Middle School Students' Interest in Statistical Literacy

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This paper presents the results of a research review into the development of middle school students' interest in statistical literacy. In particular it reviews the concept of interest and its motivational influence on learning. Findings reveal that very little research has examined the influence of positive affect such as interest on learning in the middle-school statistics context. Further, these findings suggest that interest development will be the result of a complex interplay of classroom influences and individual factors such as: students' knowledge of statistics, their enjoyment of statistics and their perceptions of competency in relation to the learning of statistics.

Through the learning of those concepts situated in the Chance and Data component of the Australian state (P-10) mathematics syllabi, students should become statistically literate; that is, they should be able to interpret and critically evaluate messages that contain statistical elements (Gal, 2003). A statistically literate person, for example, should be able to recognize bias as a possible source of error in media reports of survey data. Models have been conceptualized that describe the development of statistical literacy in learners (Gal, 2002; Watson, 2006). Whereas these models have acknowledged the importance of affect in this development, little research has actually focussed on affect in this context. The purpose of this paper, therefore, is to review the literature in relation to the development of affect in the statistical literacy context.

Students in a middle school context (years 6 to 9) are typically in early adolescence, which appears to be a critical stage in their affective development. In the mathematics education context, for example, evidence points to a decline in levels of affect as a student progresses through school (Fredricks & Eccles, 2002) with such levels reaching a minimum in year 10 (Watt, 2004). The correlation between student attitudes towards mathematics and their achievement in mathematics, however, appears to be strongest for students in years 8 to 10 (Ma & Kishor, 1997; Ma & Xu, 2004). The influence of affect on learning appears to be more pronounced for this group of students. Such findings are supported by reported physiological changes to the brain that occur during adolescence (Wigfield, Byrnes, & Eccles, 2006), changes that result in the greater likelihood of affective activity. In the statistics context, later high levels of reported statistics anxiety (Onwuegbuzie & Wilson, 2003) and shortages of skilled statisticians (Trewin, 2005) could be the result of students developing a negative affect towards statistical literacy during adolescence.

Interest is an affect that is fundamental in the development of a person's concept of self (Deci, 1992). Moreover, recent research suggests that interest is necessary for psychological growth, with absence of interest in adolescents being linked with psychological disorders such as depression (Hunter & Csikszentmihalyi, 2003). Interest is known to have behavioural consequences and in learning contexts has been shown to be positively associated with achievement (Schiefele, Krapp, & Winteler, 1992). Given the importance of interest development in adolescence and its association with learning, a study of the development of affect in students should include, if not entirely focus on, the development of their interest.

Interest has been regarded as having both trait and state characteristics (Schiefele, 1991). At the trait level *individual interest* is an internalized affective element described as a "person's relatively enduring predisposition to reengage particular content over time" (Hidi & Renninger, 2006, p. 113). Interest at the state level is more transitory; it is typified by high levels of arousal and accompanied by positive emotions. This state can be induced by aspects of the environment and in such instances is termed *situational interest* or can be induced from the individual's predisposition to engage and in such instances is termed *actualized interest*.

Under certain circumstances, it is believed that situational interest will develop into individual interest. Silvia (2001), for example, proposed that such development is essentially the result of the individual resolving the cognitive conflict that occurs when he or she interacts with the object of interest. More specifically, he argued that during the person-object interaction, incoming stimuli are collated with current personal information on the basis of a number of *collative variables* that are associated with the learner's response to the stimuli. These collative variables include; novelty, uncertainty, and complexity. During this interaction, the learner will fail to engage in any significant way with stimuli that are considered routine (low levels of novelty).

Similarly the learner will fail to engage when the stimuli are too unknown or frightening (high levels of novelty). For optimal levels of these variables a state of curiosity will be evoked that is characterised by high levels of arousal and positive emotions, including interest. In this state the learner will be motivated to resolve the conflict created by the particular collating variable. If this conflict cannot be resolved quickly, the learner will be motivated to persist with the object, even returning to it at later times. Such persistence with the object may uncover further stimuli that in turn create a conflict in need of resolution. In such a way it is hypothesized that both knowledge and interest in the object will develop, with people losing interest in simple objects and pursuing those with more complex associated knowledge. This close relationship between knowledge and interest is supported by the Model of Domain Learning (Alexander, 2003), which posits that as individuals move from acclimation to proficiency in a particular knowledge domain, their individual interest in the domain and knowledge of the domain will both increase.

Although the discussion above has identified knowledge as a factor that contributes to the development of students' interest, it has not specifically examined interest development in the current context. Accordingly, this paper seeks to answer the following question: what are the factors documented in the literature that influence middle school students' interest in statistics?

Methodology

The literature review was conducted in two phases, commencing with a search on the specific question and then generalising the search to encompass related contexts. Searches in both phases commenced with databases of academic journals and abstracts including: *A+Education*, *Emerald*, *ERIC*, *Expanded Academic*, *JSTOR Education*, *Proquest*, *PsycINFO*, *SAGE*, *SpringerLink* and *Wiley Interscience*. In addition *Google Scholar* was found to be a particularly useful search engine. Secondary searches of others' bibliographies and searches using citation indexes were also conducted in each phase.

The initial search specifically addressed the research question using keywords: interest, statistics (or statistical), in the article title. In addition to the databases discussed above a search was conducted on specific statistics education journal archives including: *Statistics Education Research Journal*, *Journal of Statistics Education* and *Teaching Statistics*. Further, an archive of statistics education dissertations retained by the *International Association for Statistical Education* was also searched. Only one study located in the search specifically examined the concept of interest as it relates to the learning of statistics in a school context. The search was then expanded to include mathematics contexts and tertiary statistics contexts.

The final search resulted in 36 hits with publication dates that ranged from 1976 to 2007. Thirteen of these could not be readily accessed and in most cases were published prior to 1995. Of the remaining 23 articles, six were discarded as the term interest was used generically to describe a feeling of well-being that was neither defined nor measured. A further three articles were also discarded as they had included interest items in larger attitudinal scales, but had not reported specific interest outcomes. The 14 studies used in this review are described in Table 1.

Results

A review of the themes common to these articles suggests that factors influencing interest development can be broadly classified into environmental and individual factors (see Table 2). Teacher practices, including the types of learning experiences that students encounter, can be classified as environmental factors. Several studies provided evidence to support the notion that teacher practices can enhance student interest (Heinze, Reiss, & Rudolph, 2005; Mitchell, 1993, 1997; Sciutto, 1995). As an example, Mitchell (1993) noted that learning activities that involved puzzles, computers and group work would catch students' interest. Similarly, teaching strategies that promoted student involvement and which students found meaningful were found to hold students' interest. Mitchell was able to provide some evidence to suggest that the individual interest of students in environments high in situational interest would increase in both a mathematics (Mitchell & Gilson, 1997) and statistics (Mitchell, 1997) secondary school context. It is arguable whether changes in interest reported after a period of only 14 weeks, the period used in these studies, reflect changes in individual interest. Nevertheless, teacher practices undoubtedly influence the situational interest in the classroom, which it is argued will ultimately develop into individual interest (see earlier discussion).

The social environment also plays an important role in developing interest. In a mathematics education context, Bikner-Ahsbahs (2004) argued that a type of interest, termed *situated collective interest*, could emerge in a group situation where one by one students become involved in an activity and come to value the activity. Through observations of children she was able to provide some evidence to support this theory. In relation to the social environment, Fox (1982) found that the views of significant others, including parents and teachers, influenced student ratings of *career interest* (the type of career they would be interested in pursuing), but indirectly through their ratings of confidence and the utility of mathematics.

Table 1

Results of Literature Search

Article	Description	Context
(Bikner-Ahsbahs, 2004)	Observational to support theory development.	Sixth grade mathematics class (Germany).
(Fox, 1982)	Empirical study ($N = 125$).	Junior-secondary (year 7) mathematics (US)
(Heinze et al., 2005)	Empirical study ($N = 500$).	Junior-secondary (years 7 and 8) mathematics (Germany)
(Koller, Baumert, & Schnabel, 2001)	Empirical study ($N = 602$).	Secondary (years 7 to 12) mathematics (Germany).
(Lawless & Kulikowich, 2006)	Empirical study ($N = 267$).	Tertiary statistics (US).
(Lopez, Brown, Lent, & Gore, 1997)	Empirical study ($N = 296$).	Secondary (age 15 -16) mathematics (US).
(Marsh, Trautwein, Ludtke, Koller, & Baumert, 2005)	Empirical study ($N = 7913$).	Secondary (years 7 to 12) mathematics (Germany).
(Mitchell, 1993)	Validation study ($N = 350$).	High-school mathematics (US).
(Mitchell, 1997)	Empirical study ($N = 51$).	High-school statistics (US).
(Mitchell & Gilson, 1997)	Empirical study ($N = 598$).	School and tertiary mathematics (US).
(Renninger, Ewen, & Lasher, 2002)	Observational to support theory development.	Primary school mathematics (age 11).
(Sciutto, 1995)	Evaluative study ($N = 17$).	Tertiary statistics (US).
(Stevens & Olivarez, 2005)	Validation study ($N = 724$).	School (year 4 to 10) mathematics (US).
(Trautwein, Ludtke, Koller, Marsh, & Baumert, 2006)	Empirical study ($N = 14341$).	Secondary (grade 9) students (Germany).

At an individual level, several studies demonstrated an association between student achievement levels and their level of interest (see Table 2). The direction of this relationship has also been explored. Koller et al. (2001) found that interest in early adolescence predicted later interest but not achievement. They concluded that age was a factor in interest development and argued that younger adolescents were more sensitive to achievement feedback than older adolescents who presumably have more stable interests. Marsh et al. (2005) on the other hand demonstrated that a reciprocal effects model existed: Levels of interest were predicted by earlier achievement but also predicted later levels of achievement. The strength of the association between achievement and interest is known to be influenced by the structure of the knowledge domain in question. Lawless and Kulikowich (2006), for example, reported a stronger association for statistics than for psychology and argued that the former was a more structured knowledge domain.

Several studies also demonstrated a link between students' conceptions of their competency and their level of interest. Lopez et al. (1997) provided evidence to suggest that students' self-efficacy beliefs predicted their interest in mathematics. The strength of this relationship, however, was dependent on the branch of mathematics being studied: A stronger correlation existed for geometry than for algebra. Marsh et al. (2005) and Trautwein et al. (2006) demonstrated the link between students' academic self-concept and interest in mathematics, with Trautwein et al. asserting that self-concept was a strong predictor of interest, which almost entirely mediated the influence of achievement and tracking (the assigned level of class). Moreover, Trautwein et al. argued that this relationship was influenced by the frame of reference used by students to judge their competency: High achievement students who were in a group of even higher achieving students reported low levels of interest in mathematics while low achieving students in a group of even lower achieving students reported high levels of interest.

Table 2

Content Themes

Common themes	1. Environmental factors that influence interest include: Classroom influences (Bikner-Ahsbahs, 2004; Heinze et al., 2005; Trautwein et al., 2006); the views of significant others (Fox, 1982); learning experiences (Mitchell, 1993, 1997; Mitchell & Gilson, 1997; Sciutto, 1995); and the nature of the domain of knowledge studied (Lawless & Kulikowich, 2006). 2. Individual factors that influence interest include: Students' competency based beliefs and their prior knowledge (Fox, 1982; Koller et al., 2001; Lawless & Kulikowich, 2006; Lopez et al., 1997; Marsh et al., 2005; Trautwein et al., 2006); and also their age (Koller et al., 2001).
Divergent theme	Operationalisation of the interest construct: Assessing both enjoyment and importance (Koller et al., 2001) or assessing levels of interest (Lawless & Kulikowich, 2006).

Differences were evident regarding the operationalisation of the interest construct. The German studies (Koller et al., 2001; Marsh et al., 2005; Trautwein et al., 2006) regarded interest as having both a value and an emotion component, with the former including the importance of the task and the later the enjoyment of the task. Interest, however, is regarded as the underlying affect of intrinsically motivated behaviour (Deci & Ryan, 1985): A student interested in statistics will engage in statistical activities for their inherent value. The concept of importance may assess the usefulness or utility of the task, an extrinsic motivator. Students, who report mathematics as important, may do so because they perceive it to be necessary for future job prospects. Such importance may not reflect interest, although evidence suggests that it may predict interest (Fox, 1982). Other studies operationalised interest through asking students to indicate their level of interest in a given task (Lawless & Kulikowich, 2006; Lopez et al., 1997; Sciutto, 1995). Of concern, is whether students' assessment of interest is similar to their assessment of enjoyment, with some authors suggesting the two are quite distinct emotions (Izard, 1984; Reeve, 1989; Silvia, 2001).

In this section a content analysis has identified factors that influence the development of a students' interest, primarily in a mathematics context. This has revealed that interest development can be attributed broadly to both individual and environmental factors. Further, the empirical studies cited, revealed a high level of complexity between such factors. The content analysis has also revealed differences in the way that studies have operationalised the interest construct. Such differences may have implications for the generalisability of the findings.

Discussion

Self-determination Theory (Deci & Ryan, 1985) provides a unifying framework for interest based studies such as those described in this paper. Deci (1992) argued that a person would experience interest when he/she encountered novel activities in a context that allowed for the satisfaction of their basic psychological needs; that is, competence, autonomy and social-relatedness. A student's need for autonomy (being able to choose what he/she does) and social-relatedness can be met if aspects of the classroom environment, of which the teacher is the primary architect, are conducive. A student's need for competence in statistical literacy, however, will be met if he/she possesses the necessary individual factors; that is, a sufficient knowledge of statistical literacy and positive competency-based beliefs regarding his/her ability to acquire statistical literacy. The studies cited in the last section either examined the influence of individual factors or the influence of environmental factors, but not both. There is a need for research aimed at providing a linkage between these two types of factors.

The relationship between students' competency based beliefs, their achievement and interest, which was explored by several of the studies, could be further clarified if the emotions of enjoyment and interest were disentangled. Reeve (1989) provided some evidence to demonstrate that interest is derived from collative sources (see earlier discussion) and enjoyment from the feelings of satisfaction that accompany task competency. He argued that both emotions were necessary for intrinsically motivated learning. Students enjoy success and are likely to reengage with tasks with which they perceive likely success. With no interest, however, they are likely to tire of the task. It is argued, therefore, that positive competency based beliefs in a learning situation will directly influence achievement and that this relationship will be mediated by feelings of enjoyment. Interest, on the other hand, will directly influence achievement.

Implications

The literature review reported in this paper identified a significant gap in the literature as it applies to interest in statistics and indeed statistical literacy. Related research in the mathematics education context suggested that interest in mathematics is predictive of achievement for senior secondary school students but not for middle school students (Koller et al., 2001). Further, there appeared to be a difference in the strength of this relationship according to the knowledge domain in question (Lawless & Kulikowich, 2006). Such findings suggest that further research into the development of middle school students' interest in statistical literacy is needed. As discussed earlier, such research needs to include both environmental and individual factors in order to obtain a broader view of how students' interest develops.

The empirical studies cited in this paper, broadly operationalised interest in two ways. The first was to assess interest in mathematics through measures of importance and enjoyment, and the second was to assess interest through task related interest ratings. As discussed in the last section, enjoyment and interest are distinct emotions. Given that they can be assessed separately, further research in this area may clarify the complex relationship that appears to exist between students' competency based beliefs, their achievement and their interest.

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