The relevance of mathematics: The case of functional mathematics for vocational students

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This study of recent school-leavers in Further Education explores students' opinions of relevance and how these are influenced by their experiences of different mathematics curricula in school and college. These vocational students are taught mathematics as a functional 'tool for life' rather than a discipline of rules.

Perceptions of relevance are influenced by personal goals and interests (Ernest, 2004) and may depend on whether students identify a value for the qualification, a practical usefulness or some transferable skills (Sealey and Noyes, 2010). These can provide reasons for studying mathematics but, in this study, students who encountered mathematics as a 'tool for life' engaged in learning experiences that connected with their personal life experience. This changed their conceptual view of mathematics and added a different perspective to their views of relevance.

The research is part of a larger study of the student experience of functional mathematics in colleges but this paper will focus on qualitative data from student focus groups and lesson observations. Transcriptions were coded and compared to identify common themes in student experiences. The results suggest how teaching mathematics as a 'tool for life' can influence perceptions of relevance and effect some positive changes in student attitudes.

Keywords: relevance, vocational, functional mathematics.

The concept of mathematics as a 'tool for life'

Political interest in the skills that adults need for life and work is long-standing and an intention to address these needs has been re-iterated many times. Various curricula have been developed and discarded in successive attempts to develop and assess such skills. The emphasis on using and applying mathematics in practical situations has been a common theme in Adult Numeracy, Key Skills, quantitative literacy and, more recently, in functional mathematics (QCA, 2007).

At the heart of these curricula lies the concept of mathematics as a 'tool for life', a set of knowledge and skills that, allegedly, equip students to apply mathematics and solve problems in life and work situations. This concept contrasts with the traditional knowledge-based school curriculum. Although, theoretically, functionality in mathematics has been embedded into the GCSE curriculum, there remains some doubt about whether this is a token offering or a real commitment to the meaningful application of mathematics to everyday life.

The students in this study mostly fell within the category of school-leavers at age 16 years who had failed to reach the 'gold standard' of a GCSE grade C in mathematics and had opted to take a vocational course in a Further Education college.

After following a GCSE mathematics course in school, they were then exposed to a functional mathematics curriculum in college. This involved the application of mathematics in a range of contexts, the use of 'realistic' scenarios and a problem-solving approach (QCA, 2007). This study looks beyond the difficulties implicit in implementing this curriculum, in order to understand the effects on students' perceptions and responses when taught mathematics as a functional tool rather than a knowledge-based subject.

As a result of the government's response to the Wolf report (2011), post-16 students who fail to achieve a grade C in mathematics are now expected to continue with GCSE mathematics but the suitability of repeating the same qualification is questionable. Recent research suggests that current workplace practices require applications of basic mathematics in complex situations rather than higher-level knowledge of mathematics (Hodgen and Marks, 2013). For vocational students, developing skills in applying mathematics may have more value for their intended careers than acquiring a particular academic qualification. In this research, a comparison of the impact of a different curriculum on students' perceptions of relevance provides some indications as to why an alternative to GCSE may be a preferable option for these students.

Relevance and reasons

The relevance of mathematics, as seen by educational and political figures, is linked to goals that have benefits to society but hold little meaning for students (Ernest, 2004). Their neglected perspective, Ernest (2004) argues, is an important part of the discussion about relevance and should be seen in relation to their personal interests and goals.

For students, relevance may be established for a number of reasons. Firstly, mathematics may be perceived as relevant because the qualification itself is useful to them (Sealey and Noyes, 2010). The value of mathematics in society and its 'gate-keeping' role for higher-level study make a qualification in mathematics a desirable asset in a student's portfolio. A qualification in mathematics may have a direct 'exchange value' as a prerequisite for a chosen career, or for further training related to a personal goal. In these ways, students may recognise their need for a mathematics qualification and consequently have a reason to engage with the subject.

Secondly, students may identify practical or transferable skills (Sealey and Noyes, 2010) that may be useful to them and thereby recognise the relevance of the subject. Discovering a use-value for these skills may be dependent on students' awareness of mathematics in other areas of life apart from the classroom. Similarly, appreciating that certain transferable skills have value in the future may help some students to engage with topics, but the connections are not always apparent. Their limited life experience and unfamiliarity with the demands of the workplace may make it difficult to identify how mathematics is used in different situations. Establishing links to students' lives can provide reasons to engage with the subject but a cognitive acceptance of the value of mathematics may still be insufficient to influence their views of the subject.

Attempts to make mathematics more relevant in the classroom may involve using 'realistic' contexts for mathematics questions, but the interpretation and impact of these on students' responses to questions can vary (Cooper and Harries, 2002). One of the problems may be that the context itself is often no more than a metaphor to illustrate an aspect of pure mathematics rather than authentic use of a scenario as a

source of mathematics (Wiliam, 1997). Making connections between mathematics and life that appear authentic and convincing for students is not a simple task.

In the Realistic Mathematics Education (RME) approach, context is used as a base for the construction of knowledge but being 'realistic' refers to situations that students can imagine and not necessarily to authentic problems from real life (Van Den Heuvel-Panhuizen, 2003). Moving from these 'realistic' situations to symbolic representation is as an important element of the learning process. Used in this way, context is a means of developing understanding but the connections to 'reality' may also bring mathematics closer to the individual and demonstrate a value for the subject beyond the classroom.

Engagement and emotion

There is evidence that students who fail to see the relevance of mathematics also demonstrate poor motivation and disaffection, even when their attainment is high (Nardi and Steward, 2003). The term disaffection is commonly used to refer to negative attitude or emotion, suggesting that student perceptions of relevance and attitude to mathematics may be connected.

Attitudes and emotions are often seen as part of an affective structure that includes beliefs (McLeod, 1994) and values (DeBellis and Goldin, 2006). Definitions of these constructs vary and the relationships between the components are complex but there is a wide acceptance that affect is inter-linked with cognition in the learning process. Affective responses to mathematics may be seen as part of an engagement structure (Goldin, Epstein, Schorr and Warner, 2011), in which beliefs are intertwined with other aspects of affect and cognition in a personal framework that influences behaviour. Goldin et al. (2011) consider that affect permeates many of the strands within this structure, highlighting the relationships between goals, affect and behaviour. From this viewpoint, if relevance is connected to personal goals, then it involves more than a cognitive reason for engaging with the subject. Affective associations, such as interest, are influential and will have an effect on student perceptions of the relevance of mathematics.

Considerations of the affective domain have led to considering the elements, such as emotions, as having transient states or more stable traits (McLeod, 1994). Hannula (2012) takes the view that each affective component has both characteristics and suggests that attitude may be seen as the more long-lasting trait related to emotions. For the purposes of this study, the possibility of short-term fluctuations in emotions but slower shifts in attitudes means that effects may be evident over the research period that are linked to the same basic construct.

The concept of mathematics as an academic discipline, with a well-defined system of rules, has an appeal for some students but may seem unattractive to others. The role of relevance is, perhaps, an intermediary construct in the linking of student views of mathematics to their attitudes but the effects may be influential on the learning process due to the entwining of affect with cognitive processes.

Research methods

This research formed part of a wider study of vocational students' experiences of functional mathematics, which had the aim of exploring the main factors that influenced their experience. The research question of interest for this paper was to identify the ways in which functional mathematics was relevant to students. This will

be examined with particular reference to findings that related to student perceptions of relevance, their views of mathematics and affective responses.

A grounded theory approach was adopted for the main research due to the exploratory nature of the study. Qualitative methods were preferred because of the emphasis on understanding 'how' and 'why' certain factors influenced the student experience. Student focus groups were used to explore their perceptions, whilst observations of functional mathematics lessons and semi-structured interviews with teachers provided additional data sources for comparison. The interviews and focus group discussions were audio-recorded and transcribed.

The student focus groups were conducted in a semi-structured manner with the researcher using a flexible framework of questions as prompts for discussion. Students also gave individual responses to sets of statements regarding their experience of mathematics in school and college. Each student group met three times during the college year, with the following topics providing the main focus:

- the transition from school to college and students' early experience of functional mathematics (Term 1)
- students' opinions of a range of contextualised materials (Term 2)
- a review of the students' experience over the year and the outcomes (Term 3)

Lesson observations were unstructured in the first term and used alongside the data from the focus groups to identify the areas to be explored further in the second phase of data collection. A series of structured observations in the second term focussed on particular aspects of teaching and learning. Written records were made rather than video-recording due to concerns regarding the possible effect on student behaviour for classes unused to being recorded.

The study involved comparisons of the student experience in three Further Education colleges on courses in Public Services, Hairdressing and Construction. These represented vocational areas with different gender biases, practical skills and training bases (salon, workshop, outdoor/classroom) that were available at all three colleges. Where possible, two student groups, with different teachers, were recruited for the research from each vocational area at each college. Within the constraints of access and consent, this resulted in a total of seventeen student groups that were studied in some depth over a period of nine months.

The analysis, based on an iterative process of coding and comparison, led to the construction of case studies of these student groups, from which the main themes were extracted and examined further. Two contrasting case studies will be used in this paper to illustrate some of the main themes that emerged in relation to the particular research question being addressed.

Research findings

Individual responses in the first term showed that many of the students in this study were disaffected by their experience of mathematics at school but there was a significant shift towards more positive attitudes in college. In particular, students indicated that in college they were less stressed, more interested and less bored in functional mathematics lessons than they were in GCSE mathematics in school. When the same individual activity was repeated in the third term the results were similar and showed that students had largely retained the attitudes they expressed in the first term.

The reasons for these changes in attitude between school and college were explored in the focus groups. Although reactions were sometimes mixed, student attitudes within groups were generally similar. Groups were often enthusiastic about

their experience of functional mathematics compared to school although some felt there was little difference. This polarisation into positive and negative groups allowed contrasting cases to be compared in order to explore the causes. For the purposes of this paper two contrasting case studies will be outlined. Both groups were considered by their teachers to be 'challenging' but the differences in outcomes make these cases particularly interesting to compare.

Case study 1 – Lindsay's Public Services group

Lindsay was teaching Public Services students who were aiming for careers in the armed services or emergency response teams (police, fire or ambulance). She did not view herself as an expert mathematician but as a functional skills specialist. Her own experience, prior to teaching, was in retail management where she frequently used mathematics in a practical way. She explained that functional mathematics, in her opinion, was about applying mathematics and solving problems in everyday life.

In lessons Lindsay used contexts for questions that she believed would relate to students' lives and interests. These included tasks about the calories in burgers, alcohol consumption in England and the cost of smoking. Occasionally the context was linked to the students' vocational course. Although Lindsay was careful to use current prices and authentic sources of information, the mathematical calculations involved in these tasks often seemed unrelated to anything the students would realistically want to work out in that scenario. This was not a concern for Lindsay because her strategy was to engage the students in the lesson through discussion about the context or scenario, even when this deviated from mathematics.

Lindsay's students were enthusiastic about functional mathematics. In the focus group, they explained how their attitudes had changed because they saw the relevance of mathematics to their lives. The contexts were convincing for them and they readily described situations in their own lives that required mathematics. The students seemed unconcerned that the actual mathematics was sometimes only loosely linked to some of the scenarios used. The connections made to their vocational area, although limited, were valued and the students provided several examples of vocationally-related applications of mathematics that would be useful to them in the future.

The students' perceptions of functional mathematics were of a subject with similar content to GCSE mathematics but with an emphasis on application to life that made the lessons very different. Students felt the curriculum had allowed them to concentrate on mathematics that was useful and understandable. They had enjoyed the discussions about issues pertinent to their lives and felt these had helped them engage in the lessons. As a result they believed they had learned useful skills and were more confident about using mathematics in their lives.

Case study 2 – David's Public Services group

David also taught Public Services students. He identified himself as an engineer with high-level skills in mathematics. His definition of functional skills was about using mathematics and solving problems, but his interpretation was more about using logical processes than finding practical solutions.

David used contexts that he believed would interest students such as buying sufficient carpet for a flat or going clubbing but details such as outdated prices suggested these were contrived rather than authentic. He rarely made any links to the vocational area. The emphasis in David's lessons was for students to 'get on with the

work', by which he meant the mathematics. There was little discussion about the scenarios or contexts used. Discussion seemed to be viewed as a distraction from the main purpose of the lesson, which was learning mathematics. He was concerned when students failed to engage with the lessons because he believed mathematics was relevant to them and they would need the skills in the future.

David's students did not enjoy their functional mathematics lessons. They saw very few differences between their school and college experiences of mathematics. These students viewed the curriculum as simply basic mathematics that they had already covered in school and were reluctant to repeat. They did not associate aspects of functionality, such as applying mathematics and practical problem-solving, with their experience in college. Some of the students welcomed the absence of certain topics from the curriculum that they had found challenging in school, such as algebra, because they thought these to be particularly irrelevant parts of mathematics.

The contexts used in lessons were perceived to be outdated and unconnected to their lives. In the focus groups, students explained how they found it difficult to see any links to their vocational area and struggled to provide any specific examples of applications of mathematics that might be useful in their future lives. Their attitudes to mathematics that developed in school remained unchanged in college and they failed to see the relevance of functional mathematics. For them, their functional mathematics course was a 'waste of time' because they had not improved or learned any new skills.

Main findings and discussion

For the students in these case studies, the functional mathematics qualification did have an 'exchange value' and therefore could be considered relevant (Sealey and Noyes, 2010) because it was required for progression to the next level of vocational training. For the students in David's group, this reason seemed to provide insufficient motivation for them to engage with mathematics. Relevance was limited to a cognitive recognition that the qualification had some value but this seemed remote to the students and attitudes remained unchanged. In contrast, the students in Lindsay's group grasped the relevance of functional mathematics and there were changes in both attitudes and behaviour. The case studies suggest that the following aspects of the students' experiences were influential in their perceptions of relevance.

Firstly, the curriculum content in college was more limited than GCSE mathematics and excluded certain topics that students considered were unconnected to life. This meant that there was a greater focus on the mathematics that students recognised as having a practical use. In isolation, this represents a rather utilitarian view of the value of mathematics (Ernest, 2004) but identifying a practical usefulness can provide a reason for students to see the relevance (Sealey and Noyes, 2011) and begin to make connections between the classroom and their lives.

Secondly, the emphasis on using and applying mathematics in 'real life' situations provided opportunities to communicate the concept of *mathematics as a 'tool for life'* rather than an academic knowledge-based subject. This emphasis on the use of mathematics relates strongly to the identified needs of the workplace (Hodgen and Marks, 2013) in which application skills are important. Students who grasped this conceptual view could see more easily the purpose of mathematics for their current or future lives. A connection to their personal goals or interests was associated with a positive emotional response and behavioural changes (Goldin et al., 2011) so they became enthusiastic about functional mathematics, engaging with lessons and gaining

confidence. This appeared to be more than a transient emotional change and there was evidence of a shift in longer-term attitude towards mathematics (Hannula, 2012).

Thirdly, the *use of context* for these students was a factor that had the potential to increase the relevance of mathematics. Both teachers in these case studies attempted to use context to make mathematics relevant but with different outcomes. The examples used by Lindsay may not always have been 'authentic' in the sense used by Wiliam (1997) but appeared to be 'realistic' to students because the details of the scenario accurately matched their experience in real life. The images these descriptions created in students' minds (Van Den Heuvel-Panhuizen, 2003) seemed to be effective for learning purposes and connections to life were established.

The contexts selected by Lindsay were ones that stimulated student interest and she also reinforced these links to everyday life through discussion. This sometimes deflected the focus of the lesson from mathematics, but had a positive effect on their perceptions of relevance. Maximising the *emotional connection*, through careful selection of contexts and discussion, drew students into a closer relationship with mathematics.

In both of these case studies the teachers were working with the same functional mathematics specifications but their interpretations varied. Lindsay had a clear grasp of mathematics as a 'tool for life' that was rooted in her own experience of using mathematics in employment. She communicated this effectively and her students became convinced that mathematics was a useful tool with relevance for their lives. In contrast, David's interpretation was focussed on the need to acquire knowledge of basic rules and procedures rather than solving problems that arose from the contexts. This influenced his teaching approaches and his students saw little change from the mathematics they had learned in school. The subject remained remote and unconnected to their lives.

For Lindsay's group, her interpretation of functional mathematics as a useful 'tool for life' led to teaching approaches that had a positive effect on students' views and responses to mathematics. The emotional connections, established through contexts and discussion that linked mathematics to students' lives, added a further dimension to their perceptions of relevance than a simple cognitive recognition that the subject was important.

Conclusions

Teaching *mathematics as a 'tool for life'* increased the opportunity for the *connections to students' lives* because of the emphasis on using and applying mathematics. For these vocational students, this was an appropriate focus. They were unlikely to require knowledge of higher level mathematics but the ability to use mathematics, even in a limited number of applications, was required for their vocational pathway and their intended future careers (Hodgen and Marks, 2013).

The teaching approaches associated with the communication of *mathematics as a 'tool for life'* served to enhance the relevance for students when teachers *used contexts* that related to students' personal lives. Effective connections to students' life experiences stimulated emotional responses that helped them identify with mathematics in a different way. These students began to see mathematics not just as a useful set of skills or a qualification required to reach a personal goal, but as an intrinsic part of their current and future lives. Their view of relevance became more than just a cognitive recognition of the value of mathematics. The affective connection to their personal experience added a new strength to their perceptions of

relevance, changed previously negative attitudes and led to increased engagement with mathematics.

Although it is widely acknowledged that affect and cognition are both important, the way *emotional connections* can be used to increase relevance and change attitudes to mathematics seems to have received little attention. This research suggests that a functional curriculum, taught with an emphasis on mathematics as a 'tool for life', can create opportunities to increase the relevance of mathematics through these emotional connections. The resulting changes in student attitudes and engagement mean that this aspect of relevance may be a useful area for further study.

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References

Cooper, B. & Harries, T. (2002) Children's responses to contrasting 'realistic' mathematics problems: Just how realistic are children ready to be? *Educational Studies in Mathematics,* 49(1), 1-23.

DeBellis, V.A. & Goldin, G.A. (2006) Affect and meta-affect in mathematical problem solving: A representational perspective. *Educational Studies in Mathematics,* 63(2), 131-147.

Ernest, P. (2004) Relevance versus utility: Some ideas on what it means to know mathematics. *International perspectives on learning and teaching mathematics*, 313-327.

Goldin, G.A., Epstein, Y.M., Schorr, R.Y. & Warner, L.B. (2011) Beliefs and engagement structures: behind the affective dimension of mathematical learning. *ZDM The International Journal on Mathematics Education,* 43, 547-560.

Hannula, M.S. (2012) Exploring new dimensions of mathematics-related affect: Embodied and social theories. *Research in Mathematics Education,* 14(2), 137-161.

Hodgen, J. & Marks, R. (2013) *The Employment Equation*. Report for the Sutton Trust.

McLeod, D.B. (1994) Research on affect and mathematics learning in the JRME: 1970 to the present. *Journal for Research in Mathematics Education,* 25(6), 637-647.

Nardi, E. & Steward, S. (2003) Is mathematics TIRED? A profile of quiet disaffection in the secondary mathematics classroom. *British Educational Research Journal,* 29(3), 345-366.

QCA (2007) Functional Skills Standards. London: Qualfications and Curriculum Authority.

Sealey, P. & Noyes, A. (2010) On the relevance of the mathematics curriculum to young people. *The Curriculum Journal,* 21(3), 239-253.

Van Den Heuvel-Panhuizen, M. (2003) The didactical use of models in realistic mathematics education: An example from a longitudinal trajectory on percentage. *Educational Studies in Mathematics*, *54*(1), 9-35.

Wiliam, D. (1997) *Relevance as MacGuffin in mathematics education*. Paper presented at the British Educational Research Association Conference, York, September 1997.

Wolf, A. (2011) *Review of vocational education*. London: Department for Education.