Emotions and the Development of Statistical Literacy

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Emotions play an important part in learning and are known to influence human development. The positive emotions of enjoyment and interest are thought to contribute to learning in distinctive ways, yet this distinction tends to be blurred in some learning research. This paper explores the role these two emotions play in the development of children's statistical literacy. It focuses on the responses of 220 middle-school children to just six self-descriptions, three assessing interest and three assessing enjoyment. Analysis of these responses suggests that the two emotions are difficult to differentiate empirically, but that differences in reported levels of enjoyment and interest may depend on students' perceptions of competence in the specific tasks with which they are engaged. Implications of this for teachers and researchers are discussed.

"I like using a calculator to work out problems, even though it's not that interesting". Children, such as the Year 7 boy who spoke these words, make emotion laden appraisals of the tasks that they encounter during mathematics lessons. Emotions are an important part of learning, in that children will engage in tasks where they are likely to experience positive emotions (Deci, 1992). Consequently, emotions play a key role in the development of mathematical knowledge. Of interest in this study, is the role that they play in the development of children's statistical literacy, regarded as an ability to critically engage with messages containing statistical elements. Researchers have proposed theoretical hierarchies associated with the development of this literacy that include necessary dispositions, such as a critical stance (Gal, 2002) and skepticism, curiosity and imagination (Watson, 2006). It is argued that these dispositions are more likely to develop when children experience positive emotions during their learning of the concepts and skills associated with statistical literacy. Research has suggested that the emotion of interest, for example, has a positive impact on the development of children's statistical literacy (Carmichael, Callingham, Hay, & Watson, 2010). Enjoyment, however, is also a positive emotion associated with learning. The boy quoted earlier mentioned that he liked using calculators, but didn't find them interesting. The study seeks to explore the role of both emotions in the development of children's statistical literacy.

Background

In her seminal work on human emotions, (Izard, 1977) identified interest and enjoyment as two distinct and fundamental emotions, yet this distinction becomes blurred in the motivational research literature, especially that related to intrinsic motivation. Interest is regarded as an affect with both state and trait like properties. As an emotion, it is defined as "the feeling of wanting to know about something or someone" (Soanes & Stevenson, 2008). Enjoyment, on the other hand is defined as "the state or process of taking pleasure in something" (Soanes & Stevenson, 2008). Both emotions are closely related in that Izard (1977) reported that people asked to describe past experiences of interest were likely to report pleasant experiences, similar to enjoyment. This closeness may have influenced the treatment of these emotions in the motivational literature. In relation to intrinsic motivation, for example, children's motivation to engage in tasks for their intrinsic value is thought to rely primarily on their anticipation of experiencing interest (Deci, 1992). Yet in their study of intrinsic motivation, Marcoulides, Gottfried, Gottfried, and Oliver (2008) conceptualized

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intrinsic motivation as being derived from enjoyment only, with interest providing a separate collative motivation (Berlyne, 1960), one that is based on a desire to resolve task-features that are novel, complex and/or uncertain. Other researchers, for example Eccles and Wigfield (2002), argue that both emotions influence intrinsic motivation. These different conceptualizations have influenced the design of instruments that measure this construct. Some instruments contain interest items, for example "I'm interested in", and enjoyment items, for example "I enjoy" (Watt, 2004). Others contain only enjoyment items (Hulleman, Durik, Schweigert, & Harackiewicz, 2008) and then compare these with separate measures of interest. Even in interest based research, the distinction between enjoyment and interest is blurred, with some researchers assessing the emotional dimensions of interest using enjoyment items (Schiefele, 1991). The ensuing discussion attempts to disentangle these emotions in the learning context.

The control-value theory of achievement emotions (Pekrun, 2006) maintains that in learning contexts, interest and enjoyment are distinctive emotions, influenced by the value and difficulty of learning tasks. Enjoyment is thought to occur when students both perceive a level of control in achievement based tasks, and value the task. Perceptions of control are strongest when task competence is regarded as likely. Boredom, or lack of interest, is thought to occur when students do not value the task, irrespective of their level of control. Enjoyment, therefore, is closely related to perceptions of self-competency and value, whereas interest related to value alone. This suggests that irrespective of the value that is placed on a learning task, levels of enjoyment and interest are likely to differ when perceptions of competency are either strongly positive or strongly negative. It is hypothesised that a student who values a task and perceives it as easy will report higher levels of enjoyment than interest, whereas one who values a task but perceives it as difficult will report lower levels of enjoyment than interest.

Studies on the roles of emotions in learning, including flow, suggest that interest and enjoyment play important complementary roles. Interest is thought to play a key role in the learning process, in that it governs initial task engagement and subsequent exploration (Reeve, 1989). If this initial interaction with the task results in positive appraisals of competence then feelings of enjoyment will emerge (Reeve). These feelings will motivate re-engagement with similar tasks. If new tasks do not generate optimum levels of collative motivation, students will soon tire of them (Berlyne, 1960). This interaction between the two emotions may explain individual's attempts to enter and remain in the 'flow-channel' (Csikszentmihalyi, 2002), a location in time where they experience a total absorption of self in the learning task. Csikszentmihalyi maintained that flow occurs when task complexity is close to the skill level of the learner. Students who are confronted with a task that is too complex are motivated to either increase their skill level or engage in a task of less complexity. It is argued that enjoyment and interest work in different ways during this process, in that students' motivation to increase their level of skill emanates from a desire to experience the enjoyment associated with competence, whereas their motivation to engage in more complex tasks lies in a desire to experience interest.

The above theoretical discussion highlights the close relationship that is thought to exist between the emotions of interest and enjoyment in a learning context. Testing this and/or seeking to apply it in a middle school statistics context, is premised on the assumption that it is possible to empirically differentiate between the two emotions. Whereas researchers have achieved this with adult subjects (Reeve, 1989; Turner & Silvia, 2006) none noted have done so with adolescents, who are characterized by emotional instability (Larson, Moneta, Richards, & Wilson, 2002). The study, therefore, aims to determine the extent to which interest and enjoyment can be differentiated in a middle school statistics context.

Research Questions:

1. To what extent do students' levels of enjoyment and interest differ for tasks of varying complexity?
2. Do students' responses to interest and enjoyment items separate onto distinctive interest and enjoyment factors?

Method

Sample

Students from six Queensland schools were invited to participate in the study, which formed a part of a larger interest-based study described in Carmichael et al. (2010) and conducted during 2008 and 2009. The schools were selected for their proximity to the researcher and also to be broadly representative of the types of schools operating in Queensland. Three of the schools were state high schools; one a large metropolitan high school and the other two smaller rural high schools. The other three schools were independent K-12 schools, one of which was a single-sex school. A total of 424 students attending these schools were invited to participate in the study and 221 agreed to participate, a response rate of 52%. The majority of these students were female (62%) and the age of students ranged from 11 to 15 years, with a mean of 12.9 years. Most students were in the first two years of high school (79%), whereas the remainder was in the last year of primary school for that state.

Instrument

Students responded to an instrument containing 40 self-descriptions that assessed a number of constructs related to the acquisition of statistical literacy. Details regarding the instrument are given in Carmichael et al. (2010). Of interest to this study are three pairs of identical self-descriptions, with one in the pair assessing interest through the stem 'I'm interested in' and the other assessing enjoyment through the stem 'I enjoy (or would enjoy)". These items are listed in Table 1 together with identifying codes that indicate where in the overall questionnaire they were situated. For example item I2, the second item in the questionnaire, assessed interest in using surveys to find out about others, whereas item E38, the 38th item in the questionnaire, assessed enjoyment in using surveys to find out about others. Students responded to each item using a five-point Likert Scale that ranged from 1 (*Not me at all*) to 5 (*Describes me well*).

Table 1
Self-descriptions Used in the Study and Associated Question Codes

Self-description	Interest code	Enjoyment code
Using surveys to find out about others	I2	E38
Working on problems involving data and statistics	I3	E35
Working out the probabilities (or chances) for dice, coins and spinners	I11	E34

The items reflect common tasks that these students should have encountered in their study of mathematics in Queensland (Queensland Studies Authority[QSA], 2004). By the end of Year 5, these students should have designed and conducted a variety of date

collection methods including surveys (QSA, 2004). Consequently many of the students should have competence in using surveys to find out about others. Similarly, students at the end of Year 5 in Queensland should be familiar with the term sample space and have used probability experiments to compare likelihoods. As a result, many of the students should have competence in the context presented in the third item, namely being able to work out probabilities. Although all students should have had experience solving problems, through the "thinking, working mathematically and reasoning" dimension of the syllabus, the very term "problem" suggests a challenge and with this some threat to students' perceived competence.

Given the theoretical role of each emotion in the motivational process and the expectation that enjoyment would exceed interest when perceived competence was high, the nature of these items suggest that reported enjoyment levels should exceed interest levels for the item pairs I2/E38 and I11/E34. However, given the threat to competence posed by the term "problem", reported levels of enjoyment should be lower than reported levels of interest for item pair IE/E35.

Analysis

In order to assess differences between levels of interest and enjoyment, the analysis commenced with the calculation of mean Likert responses for each of the items. In order to assess whether student responses to the six items loaded onto two factors an exploratory factor analysis was undertaken. In addition to this, a confirmatory factor analysis was also applied to the six items using AMOS (Arbuckle, 2008). More specifically, a structural model was established with items I2, I3, and I11 loading onto a latent interest variable, and items E34, E35 and E38 loading onto a latent enjoyment variable. Both latent variables were assumed to be correlated.

Results

Response distributions for each of the six items are shown in Figure 1, which lists plots of the interest items in the left-hand column and enjoyment items in the right-hand column. As is seen from the plots, the mode level of enjoyment was higher than the mode level of interest for item pair I2/E38, but it was lower than the mode level of interest for item pair I3/E35. Modes for the third item pair appear to be similar. In addition to this, means were also calculated for each item. These means are reported in Table 2, which reports the self-description, the mean level of interest in the self-description, and the mean level of enjoyment. As is seen from the table, all means were considerably less than the median Likert value of 3. The closest that these means came to reaching this value was for students' enjoyment in 'using surveys to find out about others', which was 2.92.

Table 2
Mean of Students' Likert Response to Interest and Enjoyment Items

Self-description	Mean interest	Mean enjoyment
Using surveys to find out about others (I2/E38)	2.24	2.92
Working on problems involving data & statistics (I3/E35)	2.40	2.26
Working out the probabilities for dice, coins & spinners (I11/E34)	2.32	2.48

Given the obvious non-normality of response distributions, differences between means were assessed with the Mann-Whitney test using SPSS (SPSS Inc, 2009). Only the enjoyment/interest means for the first item pair (I2/E38) were significantly different at the 5% level of significance ($Z = -5.4, p = 0.00$).

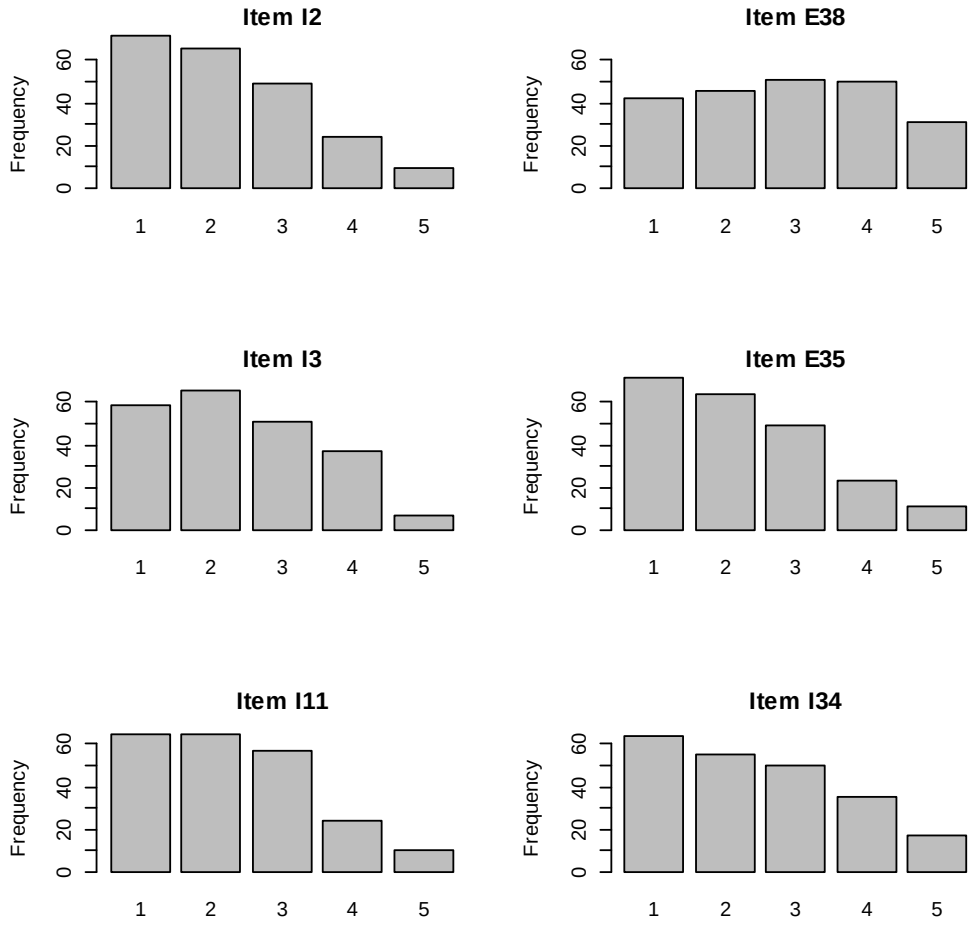

Figure 1. Response distributions for each of the three item pairs

An exploratory factor analysis was then applied to the six items. The scree plot and subsequent parallel analysis implied a two factor solution. Principal axes factoring followed by an Oblimin rotation produced the factor loadings shown in Table 3.

Table 3
Factor Loadings for Enjoyment and Interest Items (pattern matrix)

Item	Factor 1	Factor 2
I2		.840
E38		.787
I3	.749	
E35	.771	
I11	.815	
E34	.704	

Values less than 0.34 are suppressed because there is insufficient statistical power to differentiate them from zero. As shown in the table, the enjoyment items load onto the same factor as their corresponding interest items, indicating that students' ratings of enjoyment and interest for these tasks appear to be indistinguishable. A confirmatory factor analysis was also undertaken as described earlier. Model fit statistics $(RMSEA = 0.173, CFI = 0.843)$ were outside of acceptable limits (Byrne, 2001), providing insufficient evidence to support the separation of the items into two factors.

Discussion

The reported differences between mean levels of enjoyment and mean levels of interest support the earlier hypothesis that levels of both emotions will differ when perceived task competence is high or low. Of the six items discussed above, using surveys to find out about others, reported the highest mean enjoyment rating, but reported the lowest mean interest rating. This significant discrepancy suggests that irrespective of the value that children placed on this task they viewed it as easy. Moreover, that perceived competence in using surveys positively influenced their levels of anticipated enjoyment.

Differences between the remaining two item pairs, although not statistically significant, were in the anticipated direction. Reported levels of interest in working on problems involving data and statistics (I3/E35) were higher than levels of enjoyment. This is likely a result of the inherent complexity associated with the term "problem". Such complexity induces interest (Berlyne, 1960) but at the same time challenges competency and thus task enjoyment. Similarly, reported levels of enjoyment in working out the probabilities for dice, coins and spinners (I11/E34) were higher than levels of interest. This result is likely a consequence of these children's competence in the task described in the item.

The small magnitude for the reported differences in item pairs I3/E35 and I11/E34 may reflect a lack of detail in the associated task descriptions. Working out probabilities associated with dice, for example, can include tasks with a considerable range of difficulties. Such lack of detail and the small number of items using in the study is a limitation and points to the need for further study using more and clearer items.

The results of the factor analyses did not lend support for the view that the emotions of interest and enjoyment are distinct, but rather that items load onto factors according to the contexts associated with the tasks. As shown in Table 3, the item pair I2/E38 loaded onto the same factor. It is argued that children may use surveys, for example online polls, outside of the classroom and that this factor may be influenced by this non-school context rather than the activity of using surveys. Similarly, the other item pairs appear to load onto a factor with a context that is more associated with the mathematics classroom, in that working on problems and working out probabilities are activities that are likely to occur in the classroom. The inability of the factor analysis to detect two distinct emotions may therefore be a result of the influence of these contexts. In a study of physic students, Haussler (1987) reported that the context associated with given learning tasks explained up to 60% of the variance in students' interest. Such an influence in the statistical literacy domain may invariably muddy the waters, making it difficult to differentiate empirically between two closely related emotions.

The low responses for all six items might also have influenced the results of the factor analyses in that they created a "floor" effect. Only the mean level of enjoyment in using surveys came close to the median Likert response of 3, the remaining means were considerably less. Had the items been able to elicit stronger levels of endorsement, response distributions may have been more symmetrical than those displayed in Figure 1, and factor

results may have differed. The inability of the items to elicit stronger levels of endorsement is another limitation of the study.

The large difference between the mean interest and enjoyment ratings for using surveys to find out about others is noteworthy. Children enjoyed this task but did not find it nearly as interesting. This is surprising, given the relatively large proportion of girls in the sample and evidence that girls tend to find interest in social applications (Jenkins & Pell, 2006). The result suggests that surveys have been used as a means of motivating these students in statistics lessons, but the topics covered in these surveys have lacked value. Statistics lessons can be fun if surveys are used, but they can be fun and interesting if the survey is used to answer a question that is of some value. A nice example of an activity involving data collection, though not specifically one using a survey, has been developed by Watson (2008). It stimulates children's interest through a media claim that is both uncertain and challenging.

Conclusion

It is important that children experience positive emotions when they engage in tasks associated with the development of statistical literacy, because this experience provides the motivation for further engagement. In this paper, theoretical perspectives have suggested that teachers and researchers need to consider specific positive emotions, such as interest and enjoyment. Despite the small sample of items used in the study, results support the view that feelings of enjoyment emerge when students gain competence in tasks. Yet attempts to differentiate between the two emotions were inconclusive, possibly because the contexts associated with statistical literacy tasks induce more emotion than the task itself, minimising the influence of students' perceptions of task competency and task value.

Whereas children need to experience the enjoyment that comes from successfully completing tasks, they also need to value the task. Teachers need to plan for the interest that children might find in tasks. A good starting point is a consideration of the novelty, complexity and/or uncertainty that students can anticipate from the task. As suggested by the first quote in the paper, children need to experience both enjoyment and interest.

References

Arbuckle, J. (2008). *Amos (17.0.0*). Crawfordville, FL: Amos Development Corporation.

Berlyne, D. E. (1960). *Conflict, arousal, and curiosity*. New York: McGraw-Hill.

Byrne, B. M. (2001). *Structural Equation Modelling with AMOS*. Mahwah, NJ: Lawrence Erlbaum Associates.

Carmichael, C. S., Callingham, R., Hay, I., & Watson, J. M. (2010). Measuring middle school students' interest in statistical literacy. *Mathematics Education Research Journal*, *22*(3), 9-39.

Csikszentmihalyi, M. (2002). *Flow: The classic work on how to achieve happiness*. London: Rider.

Deci, E. L. (1992). The relation of interest to the motivation of behavior: a self-determination theory perspective. In K. A. Renninger, S. Hidi & A. Krapp (Eds.), *The role of interest in learning and development* (pp. 43-70). New Jersey: Lawrence Erlbaum Associates.

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology*, *53*, 109-132.

Gal, I. (2002). Adult's statistical literacy: Meanings, components, responsibilities. *International Statistical Review*, *70*(1), 1-51.

Haussler, P. (1987). Measuring students' interest in physics-design and results of a cross-sectional study in the Federal Republic of Germany. *International Journal of Science Education*, *9*(1), 79-92.

Hulleman, C. S., Durik, A. M., Schweigert, S. A., & Harackiewicz, J. M. (2008). Task values, achievement goals, and interest: An integrative analysis. *Journal of Educational Psychology*, *100*(2), 398-416.

Izard, C. E. (1977). *Human Emotions*. New York: Plenum Press.

Jenkins, E. W., & Pell, R. G. (2006). *The Relevance of Science Education Project (ROSE) in England: A summary of findings*: Centre of Studies in Science and Mathematics Education, University of Leeds

Larson, R. W., Moneta, G., Richards, M. H., & Wilson, S. (2002). Continuity, stability, and change in daily emotional experience across adolescence. *Child Development, 73(*4), 1151-1165.

Marcoulides, G. A., Gottfried, A. E., Gottfried, A. W., & Oliver, P. H. (2008). A latent transition analysis of academic intrinsic motivation from childhood through adolescence. *Educational Research and Evaluation, 14*(5), 411-427.

Pekrun, R. (2006). The Control-Value Theory of Achievement Emotions: Assumptions, Corollaries, and Implications for Educational Research and Practice. *Educational Psychology Review*, *18*(4), 315-341.

Queensland Studies Authority. (2004). *Mathematics Years 1 to 10 Syllabus*. Retrieved from http://www.qsa.qld.edu.au/syllabus/770.html.

Reeve, J. (1989). The interest-enjoyment distinction in intrinsic motivation. *Motivation and Emotion*, *13*(2), 83-103.

Schiefele, U. (1991). Interest, learning, and motivation. *Educational Psychologist, 26*(3 & 4), 299-323.

Soanes, C., & Stevenson, A. (Eds.). (2008) *The concise Oxford English dictionary*. Oxford: Oxford University Press.

SPSS Inc. (2009). *Statistical Package for the Social Sciences (SPSS): Windows (Version 18.0.0)* [Computer Software]. Chicago: SPSS Inc.

Turner, S. A., & Silvia, P. J. (2006). Must interesting things be pleasant? A test of competing appraisal structures. *Emotion*, *6*(4), 670-674.

Watson, J. M. (2006). *Statistical literacy at school: Growth and goals*. Mahwah, New Jersey: Lawrence Erlbaum Associates.

Watson, J. M. (2008). Eye colour and reaction time: An opportunity for critical statistical reasoning. *Australian Mathematics Teacher, 64*(3), 30-40.

Watt, H. M. G. (2004). Development of adolescents' self-perceptions, values, and task perceptions according to gender and domain in 7th through 11th grade Australian students. *Child Development, 75*(5), 1556-1574.