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THE FORMATION AND EFFECTS OF ATTITUDES TOWARDS MATHEMATICS IN UPPER SIXTH-FORM STUDENTS

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Abstract

This study concerns upper sixth-form students' attitudes towards mathematics and the influence these attitudes have on their mathematical behaviour. Interviews with A-level students, conducted before their final exams, explored their beliefs, previous experiences and, in solving a general problem, their initial mathematical behaviours. The analysis suggests that attitudes towards mathematics are the product of students' beliefs about mathematics and of their previous experiences with it and that this attitude has a strong influence on their behaviour.

Introduction

Students' affective responses in mathematics play a significant role in their working and thinking in a mathematical task, a role that cannot be ignored in investigating students' cognition. In this paper we will be concerned mainly with the role of attitudes, and more specifically with the formation of attitudes and their relation to mathematical behaviour in upper sixth form students.

Research on mathematics education has focused mainly on the cognitive processes of learning, leaving little space for the consideration and integration of affective issues. However, some recent research in the field of mathematics education has concentrated on affective aspects (McLeod & Adams, 1989; Meyer & Eley, 1999). Affective responses can be differentiated into beliefs, attitudes and emotions as Simon (1982) notes, but such a distinction is not always clear. Often the term attitude is referred in the literature as beliefs (Neale, 1969; Cook & Leckey, 1999) or feelings (Royster *et al*, 1999) and its own definition is "implied by items of instruments measuring attitude" (Kulm, 1980). Such an approach begs the question of what we actually mean by *attitude*.

Many social psychologists (Ajzen & Fishbein, 1980; Allport, 1935; Triandis, 1971) tried to define the term and the most commonly used definition is that of Ajzen's (1988):

> "An attitude is a disposition to respond favourably or unfavourably to an object, person, institution or event." (p. 4).

However, the above definition does not include any cognitive aspects of mathematics nor explain the way attitudes are formed or link with behaviour. For that reason, we define and use attitude as:

> the amalgam of the emotional experiences of a topic and the beliefs about the nature of the topic which leads to a predisposition to respond with similar emotions and similar expectations in similar experiential settings.

This definition indicates that we do not aim to simply measure the degree to which a student likes a mathematical topic or to identify students' beliefs about mathematics itself. We rather attempt to explain that the behaviours exhibited by students are formed from their attitudes towards it. Our implicit hypothesis is that attitudes are shaped by students' initial views of mathematics and their experiences in it. The repetition of several mathematical situations and the approaches students use to deal with them, along with their idiosyncratic views about the nature of mathematics form a specific attitude towards a mathematical topic or mathematics in general.

We believe that if we are able to uncover students' attitudes towards mathematics then we will be able to "predict" the way they approach a mathematical task.

Methodology

The work presented here is the first part of a longitudinal study that examines the development of students' attitudes towards mathematics in relation to cognitive aspects during the transition from school to university.

Semi-structured interviews with 11 students were conducted at their schools just before their A-level exams. The students who were selected to participate in the research had been offered a place at Warwick's Mathematics Department. The interviews' purpose was to form an in-depth view of their beliefs and feelings about mathematics. An attitudinal questionnaire about the nature of mathematics and the student's beliefs and emotions about it was administered to them. In addition, a mathematical problem, taken from Mason *et al* (1982), was given to them the last 20 minutes of the interview. The content of problem was chosen to be within the mathematical knowledge one would expect of a sixth-form student. The problem was: "A four digit palindrome is always exactly divisible by 11. Is that true?".

Trying to uncover students' attitudes, let alone to examine the way those attitudes towards mathematics are formed, is a very hard task and there is often the risk of missing out important factors or misinterpreting some others. What we tried to do was to gather our data in a way that would enable us to analyse students' responses to the questionnaire, their language and their work on a mathematical task in as natural a setting as possible.

To show what our theory supports we are going to present extracts from the interview with just one student, Kathy, and her responses to the questionnaire along with her working in the mathematical problem. The conclusion we draw, however, is seen generally across all students in the study.

The Student's Profile

In order to outline Kathy's profile we first analysed her responses to the first part of the attitudinal questionnaire, in which students were asked to rank seven statements about the nature of mathematics. Kathy ranked "mathematics is abstract" followed by "mathematics is about putting things together", as the highest significant statements[1]. Kathy's view that mathematics is about ordering things was implicit throughout the interview with her. The following episodes illustrate that in more detail.

Episode 1:

K: Generally I really like the algebra more.

I: All right?!

K: And **I like fiddling around with equations.**

I: Why do you prefer algebra?

K: I don't know. It's just...looking at it it seems a lot simpler to me, for me to just sort out everything and you can, **with equations you can just...see where they're going**. I find it easier to see what's happening with the, uhm, when it comes to like geometry and stuff and I'm thinking in other planes I find it a lot harder.

I: Oh, really?

K: Uhm, sometimes you feel that you've kind of fudged away through it and made things happen and **you're just not sure whether you've actually followed on the logic fully or you've just kind of made it happen 'cause you wanted to**.

Episode 2:

I: Yeah. You said that you always were sure that you wanted to do maths. How...why is that?

K: I'm not entirely sure. I definitely always liked science

I: yeah

[1] At this point we have to note that we did not include the item "mathematics is about problem solving" in our further analysis of the students' responses even thought it was ranked first by all students but one, since the interviews showed that problem solving could be interpreted by some as the routine completion of exercises and by others as the investigation of a mathematical situation.

K: **because I think it's just the way everything fits together** and the patterns and things that are initially...and just the problem solving that I initially really liked as a child.

K: Uhm, **I could see how problems could be split up into smaller problems and could be solved** and things like that...just breaking down problems...

When it comes to the mathematical problem, Kathy's first reaction was to represent algebraically the four-digit palindrome as *abba*. However, her further attempt to start solving it algebraically had as a result to produce the following:

If ab is divisible by eleven then abba is

$ab/11 = c + x/11 \quad 0 \leq x < 11$

$ab = 11c + x$

Discussion

We believe that the formation of attitudes towards mathematics is the product of beliefs about it and the experiences with it. In the case of Kathy, we can claim that this is true. Kathy's "positive" attitude towards algebra in particular and mathematics in general, emerges firstly from her beliefs about the nature of mathematics that could be summarised as the ordering of equations and smaller problems. This, along with her successful previous experiences in mathematical tasks, while approaching them algebraically through equations, results in the formation of her positive attitude towards mathematics. When a student participates and works in the school environment she forms certain beliefs about mathematics according to the mathematical instruction; the syllabus; the requirements of homework, tests and A-level exams; its usefulness and to the way it is connected with other school subjects. All these beliefs are reinforced by the student's experiences with everyday mathematical questions and more specifically by the way she approaches it and the degree of success she has in it.

Revealing the way attitudes towards mathematics are formed and uncovering them is not necessarily of intrinsic value from a cognitive point of view. However, the evidence from our study is that there is an intimate relationship between attitudes and mathematical behaviour and it is this relationship that makes the research on attitudes so valuable.

In the case of Kathy, this relationship appears clear. Kathy's belief is that mathematics is about 'sorting things out' and being 'abstract'. Her initial approach to the problem is an algebraic approach: this is, we suggest, the nature of her belief made manifest in her behaviour. Kathy's first attempt to solve the problem is exactly what she likes the most and has proved successful so far in her past mathematical questions: "fiddling around with equations", even though she was unable to justify why or how she thought of her starting equation when asked. At this point we can

see the effect attitudes towards mathematics have to a student's mathematical actions. Kathy did not start doing calculations as other students did; she started immediately from the algebraic form of the four-digit palindrome and she continued with an equation. Even after she wrote down that equation she kept working with the manipulation of algebraic symbols "so that they're relevant" as she said, a view that is consistent with her statement that "everything fits together" as mentioned in Episode 2.

We believe that attitudes towards mathematics, which are conceptualised as predispositions according to our definition, have a causal influence on a student's mathematical behaviour. We support the view that when a student faces a mathematical problem she first tries to associate it with previous mathematical problems she has encountered in the past. It is at this point that her attitude towards mathematics, or towards that broad category of the mathematical question, is activated. If the mathematical situation is novel, the student associates it with previous ones and with the approaches used and at the same time her beliefs about what mathematics is about and how it should be approached come to the surface and predispose her to act mathematically in a particular way. If the mathematical situation is an already known one, the student is predisposed to approach it in a way that is consistent with her previous experiential settings and the corresponding beliefs about it.

Conclusions

Students' attitudes towards mathematics can be a very useful tool for interpreting or even predicting their mathematical behaviour. However our findings raise questions about the way to change students' mathematics attitude and the effects that change might consequently have to their mathematical behaviour.

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