

Gender Differences in Middle School Students' Interests in a Statistical Literacy Context

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This paper reports gender differences in the types of interests that middle school students have towards statistical literacy. These differences are detected from the responses of a sample of 366 middle school students to items in a statistical literacy interest inventory. In particular, dominance statistics are calculated in order to detect evidence for gender differences in student responses. Results indicated that girls were more interested in aspects of statistical literacy that related to surveys and boys were more interested in aspects relating to problem solving and also contexts that are associated with sports. The findings are interpreted using Dweck's achievement goal theory as it pertains to gender, and classroom implications are reviewed.

There is currently a shortage of mathematics and statistics graduates in Australia. In their review of mathematical sciences research, the Australian Academy of Science (2006) reported that in 2003 only 0.4% of Australian graduates majored in either mathematics or statistics, which compared unfavourably with an OECD average of 1%. Further, the Australian Bureau of Statistics has reported difficulty in obtaining suitably qualified statistics graduates (Trewin, 2005). Such shortages have their origins in the secondary school context, where the number of students enrolled in higher level mathematics courses is showing a declining trend (McPhan, Morony, Pegg, Cooksey, & Lynch, 2008). In addition to this, McPhan et al. (2008) reported that students' lack of interest and liking for mathematics during their middle school education was one of five factors that contributed to this decline, the other factors being: their previous achievement in mathematics; their mathematics self-concept; and, their perceptions regarding the usefulness and difficulty of mathematics. Of these five factors, evidence suggests that the first is dominant (Watt, 2005; Wigfield, Tonks, & Eccles, 2004). Students are more likely to participate in mathematics if they value or are interested in the subject.

There is evidence that males tend to participate more than females in mathematically related vocations such as engineering and the physical sciences (Collins, Kenway, & McLeod, 2000; Tytler, Osborne, Williams, Tytler, & Cripps-Clark, 2008). Such over participation is reflected in Australian senior secondary mathematics courses. In those courses that are prerequisites for tertiary level mathematics, male participation rates exceed those of females (Forgasz, 2006; Helme & Lamb, 2007; Watt, 2005). It is argued that gender differences in these participation rates emanate from gender differences in the valuing that middle school students have towards mathematics and in particular differences in their interest. The current study reports on gender differences in the interests that students have in one area of the middle school mathematics curriculum, namely the development of statistical literacy. This literacy, arguably important in our information rich society, is defined as the ability to interpret and critically evaluate messages that contain statistical elements (Gal, 2003).

Theoretical background

As detailed in Carmichael and Hay (2008), students' interest in statistical literacy will have both trait and state like properties. At the trait level "individual interest" is described as a "person's relatively enduring predisposition to reengage particular content over time" (Hidi & Renninger, 2006, p.113). At the state level "situational interest" is more transitory and is characterized by a positive emotion akin to excitement. In a learning context, students who are motivated out of an interest in the subject produce qualitatively superior learning outcomes to their less interested peers (Schiefele, 1991). Consequently there is a significant association between students' interest and their academic achievement in that domain (Schiefele, Krapp, & Winteler, 1992), and their future choice of subjects (Köller, Baumert, & Schnabel, 2001).

During their middle school education, students' interest in statistical literacy may develop in a number of ways. Students are likely to develop an interest as they acquire knowledge of the subject (Alexander, 2003). Further, students who encounter situational interest during their lessons are likely to develop an individual interest towards the subject (Hidi & Renninger, 2006). Of particular relevance to this study, however, is that the emergence of interest may be influenced by the individual's unique set of "interests", those interest objects with which he/she is particularly interested. Students who are fortunate enough to acquire their statistical literacy in contexts that align with their personal interests may transfer that interest to statistical literacy itself (Krapp, 2002).

Students' personal interests are in part idiosyncratic. As a result it may be difficult for a teacher to find suitable statistical literacy contexts that match each of his/her students' interests. Nevertheless there do appear to be broad categories of such interests that are favoured by particular sub-groups of the student population. Gender differences in students' interests have been explored in a number of contexts. For example, in a science education context, Jenkins and Pell (2006) reported that girls are more likely to be interested in topics that deal with the self and the natural world, while for boys there is more interest in topics that deal with destructive technologies. In relation to career interest (Holland, 1985), Lubinski, Benbow, and Morelock (2000) reported that girls are significantly more likely to favour social and aesthetic careers, while boys are likely to favour economic and political careers. This paper reports gender differences in contexts and topics that relate to the acquisition of statistical literacy. It forms a part of a larger study that seeks to explore the development of middle school students' interest in statistical literacy.

Methodology

The methodology used in this study is reported in three parts: the development of suitable items in an interest inventory; the testing of this on a sample of students; and, the subsequent analysis of their responses.

The development of an Interest Inventory

Initially a bank of items was written to reflect the topics and contexts used in the teaching of statistical literacy. Some general items were also included in order to assess a broader interest in the learning of statistical concepts. The topics comprising statistical literacy are identified by Watson (2006) as: sampling or data collection; graphs or data presentation; average; chance; beginning inference; and, variation. It was decided that the

later, although paramount to statistics, would be difficult to assess. Many students of this age would not be sufficiently cognizant with the term to meaningfully answer self-descriptions relating to variation. Thus the topics used in this study were restricted to the first five of Watson's topics, reflecting an earlier classification by Holmes (1986).

A student's interest in the learning of statistical literacy will be influenced by the contexts in which the material is presented. A review of the associated literature suggests that contexts including sports (Lock, 2006), social issues (Bidgood, 2006), and, the students themselves (Lee & Famoye, 2006) may be of interest. In addition to these, media contexts will be important as it is primarily in the media that students will encounter messages that contain statistical elements. The use of technology, especially if it creates a degree of novelty, is also known to engender interest (Mitchell, 1993). Finally, school and classroom contexts were included as these are more immediate and relevant for students.

After the creation of an item bank, a panelling process was used to assess the appropriateness of the items: A number of academics and practising teachers reviewed the items. A sample of fourteen items was then used in the interest inventory. These were written in the form of self-descriptions with the common stem "I'm interested in". Students were required to gauge how closely they could identify with each self-description using a five-point Likert scale ranging from 1 ("Not me at all") to 5 ("Describes me well"). The items used in this study are shown in Table 1.

Sample Design and Participants

After the completion of ethical clearance from the relevant University and school committees, participants were recruited via invitation. Schools were chosen so that the final sample would contain middle school students of both genders and from a variety of school types, including: government, independent, metropolitan, rural, single-sex, and co-educational.

A total of 711 students from 11 schools across four Australian states, was invited to participate in the study. The results reported here are based on 366 complete responses, a response rate of 51%. Of this sample: 44% were male; ages ranged from 11.3 to 16.0 years with an average of 13.6 years; 29% of students came from single sex schools; and 43% of students from government schools.

Analysis of Student Responses

In their study of students' interest in science, Jenkins and Pell (2006) treated the ordinal data as interval data and simply compared means. This may produce spurious results, especially when the underlying distributions depart significantly from normality (Cliff, 1993). One way to overcome this problem is to use an ordinal method from the outset.

An appropriate ordinal method is to make use of the dominance statistic d (Cliff, 1993), which can be used to assess the extent to which male and female attitudinal responses differ (Watt, 2002). This statistic is an estimate of the parameter δ , which in turn is a measure of the overlap of the two population distributions. It is defined as the proportion of scores from one population that are higher than those from the other population, minus the reverse proportion. More specifically given that there are m male interest scores x_i for an item and f female scores x_j for the same item, the difference statistic for the item is:

$$d = \frac{N(x_i > x_j) - N(x_i < x_j)}{mf},$$

where $N(x_i > x_j)$ denotes the number of times x_i is greater than x_j (Cliff, 1993, p.495).

The statistic has a domain $-1 \leq d \leq 1$. Values of $d = \pm 1$ indicate that the two populations are quite separate, while a value of $d = 0$ indicates complete overlap. The sampling distribution of d is asymptotically normal, which implies that a test of the null hypothesis $H_0 : d = 0$ can be performed in the usual manner.

Table 1
Gender differences for items in the interest inventory

No.	Item ("I'm interested in:")	Topic/context	d -statistic	p -value
1	Doing magazine or online surveys.	Data collection/media	-0.36	0.00
2	Surveys that find out how people feel about things.	Sampling and beginning inference/social issues	-0.15	0.01
3	Working on problems involving data and statistics.	General/school	0.29	0.00
4	Looking up unusual statistics.	Data collection/media	0.28	0.00
5	Using averages to compare sports teams or players.	Averages/sports	0.27	0.00
6	The average rainfall for my home area.	Averages/social issues	0.04	0.48
7	Reading graphs in newspaper and magazine reports.	Graphs/media	0.08	0.18
8	Conducting surveys of other students at my school.	Sampling and beginning inference/school	-0.17	0.00
9	Working out the probabilities (or chances) for dice, coins and spinners.	Chance/school	0.17	0.00
10	Using computer programs to help me investigate problems involving data.	General/technology	0.16	0.01
11	Using statistics to prove a point or win an argument.	General/self	0.09	0.12
12	Learning more about statistics.	General/self	0.12	0.04
13	Getting a job that involves statistics.	General/self	0.12	0.04
14	Statistics that show how I compare with others.	General/self	-0.02	0.86

Note. Positive values of d indicate a bias in favour of males.

In order to detect the influence of age on any observed gender differences, a dichotomous age variable was created; students older than the mean age and those younger. The dominance statistic d was then calculated for all items in order to detect the presence or otherwise of significant age differences in students' responses.

Results

The dominance statistic d was calculated to determine any gender differences in the responses of students to the interest inventory. Table 1 shows this statistic for each of the items and also the associated p -value. At a 5% level of significance, it is possible that some items may report a significance that is entirely due to chance. Accordingly the Bonferroni adjustment was applied and reported p -values were compared with a critical value of $0.05 \div 14 = 0.004$. As a result of this adjustment, items 1 and 8 indicate a gender bias in favour of girls, whereas items 3, 4, 5, and 9, a gender bias in favour of boys.

The dominance statistic d was calculated to determine any age differences in the responses of students to the interest inventory. Students who were younger than the mean age expressed higher levels of interest in four items: item 4 ($d = 0.12$, $p = 0.05$), item 6 ($d = 0.16$, $p = 0.01$), item 9 ($d = 0.13$, $p = 0.03$), and item 10 ($d = 0.25$, $p = 0.00$). With the above Bonferroni adjustment, however, only item 10 was significant at the 5% level.

Discussion and implications

The results demonstrate the presence of some gender differences in relation to the topics associated with statistical literacy. Girls favoured those items that related to surveys while boys appeared to favour items associated with working on problems and sports related contexts.

The results for girls agree with the gender differences that were reported earlier. Given an interest in topics that deal with the self (Jenkins & Pell, 2006) and social careers (Lubinski et al., 2000), it is not surprising that girls favour items associated with surveys. Indeed such an interest for girls is predicted by psychoanalytic theories of development, with Powell (2004) arguing that a sense of self for girls is obtained through connections with others and the real world. It is surprising, though, that a greater gender difference was evident for doing surveys (items 1 and 8), than for surveys that find out how people feel (item 2). In other words, for these girls the process appears to be of more interest than the outcome.

The reported gender difference for boys is more difficult to explain. Given the different results for items 5 and 6, it can be assumed that it is the sporting context in item 5 rather than the use of averages, which is of more interest to boys than to girls. Similarly, the absence of reported gender differences in students' interest towards statistics in general (items 12 and 13) yet a reported gender difference in students' interest towards doing problems involving data and statistics (item 3) suggests that doing problems is of more interest to boys than to girls. If true, such a result is surprising and of concern. It may reflect aspects of the learning environment in which these students solve problems, as girls report higher levels of interest in mathematics when the classroom environment favours cooperation rather than competition (Eccles, 1987). It is possible that for many students in this sample, problem solving is regarded as a competitive rather than a cooperative endeavour. The results also suggest that boys favour working out probabilities (item 9) and looking up unusual statistics (item 4), although in both of these items there was a reported, albeit non-significant, interaction with age. Arguably younger students would find the

games associated with probability of more interest than their older counterparts, and similarly unusual statistics.

The patterns of results do suggest that the boys were more focussed on outcomes, (e.g., working on problems, working out probabilities, looking up unusual statistics). In contrast, the girls were more process or task engaged, focusing on mastering the process (doing magazine or online surveys). This finding suggests the presence of a difference in achievement goal orientation (Dweck, 2000), with boys favouring performance goals and girls favouring mastery goals. Indeed, Hyde and Durik's (2005) review of the literature indicated that in the domain of reading and English, girls used more of a mastery goal orientation, wanting to know how it works and the details, while boys were more outcome and performance focussed, wanting to finish reading the book.

While the full interpretation of these findings can be enhanced by using student interviews, the findings of this study point to: first gender differences in students' interests in a statistical literacy context, and second, possible gender differences in goal orientation. These findings have implications for the classroom teacher. In the first instance they suggest that the interest levels for some girls will be enhanced if their statistical learning has its foundations in data obtained from surveys and arguably those with strong social contexts. Such data are traditionally generated from the students themselves in the classroom, but are limited in size and scope. Teachers should consider larger more authentic web-based data sources that also allow student participation. For example, the data associated with the *CensusAtSchool* project (Kong & Harradine, 2006), where students are able to enter their own statistics and opinions on a range of social issues and readily download a random sample of student responses for analysis. The results of such social analyses may be of more interest to girls with a mastery focused goal orientation. In terms of motivating and engaging boys in statistical literacy activities, a more active learning approach is recommended and one that utilizes contexts of interest to boys, such as sports. This may mean that the learning tasks are smaller with more opportunities for the boys to complete one performance task.

It is acknowledged that this study is limited by the small number of items that were used in the inventory and the absence of qualitative data. In addition to this the reported effect sizes, especially in relation to items that assess interest in surveys, may be inflated. The evidence, however, does suggest that there are broad gender differences in middle school students' interests, in the statistical literacy context. This has implications for how teachers engage and motivate students in mathematics and how they construct and deliver classroom mathematical activities. Further research is needed in order to clearly identify these differences and also possible gender differences in goal orientation. As much as possible students' personal interests should be harnessed in order to engender positive attitudes towards mathematical and/or statistical career choices.

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