The Influence of the Mathematics Class on Middle School Students' Interest for Statistical Literacy

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This paper explores the differences between middle school students' interest for the statistical literacy acquired in mathematics classes, their interest for mathematics in general, and their interest for the statistical literacy acquired in other school subjects. Based on the responses of a sample of 425 Australian middle school students, it appears that such students have no more interest for the statistical literacy in mathematics classes than the mathematics that they encounter. The same students, however, have more interest for statistical literacy when it is encountered outside of mathematics classes. Follow up interviews with 17 students are used to explore the reasons for these differences. The results suggest that students' interest for statistical literacy is strongly associated with the perceived relevance of the context in which the statistics is embedded. Moreover, a number of students dislike the inherent uncertainty that is associated with statistics, preferring instead problems with clear solutions.

Statistical literacy is regarded as an ability to interpret and critically evaluate messages that contain statistical elements (Gal, 2003). The requisite concepts and skills for this literacy are usually first encountered by Australian students in their mathematics classes. These skills are then often used in a variety of contexts that occur in other school subjects. As a result, the development of Australian students' statistical literacy should occur across the entire school curriculum. This is as it should be, for statistics itself is a "methodological discipline rather than a core substantive area" (Moore & Cobb, 2000, p. 620). This paper explores the extent to which the mathematics classroom influences middle school students' attitudes to statistical literacy. More specifically, the paper seeks to explore differences between middle school students' interest for the statistical literacy encountered in the mathematics classroom, their interest for the other areas of mathematics, and their interest for the statistical literacy encountered in other school subjects.

The Development of Interest

Dewey (1910, p. 91) described interest as "the annihilation of the distance between the person and the materials and results of his action." More recently, interest has been conceptualised as an affect with both state and trait properties (Ainley, Hidi, & Berndorff, 2002). At the trait level, interest is viewed as a predisposition to attend to certain tasks (Ainley et al., 2002); at the state level it is likened to curiosity, "an emotional state aimed at understanding" (Silvia, 2001, p. 277). Students' responses to interest inventories are thought to reflect both their trait and state interests (Ainley et al. 2002).

In learning contexts, interest is known to influence student motivation, with reported positive associations between students' interest and their achievement (Schiefele, Krapp, & Winteler, 1992). Factors that are known to influence students' interest for domains such as mathematics or statistics have been documented in Carmichael, Callingham, Watson, and Hay (2009). These include individual factors such as: students' personal interests, their goals, and their competency beliefs. Situational features, such as the novelty, complexity and uncertainty associated with given tasks are also known to influence the interest that students have for that task.

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Arguably, mathematical and statistical learning experiences are sufficiently distinct for students to experience different levels of interest. In statistical investigations, for example, context is essential and the extent to which it aligns with students' personal interests and/or goals will influence the interest, or lack of interest, that they experience. Similarly, students who believe they are more competent with statistical investigations than mathematical investigations are likely to report higher levels of interest for the former. Situational aspects associated with the learning of statistics are also likely to elicit different levels of interest than those associated with the learning of mathematics. For example, Mitchell (1993) reported that novelty can be found in computer applications, so it is likely that some students will find interest in statistical investigations that use software to interrogate datasets. It is also possible that some students will experience interest as a result of the inherent uncertainty that is associated with aspects of statistics.

Methodology

The methodology for this study occurred in two stages, a quantitative study involving survey responses of 425 students, and a supporting qualitative study involving the interview responses of 17 students.

Stage 1: Quantitative Study

A convenience sample of 425 students from nine schools in three Australian states agreed to participate in a larger interest based study. Students in the study were primarily enrolled in years 7, 8 and 9 of secondary school, although students from years 6 and 10 were also included in the study. The mean age of students was 13.6 years, and 47% of students were male.

Students responded on a five point Likert scale to a series of interest self-descriptions, for example: "I'm interested in surveys that find out about people". A Rasch analysis of these responses was used to provide an interval measure of their interest for statistical literacy (Carmichael, 2008). In addition to these interest self-descriptions, and relevant to this study, students were also provided with the following three self-descriptions:

> Compared to others in my class I am good at maths.
>
> I find statistics more interesting than the other work we do in maths.
>
> The statistics that I do in maths classes is more interesting than the statistics that I do in other subjects.
>
> These were also answered on a five point Likert scale that ranged from 1 (*Not me at all*) to 5 (*Describes me well*).

Stage 2: Qualitative Study

A sample of 17 students was selected from those who had completed the interest survey. The students, from two participating schools, were selected in order to represent a range of levels of interest for statistical literacy. Interviews were semi-structured and were conducted in groups of between 2 and 4 students, details of these groups are provided in Table 1. After students explained the sorts of things they did when they encounter statistics in mathematics and other subjects, the following questions were posed:

1. For you, is statistics more interesting than the other sorts of maths you do?
2. Is the statistics you do in other subjects more interesting than the statistics that you do in maths?

Interviews took between 30 and 40 minutes. They were recorded and subsequently transcribed. A content analysis of the data (Miles & Huberman, 1984) was then performed and the results are reported in this paper.

Table 1:

Details of Students and Schools Used in Qualitative Study

Group	Students	School
1	3 boys and 1 girl from a mixed ability Y7 class	Independent, co-educational from Qld.
2	2 girls from a mixed ability Y8 class	
3	2 girls and 1 boy from a high ability Y9 class	
4	2 boys and 2 girls from a low ability Y8 class	Government, co-educational from Tasmania
5	1 boy and 3 girls from a high ability Y10 class	

Results

Stage 1

The number of student responses in each Likert category for each of the questions is shown in Table 2. Only 54 students (13.2%) responded with a 4 or 5 to question 2 and presumably felt that statistics was more interesting than the other work they did in maths. Most students either did not see any difference or regarded statistics as less interesting than other work in maths. Indeed, if responses in the lower categories reflect disagreement, then 259 students (63%) regarded statistics as less interesting than other work in maths. Students' responses, however, were influenced by their competency beliefs. Students who considered they were less competent at maths than their peers (Question 1) tended to respond with lower ratings to Question 2 than students who considered they were no less competent ($\chi^2 = 61, p = 0.000$). Interestingly students who considered they were more competent than their peers also tended to see statistics as less interesting than maths.

Table 2:

Number of Student Responses to the Three Questions by Likert Category

	1	2	3	4	5	Total
Question 1	81	78	103	90	57	411
Question 2	146	113	97	34	20	410
Question 3	136	96	108	38	31	409

Only 69 students (16.9%) felt that the statistics encountered in mathematics classes was more interesting than the statistics encountered in other subjects. Most students either did not see any difference or regarded the statistics encountered in maths classes as less interesting than the statistics encountered in other subjects. Again, if responses in the lower

categories reflect disagreement, then 232 students (56.7%) regarded statistics as less interesting when it is encountered in mathematics classes. As in question 2, students' responses to question 3 were influenced by their competency beliefs ($\chi^2 = 91, p = 0.000$). In addition to this, their responses to question 3 were also influenced by gender ($\chi^2 = 18.5, p = 0.001$), with girls more likely than boys to see the statistics encountered in mathematics classes as less interesting than that the statistics encountered in other classes.

Stage 2

In response to the first interview question, 11 of the 17 students saw no difference in their interest for mathematics and statistics. One student saw the question as irrelevant arguing that "there's some things in maths that I like and others that I don't, but you're just got to do it…" Two students said the answer depended on other factors, such as the difficulty of the actual task, or its relevance. Only three of the students found statistics more interesting. One of these was interested in statistics because they were interested in finding out about other people; the other two expressed interest in statistics because they considered it to be easier than the other work done in mathematics classes.

When students were asked to give reasons for their responses a common theme emerged. Students identified a certain definiteness about many mathematics problems that was not found in statistics. One of the Year 7 students enjoyed "racing" through the mathematics questions. In response to the question whether statistics was more interesting, he replied:

> Its not interesting to me, I'd rather sit down and work out. I like getting my times because at my last school…we'd have 30 questions up on the board, we'd race each other to see who'd finish

Some of the Year 10 students expanded this theme further. One of the boys remarked:

> I don't like statistics as much as I like other stuff, because when you get the other stuff you're actually solving a problem, and statistics, you're not really solving a problem, you're just getting lots and lots of information and solving the problem you made for yourself.

One of the girls added to this discussion with the remark:

> I just like things that are bit more…sort of definite.

In response to the second interview question, 6 of the 17 students were unsure, suggesting that they had not encountered sufficient statistics outside of mathematics classes to comment. Six thought the statistics in other subjects was more interesting, four students said it depended on the context and one student felt that the statistics encountered in mathematics was more interesting.

When students were asked to give reasons for their response most felt that the contexts encountered outside of mathematics classrooms were more relevant. One Year 9 student remarked that "…you can actually see how it is" in other subjects. Another student, who was in Year 8, enjoyed using statistics in other subjects "because you have something that goes along with it, like an experiment or something to do". In relation to the statistics she had encountered in mathematics, one Year 10 student remarked:

> …in maths the data that we use, like, it's on a very small scale, like individual people's body measurements. But it's more interesting and important when its things that concern the whole world.

Discussion

The results from the first stage of this study indicate that students do not find any more interest in the statistical literacy encountered in mathematics classes than other areas of the mathematics syllabus. Their interest, however, appears to be influenced by their competency-based beliefs. Students who believe that they are less competent at maths than their peers are more likely to provide seemingly negative responses to such self-descriptions. The results also indicate that students do not find any more interest in the statistical literacy encountered in mathematics classes than that encountered in other classes. In fact, they suggest that students find statistical literacy more interesting when it is encountered outside of mathematics classes. This result, however, may be more related to students' negative attitudes towards mathematics than their interest for statistical literacy in other contexts. Girls tend to have a lower intrinsic valuing of mathematics than boys (Watt, 2004) and the tendency for girls in this study to provide low ratings for this question may more reflect their low valuing of mathematics than a preference for statistics in other contexts.

The results from stage 2 of this study suggest that students can distinguish between statistical literacy and other areas of the mathematics syllabus. In fact one rather unique characteristic of statistical investigations, as opposed to mathematical investigations, is that they typically result in an opinion supported by the data rather than a definite solution (Garfield, 2003). This characteristic actually evoked negative attitudes in some students, who preferred the definite solutions that are typically encountered in mathematical investigations. The results of stage 2 also suggest that students' interest ratings are very much influenced by the perceived relevance of the context in which the statistical literacy is embedded. Their interest ratings, therefore, may more reflect an extrinsic valuing than the intrinsic valuing that is associated with interest.

Other than the students who were interviewed, there was no available information on the nature of learning activities that students encounter in their acquisition of statistical literacy, both within the mathematics classroom and in other subjects. These learning activities influence students' interest ratings and indeed their ability to differentiate between statistical literacy, other areas of mathematics and other areas of the school curriculum. In fact the lack of response from some students in stage 2 to question 2 suggests that they may encounter very few statistical applications outside of their mathematics classrooms. This certainly appears to be the case in Great Britain, where Holmes (2003, p.46) argued, "the lesson that statistics is an interdisciplinary subject has not been learned". Given that statistics and probability will form one of three content strands in the proposed Australian National Mathematics Syllabus, there appears to be a growing awareness of the importance of statistical literacy. Although students can acquire the requisite skills and knowledge for statistical literacy in their mathematics classrooms, this literacy must be developed in wider contexts. In acknowledging this need, the *National Numeracy Report* (Council of Australian Governments, 2008) recommended an across curriculum commitment to numeracy, which it is assumed includes statistical literacy. In response to this, the proposed Australian National Mathematics Syllabus has recommended the inclusion of references in all syllabi indicating where numeracy is relevant in those disciplines. Such a recommendation, though, is merely a preliminary step. There is a pressing need for an audit of all school-based subjects, to determine the extent to which students encounter statistical applications across the curriculum and the efficacy of these applications for developing their statistical literacy.

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