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Promoting cognitive engagement in secondary mathematics classrooms

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Cognitive engagement (including self-regulation) is crucial for promoting student learning, but research suggests that teacher beliefs about cognitive engagement are less refined than their beliefs about other kinds of engagement. We used surveys and interviews from 40 teachers across 8 secondary schools to investigate teacher beliefs and practice that the teachers report using to promote cognitive engagement in their classes. Participants responded to questions about two fictitious teacher scenarios. About half of them identified with Teacher A, believing in the importance of completing practice questions and providing students with a list of revision topics. Those who identified with Teacher B favoured encouraging students to self-assess their competency, monitor their progress, and develop individual revision plans.

Keywords: Cognitive engagement, self-regulation, mathematics.

LITERATURE REVIEW

Promoting student engagement, interest, and participation in mathematics is considered important for students' learning and subsequent study in mathematics. In educational research high levels of student engagement are consistently linked to academic success (Wang & Holcombe, 2010) and are a predictor of students' achievement (Gettinger & Walter, 2012). There is a general agreement that engagement comprises three types—behavioural, emotional and cognitive—operating together (Fredricks, Blumenfeld, & Paris, 2004). Although engagement is considered a multidimensional construct with different types of engagement operating at varying levels of intensity, this research is concerned with the role of cognitive engagement in mathematics teaching and how teach-

ers report promoting students' self-regulated learning in their classes.

Cognitive engagement

Cognitive engagement refers to students' approaches to academic tasks as well as their psychological investment in, and willingness to, master complex concepts (Fredricks et al., 2004). Conceptions of cognitive engagement draw on goal orientation and cognitive strategy use, whereas self-regulation theories that have historically been connected with motivational processes and academic functioning (Cleary & Zimmerman, 2012; Wolters & Taylor, 2012). Cognitive engagement includes thinking deeply and broadly about concepts while using strategies such as organisation, rehearsal, and elaboration as well as regulating and managing the learning process. Students' level of cognitive engagement is influenced by their goal orientations, the range of strategies students use, and students' underlying motivational factors. Components of self-regulated learning are considered particularly relevant to student cognitive engagement as they are both concerned with and are "used to understand students' functioning and performance with regard to academic contexts" (Wolters & Taylor, 2012, p. 635). For this study, frameworks for engagement and self-regulation are considered to be complementary, with the processes of self-regulation being considered important for cognitive engagement and involving a range of motivational factors as depicted in Figure 1. Although the focus of this study is on cognitive engagement and self-regulation frameworks, Figure 1 depicts how cognitive engagement is "dynamically interrelated" (Fredricks et al., 2004, p. 60) with behavioural and emotional engagement, while also acknowledging the influence of motivational and contextual factors on all types of engagement.

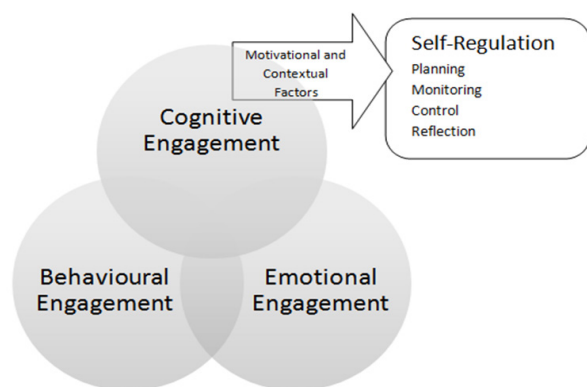


Figure 1: Types of engagement and self-regulation processes

Self-regulation

Self-regulation involves several important processes or phases for promoting deep learning. The phases include: forethought (goal setting and planning), monitoring and control, and reflecting on learning (Pintrich, 2004; Zimmerman, 2002). Self-regulation is centrally concerned with student agency and the degree to which students are active participants in their own learning. Therefore, while engagement frameworks tend to be more concerned about what students do, self-regulation frameworks focus on the processes students use to support their cognitive and behavioural functioning for managing their learning (Wolters & Taylor, 2014).

Self-regulated learners tend to be more aware of their knowledge, beliefs, motivations, and cognitive processes and, this awareness, allows these students to judge how successful or effective they are in their learning (Butler & Winne, 1995). The extent to which students are engaged in academic work and use self-regulatory processes is likely to be influenced by their goal orientation (Anderman & Patrick, 2012). Goal orientation is often determined by the student and influences the amount of time students spend prior to and during tasks on activities such as planning, organising, studying, monitoring, and reflecting. Students with high mastery goal orientations not only tend to use a variety of self-regulatory processes but also display a number of adaptive motivational factors such as self-efficacy, value, and persistence. Additionally, students' emotions play a central role in cognitive processing and engagement and should be considered together in learning settings; this is because student thinking and emotions are intrinsically linked to underlying motivational factors that influence cognitive processing (Hannula, 20006).

However, not all students have high mastery goal orientations or hold adaptive motivational factors. In any classroom the goal orientations of students are likely to be varied, and it is expected that not all students will use (effectively) self-regulative processes. Accordingly, students' ability to plan, organise, monitor, and reflect on their learning will also differ. Apart from individual goal orientations, in school settings sustained engagement in academic work is mediated and influenced by classroom contexts. Classroom contexts that can shape student engagement include the classroom environment and goal structures which are established through explicit and implicit teacher practices and teacher-student interactions (Anderman & Patrick, 2012; Reschly & Christenson, 2012). This means that what teachers do and say in their classrooms can influence students and mediate the use of self-regulatory processes, such as promoting forethought, considering prior knowledge, directing attention to key components, making effective strategy choices and reflecting on achievement to foster student cognitive engagement (Cleary & Zimmerman, 2012).

Teacher beliefs about and practices they use to promote cognitive engagement

In an earlier investigation, Skilling (2013) found that mathematics teachers' beliefs about cognitive engagement were less extensive and detailed than their perceptions about behavioural and emotional engagement. This may be in part because it is more difficult to identify signs of cognitive engagement (e.g., they are less observable than student behaviours) or because mathematics teachers feel less confident about assessing indicators of cognitive engagement. In addition, Skilling (2013) found that teachers reported practices for promoting cognitive engagement that were restricted to completing homework and study strategies focusing on behavioural aspects, such as time management; little did the teachers report about planning, monitoring, and evaluating student learning during lessons. Moreover, similar to a finding by Hardré (2011), the majority of teachers reported using practices that met students' immediate motivational needs such as explaining relevance, future use and application of mathematics concepts compared to few teachers who used practices that met students internal motivational needs, supported autonomous learning and mastery of concepts.

The focus of this study

The study we report in this paper builds on the research we described above by exploring teachers' beliefs about cognitive engagement and how these relate to the practices that the teachers report using to promote cognitive engagement in their mathematics classrooms. For this research, beliefs are defined as "psychologically held understandings, premises, or propositions about the world that are felt to be true" (Richardson, 1996, p.103). Teacher beliefs, therefore, vary according to their bearer and fundamentally reflect the relationship between what the teacher is considering when planning and executing instruction (Mason, 2008).

To conclude, this study focuses on the following research questions:

- 1) What are teachers' beliefs about cognitive engagement in early secondary mathematics classrooms?
- 2) What practices do teachers report using to promote student cognitive engagement?

METHODOLOGY

Data were collected from 40 teachers across eight secondary schools in England. The schools included five mixed ability comprehensive schools and three selective schools. There were two phases to this investigation: a teacher survey phase and a teacher interview phase. The designs of the survey and interview questions were guided by the components of cognitive engagement and self-regulation phases described earlier.

The teacher survey phase asked participants to respond to questions about two fictitious teacher scenarios (see Appendix). The scenarios outlined how Teacher A and Teacher B prepared the Year 7 students (11 years olds) in their classrooms for a mathematics test. Each scenario drew on literature from cognitive engagement and self-regulation to embed particular phrases as 'markers' to emphasise the different strategies and processes used by Teacher A and B.

The scenarios differed by the degree to which Teacher A and B promoted student involvement and used particular strategies and processes when preparing their students for a class test. For example, Teacher A

handed students a list of topics for revision and told them to revise at home by looking over their notebooks, whereas Teacher B asked students to reflect on how competent they felt about particular concepts, to contribute to a 'class revision list' and to develop an individual revision plan. Teacher A told students it was important to get a high grade in the test, to ask for help if needed, and offered a small number of practice questions in class for those who may not have been revising at home. In contrast, Teacher B told students to focus on mastering concepts they did not understand, checked their revision plans and asked them how they felt about their test preparations. There were limited expectations by Teacher A about the range and depth of self-regulatory processes the students would use and there was an emphasis on performance rather than mastery goals. Teacher B, however, displayed expectations that students would use a range of self-regulation strategies and asked students to set their own goals based on their self-assessment, to make plans for mastering concepts, and to monitor and reflect on their revision preparation.

In the surveys, the participants were asked to respond to eight open-ended questions about the fictitious scenarios by referring to relevant line numbers provided for each scenario that they felt provided evidence for their responses. For example, participants were asked to compare their practices with those used by the teachers in the scenarios, to identify perceived similarities and differences between Teacher A and Teacher B, to list practices in the scenarios that they considered important or not important for student test preparation, to consider if their practices change with different groups of students (e.g., grade level, gender, achievement), and to indicate with which of the two teachers in the scenarios they identified more.

The second phase used semi-structured interviews with 17 participants who completed the first phase. The interview questions were guided by the survey questions and asked the participants to elaborate on selected survey responses. This included questions about their beliefs and the practices they report using to promote cognitive engagement in their classrooms. Questions probed participants' approaches toward setting goals and planning revision for assessments, and about monitoring and regulating learning processes during revision and when completing tasks in their classroom. The participants were also asked about ways they encouraged their students

to self-monitor their progress. Finally, participants were asked to describe ways they provided feedback to their students about achievement, setting goals, regulating and reflecting on learning. The interviews were recorded and transcribed.

The analysis of the surveys and interviews drew on the cognitive engagement (Fredricks et al., 2004) and self-regulation frameworks (Pintrich, 2004; Wolters & Taylor, 2012), as components of these were reflected in the design of the two teacher scenarios. The responses to each survey question were listed and coded in association with the phrases or ‘markers’ that were embedded in the two teacher scenarios. The categories were then enriched with any additional practices that were reported by the teachers, providing data for addressing the research questions (Constas, 1992). This paper reports on key findings from the surveys supplemented by interview data.

FINDINGS

Of the 40 participants surveyed (coded T1-T40), 17 identified with Teacher A and 14 identified with Teacher B. From the remaining participants, six identified with both teachers and the other three identified with neither. This paper reports the participants’ responses from three selected survey questions. The three questions were chosen because together they revealed participants’ beliefs about (a) which teacher they identified with and why and (b) the practices of each teacher in the scenario that the participants believed to be (not) important in the context of the scenarios. Specifically, Question 1 asked participants: “Overall, which teacher do you identify with the most and why?” Questions 2 and 3 asked, respectively, participants to list up to two things that each teacher in the scenario did that they believed were important / not important for supporting the students’ test preparation.

Participants who identified with Teacher A

The 17 participants who identified with Teacher A provided a total of 25 responses explaining their reasons for why they identified with Teacher A. The main reason given was that Teacher A was seen to have greater teacher control/structure/leadership (36%), with a strong “teacher led focus” (T9), and “a more structured approach and more control” (T4). The second most frequent reason was that Teacher A practiced concepts in class (16%) for example, stressing the “im-

portance of practising the concepts” and holding a “revision lesson before a test to support [students]” (T7). The next most frequent reason was attending to student needs (12%), as several participants commented on the students being “needy” (T8) and that Teacher A “gave the students the most information about the test...to highlight individual weaknesses” (T2). The fourth most frequent reason was that Teacher A made better use of time in class (12%). See T6’s response, for example:

I tend to like to direct my students towards their problem areas rather than let them take time to find them for themselves. Time always seem to be too much of a factor.

In response to Question 2, the participants who identified with Teacher A made a total of 33 responses to describe teacher practices in the scenarios that they believed were important for test preparation. The following practices were noted as being particularly important: setting practice questions in class (30%), for example slotting “tests in lessons leading to the main test” (T4); supporting students seeking help (24%), for example “making time to help students both in and out of lessons” (T8); and providing a list of topics for revision (21%), such as “handing out a sheet with key concepts” (T9).

In response to Question 3, participants who identified with Teacher A provided 14 responses about the practices of Teacher B that were not important for supporting the students’ test preparation (several participants did not provide a response). The three main practices believed to not be important were: developing individual revision plans (29%), asking students to self-assess their competency (21%), and contributing toward creating a class list (21%). Some participants questioned the value of asking students to develop their own revision plans because they felt that students “may not assess themselves accurately” (T2) or that students might “identify only what they think may be included” (T5) in the test. Creating a class list was believed by three of the teachers to be a waste of time wasting, such as for T6:

It takes time to develop a topic list as a class, which could have been spent more usefully completing actual questions. Would all students be able to manage their time to successfully draw up a revision plan and fulfil it?

Participants who identified with Teacher B

The 14 participants who identified with Teacher B provided a total of 20 responses explaining their reasons for aligning with this teacher. The main reason was the emphasis Teacher B placed on student self-assessment (40%). For example, these participants believed that students should be “reflecting as much as possible” (T27) on their work and should be “actively engaged in their own learning” (T26). Participants believed that an important feature of Teacher B’s approach was that:

More emphasis is placed on students assessing what they can do and what they need to improve on and then going and working on those topics (T30)

The second reason was that Teacher B encouraged independence and student responsibility (30%). For example, several participants believed in encouraging student independence, noting that Teacher B used “strategies to encourage the students to engage with all aspects of their revision independently” (T23) and also handed “over ownership of revision to students” (T31). The third reason was the use of revision skills to plan improvements (25%). One participant believed that the purpose of revision was for “trying to get the students to understand which areas they need to improve on” (T28). Another participant noted:

Allowing students to identify their own areas to improve and implement their own plan is a step towards them improving because they want to, not because I am telling them they need to (T24)

In response to Question 2, the participants who identified with Teacher B made a total of 28 responses to describe teacher practices in the scenarios that they believed were important for test preparation. The most important practice included student self-assessment (32%), such as asking students “to assess their competency in each area” (T21) and encouraging students “to think about what might be in the assessment and self assess their confidence in these areas” (T24). The next most important practice was developing individual revision plans (29%), with one participant reporting that encouraging the “creation of revision lists and individual preparation gives the students’ responsibility for their learning” (T24). The third most important practice was monitoring revision plans (18%) with several participants noting that the value of

checking “revision plans to make them [the students] self-aware and in control of their revision” (T22).

In response to Question 3, the participants who identified with Teacher B provided 22 responses about the practices of Teacher A that were not important for supporting the students’ test preparation. The main practice viewed as not important was “telling students it was important to achieve a high grade” (T20) (32%), as this was seen as “controlling and vague” (T23). It was also reported that “telling students to study more” (T24) was not important (27%) or that students should revise everything for a test (14%), as they “may not need to revise each concept” (T21).

CONCLUSION

Overall, participants who identified with Teacher A felt that this teacher tended to “be more structured” rather than giving students “freedom to think”. Students were perceived as “needy” and Teacher A was believed to provide students with the “most information about the test”. Additionally, participants who identified with Teacher A did not believe that making individual revision plans, asking students to self-assess, or contributing to a class list were important for supporting student test preparation.

In contrast, those who identified with Teacher B believed that practices such as student self-assessment, making individual revision plans, and monitoring revision progress were important. Participants who identified with Teacher B believed that this teacher’s strategies encouraged “students to engage with all aspects of their revision independently”. These participants also explicitly referred to specific processes of self-regulation such as planning, monitoring, checking and reflecting when responding to the survey questions (Cleary & Zimmerman, 2012; Wolters & Taylor, 2012), with the majority referring to at least two self-regulatory processes in their responses. Furthermore, participants who identified with Teacher B made comments about the importance of students being actively cognitively engaged in their learning by “allowing students to identify areas for improvement and implement their own plans”; they also emphasised student autonomy and responsibility for learning. The findings also suggest that the participants who identified with Teacher B believed in the importance of fostering student autonomy, independence and strategies for learning by using pedagogical

practices that are associated with classroom mastery goal structures (Anderman & Patrick, 2012) and with promoting cognitive engagement and self-regulatory skills in their mathematics classrooms.

In this study just over half the participants identified with Teacher A and just under half identified with Teacher B, indicating that teacher beliefs about ways to promote cognitive engagement are potentially diverse. The results revealed that participants who identified with each teacher had strong beliefs about the practices they believed were and were not important for using in mathematics classes. Subsequently, one may hypothesize that participants who identified with Teacher A – and did not seem to believe in the importance of students developing individual revision plans, self-assessing their competency, or contributing to class revision lists – may be less likely than participants who identified with Teacher B to promote cognitive engagement and self-regulatory practices in their classes.

For this study the participants responded to scenarios that specifically asked about teacher practices for test preparation with Year 7 students. It is possible that different responses would be made for other situations, such as a ‘typical’ lesson covering a new topic or lessons with students of a different age. Future research can build on the findings of this study to investigate teachers’ beliefs and self-reports about cognitive engagement and teachers’ use of specific self-regulatory processes in their classrooms. For example, do teachers promote goal setting but not specific planning processes? In what ways do teachers promote students’ self-monitoring of their learning? Do teachers ask students to reflect on their thinking and feelings as they work through and master difficult concepts?

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APPENDIX: TEACHER SCENARIOS

Context: Two Year 7 mathematics classes at one school will complete a topic test during second term. The teachers of each class provided students with infor-

mation a week before the test about ways they could prepare. Below are suggestions by Teacher A and Teacher B. Please read each scenario and respond to the questions at the end. The line numbers for each scenario can help to make references to the text.

Scenario involving Teacher A

1. Teacher A reminded students about the upcoming topic test and handed out
2. a sheet with an outline of the key concepts that would likely be covered in
3. the test. The teacher suggested that the students set aside time for revision
4. and to make sure they practised each concept, by looking over their notebooks
5. as it was important for them to achieve a high grade on the test. The teacher
6. also mentioned that the students should ask questions in class if they were
7. unsure of the steps to solve questions. Alternatively, they could come and see
8. the teacher during break time to clarify any questions before the assessment.
9. In each lesson before the test the teacher set five practice questions in case
10. students had not been revising at home and students who got three or less
11. correct were advised they needed to study more.

Scenario involving Teacher B

12. Teacher B also reminded students about their upcoming topic test. The
13. students were asked to look through their mathematics notebooks and
14. textbooks during the lesson and recall specific topic concepts that they
15. thought would likely to be included in the test. Based on their class
16. work, the students were then asked to record how competent they felt about
17. each concept. During the lesson, the teacher also asked the students to draw
18. on their self-assessment notes and contribute to the creation of a 'class'
19. revision list, from which examples could be revised during lessons before the
20. test. The teacher also told the class that it was expected that each student
21. would develop individual revision plans. Students would work on their
22. individual plans at home, making time to focus on mastering the concepts
23. they believed they needed to improve on. Throughout the week the teacher
24. checked the revision plans of each student and asked how they felt about their
25. preparations.