Learners creating video revision resources to promote mathematics self-efficacy

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This paper reports on action research aimed at improving pupils' self-efficacy in mathematics. Relationships between learners' self-efficacy and achievement have been well-researched. However, less is known about practical pedagogical strategies teachers can use to strengthen learners' self-efficacy. There are four factors influencing learners' appraisal of their self-efficacy: learner' past attainment, their vicarious experiences, their experiences of being 'persuaded', and their physiological reactions. The action research was designed to develop features of mathematical self-efficacy amongst pupils in one school through their participation in creating VLE resources. During 28 lessons, various approaches were explored through addressing the aforementioned factors. Data was collected by observations, learning journals and questionnaires. The results confirmed that pupils' engagement in creating VLE resources exposed pupils to various sources of experience in developing self-efficacy. Pupils' collaboration and teachers' feedback improved pupils' subject mastery along with their experiences of vicarious success and persuasion, and positive physiological reactions.

Keywords: Mathematical self-efficacy; VLE resources; achievement; collaborative learning

Introduction

Self-efficacy refers to people's judgment of their own capability to tackle a given task and achieve the desired outcome (Schwarzer & Warner, 2013). A wealth of research findings suggest that self-efficacy influences learners' learning, motivation, decision making, goal settings and academic achievement (Bonne & Johnston, 2016; Bandura, 1997; Schunk, 1995). Self-efficacy also correlates with indexes of self-regulation, especially the use of strategies regarding effective learning. Self-efficacy, self-regulation, and cognitive strategy forecast achievement and are inter-correlated positively (Bong & Skaalvic, 2003).

Self-efficacy is based on social cognitive theory, a theoretical framework that posits that human achievement relies on interactions between behaviours of an individual and their environmental conditions (Bandura, 1997). Based on this theory, individuals are actors as well as products of their environment. If individuals believe taking action will provide a solution to a problem, they tend to act and be committed (Schunk, 1995). Compared with learners who are not sure of their capabilities to learn, those who are confident to learn or perform a given task participate with ease, work harder, are more resilient when they are faced with difficulties, and achieve at a higher level (Johnston-Wilder & Lee, 2010). Learners acquire information to judge their self-efficacy from their actual performances, their vicarious experiences (judgement about their self-efficacy through comparison with the performance of peers), their persuasion experience (verbal persuasions from others), and their physiological reactions (their somatic and emotional response to experiences such as pain, anxiety or stress) (Warwick, 2008). In spite of clear connections between self-efficacy and achievement, little research has been done on learning and teaching approaches which promote self-efficacy in mathematics classrooms. This action research explored the literature in developing self-efficacy and applied those constructs to the mathematics classroom environment, contributing to understanding of how learners can develop self-efficacy in the mathematics classroom.

Literature Review

In this section, we discuss how self-efficacy operates in a mathematics classroom. Self-efficacy and goal setting are strong influences on academic achievements (Zimmerman, Bandura & Martinez-Pons, 1992). Learning goals that are short-term, specific, and thought to be difficult, but achievable, can enhance the self-efficacy of the learners better compared to general long-term goals which are not viewed as attainable. Learners can attain the former goals with clear standards against which progress can be gauged. As learners handle tasks, they can compare their goals against their progress. The perception of progress enhances self-efficacy and encourages learners to continue working hard (Schunk, 1995). Providing learners with a means that aids their success can also raise self-efficacy. Learners who believe they have the means to perform successfully are likely to feel efficacious about doing so. As they work on tasks, they note their progress, which strengthens their self-efficacy. For example, having learners verbalise their solutions through collaborative learning can enhance their self-efficacy because the collaborative work and the verbalisation can act as the means to improve performance through directing learners' attention to important features of the task, assisting retention, and working systematically.

Mastery experience, the literature suggests, is one of the key sources of self-efficacy which can build a robust belief in learners' ability to perform specific tasks (Haro-Soler, 2017). It is very likely that higher attainment in mathematics will strengthen self-efficacy beliefs resulting in further attainment and therefore higher self-efficacy. Peers can also influence learners' self-efficacy in many ways. One way is through vicarious experiences. Observing similar others achieve can improve the observers' self-efficacy and encourage them to tackle the task (Warwick, 2008). Vicarious experience is most influential for learners who are not sure about their capabilities to perform, like those who are not familiar with the task and information to use in judging self-efficacy or those who have faced difficulties and still have doubts (Schunk, 1987). However, it is important to notice that if learners compare themselves to their peers and feel inadequate, there are higher chances of undermining self-efficacy beliefs. The perception of similarity between peers (models) and the learners (observer) is essential, especially for learners who may not be sure of their capabilities.

Social support includes the extent that teachers motivate learners to learn, help them access the resources they need for learning, and instil in them self-regulatory means that improve the acquisition and refinement of skill (Bandura, Barbaranelli, Caprara, & Pastorelli, 1996). During activity engagement, learners are affected by personal (knowledge acquisition, goal setting, etc.) and situational influences (praise, teacher feedback, etc.) that provide learners with clues about how well they are learning. Self-efficacy is improved when learners have a conception that they are doing well or becoming more skilful. Feedback can be an influential source of self-efficacy. Effective feedback makes learners aware of goal progress, enhances self-efficacy, and sustains motivation. Effort feedback such as "You got it correct because you worked hard" is highly credible as it places emphasis on the importance of effort and growth mindset. Switching to ability feedback such as "You are good at this" may infer that mathematical abilities are fixed.

Research design

Reconnaissance

A few weeks into the summer term of 2018 a group of 28 pupils in year 10, aged 15-16, from a mathematics class was selected for the research. These pupils had been identified by their teachers as being at risk of not achieving the mathematics targets for their GCSE exam. Teachers' observations suggested that for these pupils, self-belief was a barrier to learning mathematics, and it hindered their progress. More specifically, the pupils' mathematics self-efficacy was probably low.

The outset of the research was to administer an anonymous questionnaire that we had devised in order to measure pupils' mathematical self-efficacy. We wanted to know if the pupils' self-efficacy improved as a result of our interventions; therefore, at the start of the research we used a 10-item questionnaire and re-administered the same questionnaire at the end of the research. The most commonly used scale for measuring mathematics self-efficacy is the Mathematics Self-Efficacy Scale (Betz & Hackett, 1983). Betz and Hackett identified three main domains involved with studying mathematics self-efficacy: solving mathematics problems, using mathematics in everyday tasks, and getting good grades in mathematics courses. We designed a questionnaire relevant for a GCSE group based on these three main domains and asked pupils to rate each question from 1 to 5 on a Likert scale.

Planning

We started working in the school in ways that we believed would raise mathematical self-efficacy. To achieve the mastery level required to improve pupils' self-efficacy, we focused on teaching approaches which promote pupils' self-regulated skills, as development of self-efficacy depends on the extent that pupils are taught self-regulatory strategies that improve the acquisition and refinement of skill (Bandura et al., 1996). To achieve this, through considering pupils' diverse learning needs, we used a teaching approach based on an amalgamation of cognitivism (learners' active role to understand and link knowledge) and constructivism (construction of knowledge from experience and collaboration). Online learning resources can change the way learners interact, function, communicate and learn (Conradie, 2014). Through effective use of them, it is possible not only to access the information, but for learners to create the information through engagement in a process of taking control of and evaluating their own learning and behaviour. Engagement in such a process can develop skills of self-regulation amongst learners. The research was conducted in three stages.

Action

In the first stage, pupils were placed in groups to collaboratively explore various online interactive resources provided on the recommended websites and then critically evaluate some of the resources including short videos, worksheets and exam questions. The aim of this stage was to develop pupils' competency using online materials as well as encouraging pupils to work collaboratively. Once pupils were able to use the resources confidently and had developed skills of collaborative learning they were introduced to the second stage. At this point, pupils were expected to work together to first choose a GCSE exam question from the website and then solve it through teaching each other. In the third stage of the research, pupils were encouraged to develop their school's VLE resources through creating their own mathematics GCSE exam revision videos focusing on one particular exam question. This was particularly useful as learners' self-efficacy is likely to be strengthened when they see someone like them showing the rest of the class their mathematics work, or explaining how they solved a problem (Bonne & Johnston, 2016). In addition, the availability of online materials and resources are postulated to enhance and reinforce teaching (Coates, James & Baldwin, 2005). Once the videos were recorded, pupils received feedback from teachers.

Observation

At the beginning of the research, most, if not all pupils seemed reluctant to engage with the mathematics lessons, even though the mathematics activities allowed pupils with a range of understandings to be successful. Wilson (2011) suggests that factors, including self-efficacy and motivation can influence the extent of engagement of learners with mathematical activity. The results of the self-efficacy questionnaire showed that at the start of the research 67% of pupils felt that they would not be able to do well in their GCSE mathematics exams. This could be either due to pupils' lack of self-efficacy or realism. However, pupils' neutral responses to most of the questions could indicate their lack of self-appraisal skills. The groups' mean score and the standard deviation were calculated at three points: the start, the middle and at the end of the research (Table 1). The post-test results suggest an improvement in pupils' self-efficacy.

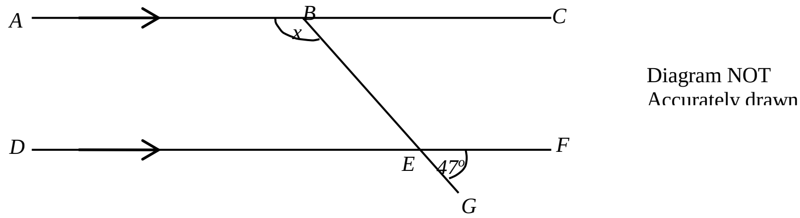
	Mean	Standard Deviation
pre-test	23.8	5.2
mid-test	24	5.4
post-test	32.1	9.6

Table 1: Self-efficacy Questionnaire Results

At the start of the second stage, pupils struggled with the tasks and were not yet able to successfully approach and solve the questions as they still had not reached the level of mastery required for problem-solving. Using Vygotsky's zone of proximal development (1978), it appeared that there was a need for scaffolding so pupils could develop their cognitive learning through constructions of the new knowledge by means from more knowledgeable other (short revision clips from the website). Bonne and Johnston (2016) suggest that learners develop self-efficacy when they have strategies for coping when learning is difficult, and when they make mistakes or fail. The idea of using mathematics revision clips in the second stage of the research was well received by pupils; they commented, for example, "*At the beginning, we really couldn't do the work if the clips weren't there to help.*"

Reflection

We concur that measuring mathematics self-efficacy is not as easy as it seems. As Bandura (1997) has suggested, simply asking learners how good they think they are at mathematics, in general, is not as closely related to their mathematics achievement as asking pupils whether they think they could successfully answer a number of specific mathematics questions. Therefore, we used another questionnaire (Figure 1) to produce more precise data and also to develop pupils' skills of self-efficacy judgment.



ABC and DEF are parallel lines.
BEG is a straight line.
Angle GEF = 47^o.

Work out the size of the angle marked x.

Give reasons for your answer.

Do you think you can solve the problem?

I definitely can't

I may not be able to

I may be able to

I definitely can

Figure 1: An example of the Mathematical Self-efficacy Questionnaire

In this questionnaire, pupils were not asked to solve the exam questions, but to decide whether they thought they could. We then used the same questions for formative assessment during the same lesson. The results of the questionnaire and the formative assessment for each pupil were compared. The positive correlation of 0.37 between responses to the self-efficacy test and results on the same question indicates a low correlation between the two variables of self-efficacy and achievement. This was a more precise measure than those used in the initial self-efficacy questionnaire. Self-appraisal skills improved with development; the correlation results for the second and third tests were +0.52 and +0.68 respectively. However, results showed that not all pupils developed self-appraisal skills. The incongruence between learners' self-efficacy and their actual performance at the start of the research might have been due to various causes. Learners do not usually have familiarity with the task and do not fully understand what is required to successfully perform a task. As they gained experience, we expected improvement in their accuracy. This is why executing tasks such as Figure 1 can help learners improve their self-appraisal. Nonetheless, learners may be swayed unduly by features of a certain task and make decisions based on these that they can or cannot perform the task while ignoring other vital features. In problem-solving, for example, learners may focus on the quantity of numbers in the problem and judge long problems more difficult than those with less information, even when the longer ones are simpler in concept. As their ability to focus on more than one feature increases, it seems so does their accuracy. However, there is a need for further research in this area.

Conclusion

Finding ways to improve self-efficacy and engagement can improve pupils' performance in mathematics; however, we cannot say that the pupils have become more universally mathematically self-efficacious from just this one project. Our action research has confirmed that during our mathematics project, pupils were exposed to a variety of sources of evidence for developing mathematical self-efficacy but that we could do more in some areas. The results indicate that we seem to be relatively successful in terms of developing pupils' overall self-efficacy and engagement in mathematics lessons, but pupils' class work and formative assessments indicate less success in terms of pupils' approaching more challenging tasks. Having developed pupils' self-efficacy and engagement, we will now be looking at how we can better use the online mathematics resources to encourage this aspect. With development, learners may be able to determine how much effort and persistence may be necessary to succeed. This issue needs to be explored further.

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