they can do when they are anxious about maths.

When the students started to look at the growth zone questions, one of the questions which Student C had labelled as in their growth zone, Student B had labelled as in their comfort zone. Therefore, the teacher asked Student B to explain to Student C how they would answer the question. What was really interesting to observe was the change in behaviour of Student B compared to when they completed the second strategy. Student B explained how to answer the question step by step without giving the other participants the answer, which was a skill the learner struggled with without the guidance of their teacher during strategy 2. This supports research from Sheridan et al. (2010) which suggests that collaborative learning is not easy to establish and initially some students may become anxious or distrust

the idea of taking responsibility for not only their own learning, but their peer's learning too. However, once collaborative learning has become the norm in a classroom, an interesting culture can evolve and effective learning can take place.

Cycle 3: Teacher Feedback

As Student B was demoralised by their assessment grade during Cycle 2, meaning they did not read the teacher feedback they had been provided with to enable progression, the action research group decided to trial giving students' assessments back without a grade for the third cycle of action research. This was carried out with a class of 12 students at the college who were a mixture of either Applied Science or Travel and Tourism students. All students were 16-19 years old. The students were given back a mock exam they had completed under assessment conditions with no grade or score. The students then had to read the feedback they had been provided with to create their own personalised revision plan with 5 topics they needed to focus on to make progress. Once they had made their revision plans, the students were set homework on AO3 questions for each of the 5 topics (1 topic per week over a 5-week period) on the online platform MathsWatch. To close the feedback loop, each week as a starter activity during lesson time, students were given a printout of a question they had not attempted or did not score full marks on when completing their homework. The students were then encouraged to work in peers so they could help each other complete their questions.

Student Interviews

All 12 students in one class were invited to take part in student interviews to help collect data on the effectiveness of Cycle 3. As 2 students were absent, 10 of the students were given a participant information sheet and were asked to provide a convenient time for an interview if they were happy to take part. Only 7 of the students consented to be participants and unfortunately only 5 of these students attended the interviews at their scheduled time. The students were asked a series of questions during their interview (see appendix 4) and their responses were transcribed and analysed (see appendix 5). Each of the participants have had their names anonymised to; Student E, Student F, Student G, Student H and Student J.

When asked how the student felt when given an assessment back with no score of grade, Student H made the following comments:

> *I really wanted to know what grade I got and didn't really get why I couldn't have it but as I read through the feedback I could see what I needed to work on which was probably better than a grade (Student H lines 1-3)*

This response was not surprising, as students are so used to being given maths assessments back with a score and grade throughout their entire education, so it is out of routine for them not to receive a grade. However, Student H did see the benefit of just being provided with feedback and a significant majority of the participants also found it beneficial. As the feedback was descriptive, it focused on how students could become more competent (Schinske & Tanner, 2014) as the teacher was sharing knowledge and setting achievable goals which emerged from the feedback.

All 5 of the participants were in agreement that working with peers through their starter activity was useful, with Student J sharing that they felt good that they were able to explain how to do something to their peers. This finding supports literature relating to self-determination theory in the literature review, as the aspect of relatedness is the need for students to feel a sense of belonging (Cherry, 2021), which Student J had achieved by helping their peers with their starter activity.

When asked what was useful about creating a personalised revision plan, Student E shared:

> *Normally I just practice the questions I already know so using the revision plan would help me to practice the questions I cannot do, so I can gain more marks in the real exam (Student E lines 8-9)*

This response supports findings from the teacher focus group that students like to practice questions they know they can already do. Therefore, when the students created their revision plan focusing on topics they struggled with, they are taking themselves out of their comfort zone and into the growth zone (Johnston-Wilder et al., 2021). Student J also commented that creating a personalised revision plan helped them to figure out which topics each of the assessment questions were. This finding links with the Edexcel criteria for AO3 questions, as students are expected to make connections between different topics in maths (Edexcel, 2021). Therefore, if the students are familiar with which topics each of the questions are based on, it would help them to make connections between different topics in an AO3 question.

When asked how the starter activity could be improved, all of the respondents provided positive feedback about the activity and they wanted it to occur from the start of the academic year so they had more time to practice to help improve their grades. Student F did provide positive responses throughout the whole interview and did not offer any recommendations for improvements; this may be taken at face value that they really enjoyed the activities, but it also important to consider that their responses may be biased as the interview was conducted by their maths teacher and they may not have wanted to say something they thought would offend their teacher.

When asked how the participants would like revision to be done differently, all of the participants would like more time to revise. Two of the respondents suggested they would like more revision to take home to bring in to get feedback on. This suggests the students are taking responsibility for their own learning, which again links back to self-determination theory and gaining competence, as the participants are focused on gaining mastery of the skills needed for success (Cherry, 2021).

Conclusions and Recommendations

Conclusions

The findings from the initial student questionnaire made it evident that re-sit GCSE maths lessons should have a lesson structure which includes time to work on AO3 style questions. The teacher focus group at the end of the first cycle of action research helped to identify that although resources which include AO3 questions are beneficial for the students, it is important the students are not given too many questions at once, as they become overwhelmed and often go off-task.

During cycle 2, both findings from the student observations and supporting literature made it apparent that growth mindset phrases alone do not benefit student confidence, so strategies which also encourage metacognitive discussions should be used alongside growth mindset strategies, so that the learners practice explaining their thought processes behind answering questions. Johnston-Wilder et al. (2021) suggest that in order to thrive in the growth zone, understanding the personal value of the maths, learning how to struggle and recruiting support from peers and teachers are required in addition to a growth mindset. The observations also made it evident that students need to be educated in how to work with peers effectively, as it did not come naturally to them during the first two strategies; this is something that might be embedded into the curriculum from the start of the academic year. However, a limitation to collecting data from the student observations using the method of convenience sampling, meant that generalisations about the whole cohort of GCSE re-sit students at the college could not be made from the findings. Therefore, for future research, alternative sampling methods will be considered.

For the final cycle of action research, although GCSE maths is focused around grades, to prevent a student becoming demoralised by a low grade in an assessment, and focus on what to do next, it helped to give students their assessment without a grade first. This gave learners the opportunity to read their feedback and take on board the steps they need to take to make progress, then they could access their grade afterwards.

Recommendations

- Encourage peer work with students when working on AO3 questions, as the students can help each other break down the questions
- Guidance on working in groups for both teachers and students should be embedded into the curriculum from the start of the academic year so that students can engage in group work effectively

- Give students feedback without grades initially so they can focus on the comments to make progress rather than being demoralised by a grade
- The lesson structure for GCSE re-sit maths lessons could include time for students to read the feedback they have been given and act on the comments to make progress, otherwise feedback becomes a tick-box activity for teachers and it is not beneficial for the students
- Understand that students may have had a bad experience with the notion of growth mindset in isolation so this needs to be embedded into notions of thriving in the growth zone, which include support from peers and teachers and putting maths into contexts which learners see the value of

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Appendices

Appendix 1: Student Questionnaire

Initial Survey

Participant Concent

* 1. Please read and tick **all** of the following before continuing:

- [ ] I confirm that I have read and understood the participant Information sheet related to this research and have had the opportunity to ask questions.
- [ ] I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason.
- [ ] I understand that all my responses will be anonymised, but with the caveat explained on the participant information sheet.
- [ ] I give permission for members of the research team to have access to my anonymised responses.
- [ ] I agree to take part in the above study

2. Name:

3. College:

- ( ) Tameside College/T1/Clarendon
- ( ) Other (please specify)

4. Teacher:

Initial Survey

Self-efficacy

5. Do you feel like you can handle problems if you are willing to work hard?

- Yes
- No
- Sometimes

6. How confident are you in your ability to achieve your goals?

Not Confident — Very Confident

7. Do you feel like you can manage unexpected events that come up?

- Yes
- No
- Sometimes

8. Are you able to bounce back fairly quickly after stressful events?

- Yes
- No
- Sometimes

9. Do you feel like you can come up with solutions when you are facing a problem?

- Yes
- No
- Sometimes

10. Do you keep trying even when things seem difficult?

- Yes
- No
- Sometimes

11. Are you good at staying calm even in the face of chaos?

- Yes
- No
- Sometimes

12. Do you perform well even under pressure?

- Yes
- No
- Sometimes

13. Do you tend to focus on your progress rather than getting overwhelmed by all you still have to do?

- Yes
- No
- Sometimes

14. Do you believe that hard work will eventually pay off?

- Yes
- No
- Don't Know

Initial Survey

Explaining Why

15. . Here is an example of two maths questions:

A) 1% of 350 =

B) John says, "1% of 350 is 35." John is incorrect, explain why.

Both of these questions are worth 1 mark, which one would you prefer to answer and why?

- A
- B

Why?

16. How confident are you when answering a maths question that asks you to justify/explain your answer?

Not Confident — Very Confident

17. Do you feel like you have done enough practice in maths lessons on questions that ask you to justify/explain your answer?

No Practice — Lots of Practice

18. . If a question in an exam or assessment asks you to give a reason for your answer, what do you do?

- Attempt all of the question
- Skip the part that asks you to give a reason
- Skip the whole question

19. If you understand a question in maths and your friend doesn't, how confident would you be at explaining what to do without giving them the answer?

Not Confident — Very Confident

Appendix 2: Focus Group Questions

1) What have been the general challenges with the resources?
2) What were the specific challenges with the resources?
3) What did you observe when delivering the resources?
4) How much time did the students spend working with their peers with the resources compared to usual?
5) How confident did the students seem when completing the resources?
6) How did you know if something in the booklet was too challenging for the students?
7) What would you like to keep the same about the resources?
8) What didn't work so well with the resources?
9) What are your suggestions for the resources?

Appendix 3: Section of the Transcription of the Focus Group with Thematic Analysis

Focus Group Themes:

- Effects of the pandemic
- Challenges with the resources
- Student motivation
- Group work
- Recommendations for the resources

Focus Group:

Question: What have been the general challenges with the resources?

A: Not necessarily due to the resources but because of tagged grades a lot of learners who are working at a grade 3 (so are aiming for a grade 4) are not actually working at that level and may have been graded based on effort at school, so the booklets are pitched too high for the learner's ability.
A: Because the learners may have been taught a limited curriculum due to the pandemic some weeks they fly through the booklets as it is a topic they have focused on heavily in school and some weeks they really struggle to work through it
C: If a learner is absent the previous lesson, they miss the new learning section which is what the resources are based on so they can't complete them, or some of the students cannot remember what they have learnt the previous week so are not motivated to complete the booklet
B: Not having the mark scheme so they weren't sure how many marks they would get for each question. Also agreed with A that students this year seem a lower level than the grade they received last year. Ao3 questions are a big jump for those lower level learners
D: the exam questions do not state whether they are calculator or non-calculator.
A: Could put them in order working on non-calc first then on to calculator so they are following the same process that they would do in the GCSE exams

Appendix 4: Student Interview Questions

1) How did you feel when you were given your feedback with no score or grade?
2) What was good about working on the feedback you had been given during the lesson?
3) What could improve the time you spent working on the feedback?
4) What was useful when you created your individualised revision plan?
5) How would you like revision to be done differently next time?
6) How did it help to work on your MathsWatch feedback as a starter?
7) What were the advantages for you of working through the starter in pairs?
8) Is there anything else you like to tell me?

Appendix 5: Section of the Transcription of the Student Interviews

Question: How did you feel when you were given your feedback with no score or grade?

Student E: I thought it was a good idea because usually if we get a grade and see we have failed I wouldn't go through and see how I could improve but when I was given the mock without a grade I was able to go through the questions I had got wrong to see how many extra marks I could have achieved then we still got the grades the week after

Student F: I did not like it at first because I wanted to know what grade I got

Student G: It didn't really bother me

Student H: I really wanted to know what grade I got and didn't really get why I couldn't have it but as I read through the feedback I could see what I needed to work on which was probably better than a grade

Student J: I found it useful because I wouldn't normally read my feedback and it told me what I needed to work on