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Research Article

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Influence of Prior Schooling on Undergraduate Biology Students' Attitudes to Mathematics and Academic Performance

Nikola S Markovina*

School of Life and Environmental Sciences, The University of Sydney, Sydney NSW, Australia

***Corresponding author:** Nikola S Markovina, School of Life and Environmental Sciences, The University of Sydney, Sydney NSW 2006, Australia, E-mail: nikola.markovina@sydney.edu.au

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Abstract

The interconnectivity between the nature and origins of mathematics and science cannot be overstated. Studies over the past decade have shown that approximately 50% of life science students lack confidence in their mathematical abilities, and as a result, often adopt a rigid attitude to learning mathematics. This study aimed to elucidate the possible reasons how students may have developed a particular attitude to learning mathematics and biology, and determine what effect this had on their academic performance. The study was framed using Bandura in 1977, self-efficacy theory. Students enrolled in an introductory biology course (n=254) were surveyed. Responses to survey items were matched to students' final grades in mathematics and biology. It was found that a majority of students believed that their prior schooling was the most significant factor in shaping their attitudes to learning mathematics and biology. Students who characterised their prior schooling negatively, were more likely to have a negative attitude to mathematics, and achieve significantly lower grades in both mathematics and biology.

Keywords: Teacher; Life science learning; Academic performance; Mathematics

Introduction

Over the past decade it has been shown that approximately 50% of life science students lack confidence in their mathematical abilities [1-6]. Bandura's self-efficacy theory states that people's belief in their abilities can influence their behaviour and the resultant outcomes [7]. If students have low self-perceptions of their mathematical ability, they will be less likely engage with the learning material and less likely to succeed academically. Studies have found evidence to support the role of primary school teachers as a possible mechanism for the development of students' low confidence and abilities. Primary school teachers with higher levels of Maths Anxiety (MA), can inadvertently transfer their negative attitudes, fear and avoidance of mathematics to their students [8,9]. This can result in students developing higher levels of MA, low confidence and mathematical abilities. These studies highlight the important influence primary school teachers can have on their students, with respect to MA, mathematical confidence and ability.

The Fennema-Sherman Mathematics Attitude scale (FSMA), has been used to measure students' attitudes to mathematics extensively within many different pedagogic environments over the last 40 years [10-14]. From an analysis of students' responses, it was possible to generate answers to a number of questions:

1. What prior experiences have shaped students attitudes to learning mathematics and biology, and are these experiences different for mathematics and biology?

2. How do these prior experiences influence student learning outcomes in first year mathematics and biology?

The overall aim of this study was to elucidate the possible reasons how students may have developed a particular attitude to learning mathematics and biology, and does this have an effect on their academic performance?

Methods

Students enrolled in an introductory biology course (n=254) at a major research focused university were surveyed as to their attitudes to mathematics, using a modified version of the Fennema-Sherman Attitude Scale (5-point Likert items). Based on their responses, students were categorised as either possessing either a 'negative' (mean Likert score <3.5) or a 'positive' (>3.5) attitude to mathematics [6]. In a similar manner similar to two open-ended questions were developed. The questions asked students to think about what experiences have influenced their attitude to learning mathematics and biology [15-18].

Qualitative data in the form of brief answers to opened-ended survey questions can often provide a clarification or explanation of previously collected quantitative data [19,20]. Within the context of educational research, open-ended questions can provide researchers with a greater insight into how students have individually responded to a novel teaching method or how they have developed a particular attitude to learning [21,22].

Analytical and thematic coding of open-ended response questions is often used to reduce large amounts of text into manageable categories or themes [19,23]. Student answers were thematically coded by hand, where they were sorted into one of five experience categories, namely; 'teacher/school', 'parent/family', 'university', 'future career', and 'other'. Where other was defined as any response that could not be categorised as any of the categories. Further analyses, were able to reveal whether or not, students believed their self-identified experience factor had been either a positive or a negative influence on their development of a particular attitude to learning mathematics and biology. Based on their content, responses were categorised as either 'positive' or 'negative', an example of a student's responses are shown in Figure 1. The student's answer for mathematics was categorised as 'positive' 'teacher/school', given that the student had used positive adjectives such as "amazing" and "inspired". Whereas for biology, the student's answer was categorised as 'negative' 'teacher/school', due to the use of negative words such as "struggled" and "resent".

Frequencies and percentages were then calculated for each experience factor for both mathematics and biology. In a manner similar to Morris et al. [24], chi-square contingency tests were then used to compare the frequencies between the different experience categories as well as the differences between positively and negatively toned responses for both disciplines.

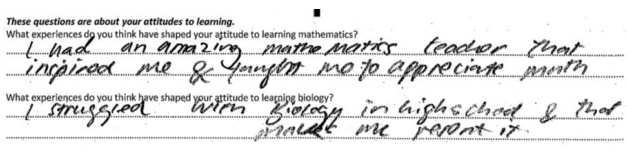

Figure 1: Example of a student's open-ended response.

To determine what effect students' prior learning experiences had on their attitudes to mathematics and learning outcomes (academic performance), parametric (student's independent samples t-test) and non-parametric (Mann-Whitney U test of medians) statistical comparisons of students' scores on the Attitude to Mathematics Questionnaire (AtMQ) and mean and median final grades for mathematics and biology, were made between the two groups: 'positive' and 'negative'.

Data analysis was restricted to the 'teacher/school' experience factor, as a majority (≈60%) of students regarded this factor as having had the greatest influence on their attitudes to learning both mathematics and biology.

Results

The results of a chi-square contingency test of the proportions of the different experience factors for both disciplines, revealed that the most commonly cited was 'teacher/school', (mathematics, χ^2=217.8, df=4, P<0.0001, biology, χ^2=80.4, df=4, P<0.0001). This suggests, at least for this population, that students believed that their prior schooling had been the most significant influence on their development of a particular attitude to leaning mathematics and biology.

The results of both parametric and non-parametric tests, found that students who regarded the 'teacher/school' factor, as having been a negative influence on their attitudes to learning mathematics, scored significantly lower on the AtMQ, compared to students who had regarded their 'teacher/school' factor, as having been a positive influence on their attitudes to learning mathematics (Table 1).

The results of both parametric and non-parametric tests, found that that students who regarded the 'teacher/school' factor, as having been a negative influence on their attitudes to learning mathematics and biology, achieved significantly lower grades in both mathematics and biology, compared to those students who regarded the 'teacher/school' factor, as having been a positive influence on their attitudes to learning (Table 2).

Discussion

It was found that students' attitudes to learning both mathematics and biology, were primarily shaped by their prior schooling. This was not surprising, as the role and influence of school teachers has been long been understood [25,26], and more recently primary school teachers have been shown to inadvertently transfer their own attitudes, aversions, and feelings of anxiety to mathematics, to their students [8,9].

S. No	'Teacher/School experience factor'	Mean (SD)	Median	t (df)	P	Mann-Whitney U	P
Attitude to Mathematics**	Positive (n=75)	3.5 (0.7)	3.5	4.9 (103)	<0.01	505.5	<0.01
	Negative (n=30)	2.7 (0.8)	2.5				

Table 1: Parametric and non-parametric comparisons of students attitudes to mathematics, based on positive and negative experience factors (teacher/school), **Stat. sig, at P<0.01.

It was possible to determine whether the influence the students had cited had been either a positive or a negative influence on their attitude to learning mathematics and biology. It was found that students were more likely to have regarded their prior experiences as having been a positive influence on their attitudes to learning biology and mathematics. For mathematics, students were more likely to have regarded their prior experiences with as having been a negative influence, compared to biology. With regards to the most commonly cited experience factor, 'teacher/school', students were more likely to have believed that their attitude to learning mathematics had been negatively influenced by their schooling, compared to their attitude to learning biology. This study is consistent with Sloan, peker and Ertekin and has found further evidence to support the major influence primary school teachers can have on their students, well after primary school. As most students in their first year of university, were still of the belief that their prior schooling had been the most significant influence on their development of a particular attitude to learning mathematics and biology [8,9].

Students who regarded the 'teacher/school' factor, as having been a negative influence on their attitudes to learning mathematics, scored significantly lower on the AtMQ, compared to students who had regarded their 'teacher/school' factor, as having been a positive influence on their attitudes to learning mathematics. Students who felt that their prior schooling had been a negative influence on their attitude to learning mathematics, developed negative attitudes to mathematics, compared to their peers who regarded their prior schooling as having been a positive influence. These findings are consistent with Sloan, Peker and Ertekin, which demonstrate that students can inadvertently be negatively influenced by their teachers' own negative attitudes to mathematics, and feelings of mathematical anxiety [8,9].

	Teacher/School experience factor	Mean (SD)	Median	t (df)	P	Mann-Whitney U	P

Mathematics*	Positive (n=37)	64.6 (11.4)	65				
	Negative (n=18)	55.1 (13.2)	56	2.8 (53)	<0.01	204.5	<0.05
Biology*	Positive (n=55)	65.8 (12.3)	66				
	Negative (n=2)	45.5 (17.7)	45.5	2.3(55)	<0.05	14.5	<0.10
*Stat. Sig. at P<0.05							

Table 2: Parametric and non-parametric comparisons of students learning outcomes, based on positive and negative learning experiences (teacher/school), *Stat. Sig. at P<0.05.

Additionally, it was found that that students who regarded their prior schooling, as having been a negative influence on their attitudes to learning mathematics and biology, achieved significantly lower grades in both mathematics, and biology, compared to those students who regarded their prior schooling, as having been a positive influence on their attitudes to learning. This is consistent with Sloan, Peker and Ertekin [8,9], who found that that students can inadvertently be negatively influenced by their teachers' own negative attitudes to mathematics, and feelings of mathematical anxiety, which can result in lower mathematical abilities. This suggests that for both mathematics and biology, the way in which students perceive their prior schooling (as either positive or negative), can have significant influences with respect to their future learning outcomes. The results support the findings of Hill and Ramirez, which appear to indicate that it is within primary school, where students' first develop mathematical anxiety, and negative attitudes to mathematics, and as a result poorer mathematical abilities [27,28].

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