Student Interest Generated During an Inquiry Skills Lesson

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Abstract: "Situational interest" is a short-term form of motivation which occurs when a specific situation stimulates the focused attention of students (e.g., a spectacular science demonstration could arouse transient interest amongst nearly all the students in a class, even those who are not normally interested in science). However, there have been very few studies of situational interest and its potential to motivate students in science classrooms. The purpose of this project was to investigate situational interest and its sources. Small groups of grade 9 students participated in a science lesson which focused on inquiry skills, and data were obtained on their interest levels and sources of interest. The results indicated that interest arousal was substantial but did fluctuate throughout the lesson, according to the types of activities in which students were involved. The main source of interest was novelty, although choice, physical activity, and social involvement were also implicated. © 2008 Wiley Periodicals, Inc. J Res Sci Teach 46: 147–165, 2009

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Motivation can be defined as any process that initiates and maintains learning behavior. It is important because students cannot learn unless they are motivated. In constructivist theory, for example, learning is viewed as an active process which requires effort on the part of the learner (Driver, 1989). It follows that students need to be motivated to make that effort. In fact, according to constructivist theory, if students are not motivated then no meaningful learning can occur. Motivation would be required initially to make students want to participate in learning, and would then be needed throughout the whole process until learning is complete. Motivation is therefore an essential pre-requisite and co-requisite for learning.

Unfortunately though, many science students are lacking in motivation. This is particularly a problem amongst adolescents, many of whom view science as a difficult and boring subject which fails to motivate them (Rennie, Goodrum, & Hackling, 2001). This implies that in many cases motivation in school science classes can be at less than optimum levels, and in turn, this can be expected to reduce the amount of meaningful learning which occurs. Consequently, one of the major challenges for science education is to address the problem of student motivation.

It is generally accepted that the classroom teacher can play a pivotal role in influencing student motivation, and a number of studies in science education have found this to be the case (Häussler & Hoffmann, 2002; Shymansky, Yore, & Anderson, 2004). It is therefore very important that research is carried out to identify classroom strategies that teachers can use to optimize student motivation, and this is the main purpose of the present study.

The term "interest" can be used to refer to either a selective preference for a particular domain of study or focused attention upon a particular situation (Hidi, 2001). Interest is generally considered to be an effective motivator—Pintrich and Schunk (1996) concluded that interest is related to increased memory, greater comprehension, deeper cognitive engagement and thinking. Two distinct types of interest have been recognized (Hidi, 1990): "personal interest" is a long-term preference for a particular topic or domain

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(a student might have a long-term interest in biology, for example) whereas "situational interest" is short-term interest that is generated by aspects of a specific situation (for example, a spectacular science demonstration could arouse transient interest even in students who are not normally interested in science). Personal interest is a relatively enduring phenomenon, but its disadvantage is that it is very difficult for teachers to take all students' personal interests into consideration when planning lessons (Hidi & Anderson, 1992). Consequently, some researchers have turned to situational interest because it concentrates on classroom events and their immediate impact on *all* students.

Although situational interest is a transient occurrence, it does have the potential to be extremely important, because research suggests that multiple experiences of situational interest can develop into long-term interest. Mitchell and Gilson (1997) for example, investigated mathematics classrooms from fifth grade through to graduate school, and found that environments high in situational interest were associated with increases in personal interest in mathematics. Consequently, it has been proposed that a focus on situational interest can be a potentially powerful way to help students who have little or no pre-existing interest in a subject (Ainley, Hidi, & Berndorff, 2002; Hidi & Harackiewicz, 2000). In addition, Palmer (2004) found that multiple experiences of situational interest in a college level science teaching methods class had positive effects on other dimensions such as self-concept in science, science anxiety, perception of the science teacher, enjoyment of science and motivation in science. These findings suggest that repeated experiences of situational interest can have powerful and wide-ranging effects on students.

Most of the previous studies of situational interest have concerned text-based interest, or features of written text that arouse interest in the majority of readers. A number of sources of situational interest have been identified. These include novelty (i.e., a new or unusual experience), surprise (i.e., unexpected or discrepant stimuli), autonomy (i.e., giving students meaningful choices), suspense, social involvement, ease of comprehension of text and background knowledge (see Anderman, Noar, Zimmerman, & Donohew, 2004; Deci, 1992; Hidi, 2001; Hidi & Anderson, 1992). By comparison though, Mitchell (1993) investigated situational interest in high school mathematics classes. His findings suggested two main sources of interest: (1) "meaningfulness" occurs when students perceive activities as being as being relevant to their present lives; and (2) "involvement" refers to the degree to which students are active participants in the learning process. On the other hand, Chen and Darst (2001) studied middle school students in physical education classes, and found that cognitive demand was the critical factor in generating situational interest in physical learning tasks. Thus, in these non-science studies there is as yet no consensus regarding the factors which generate situational interest.

Unfortunately, there have been very few studies of situational interest in science classes. Zahorik (1996) asked science teachers to write essays on how they created situational interest, so this study was focused on the teachers' perceptions rather than the students', and it was found that most teachers believed that hands-on activities were the primary source. Laukenmann et al. (2003) collected data on cognitive, emotional and cognitive-emotional variables, including situational interest, in eighth grade physics classrooms in Germany. They found there was a significant link between situational interest and test results. However, the primary focus of this study was on the effects of emotional variables on learning, so the actual sources of situational interest were not identified. The study by Palmer (2004) identified the sources of situational interest in a science methods course for elementary teacher education students. These students reported that interest had been aroused by factors such as learning how to teach science, learning science concepts, hands-on activities, novelty, surprise, group work, and personal anecdotes. However, this study focused only on college level students, so it did not provide any information about whether these sources would also apply in school science classes. There is a lack of further studies of situational interest in school science classrooms, so we still have very little idea about the factors which might generate situational interest, or the amount of situational interest that would be produced, in school science lessons.

Further evidence for situational interest and its sources as forms of motivation has been provided by studies in neurobiology. Dopamine is a neurotransmitter produced in numerous parts of the brain, and there is a very close correlation between dopamine activity and motivational states (Niv, 2007). In particular, dopamine regulates selective attention (which is analogous to situational interest) and it appears to do this by filtering spurious activity and suppressing background noise (Alcaro, Huber, & Panksepp, 2007; Hitchcott, Quinn, & Taylor, 2007). Novelty and surprise have been shown to enhance dopamine activity (Alcaro et al., 2007; Lee, Youn, O, Gallagher, & Holland, 2006; Moncada & Viola, 2007) and researchers have also found links between dopamine activity and social interaction (Rodriguiz, Chu, Caron, & Wetsel, 2004) and choice-making (Roesch, Calu, & Schoenbaum, 2007) which are sources of situational interest. Thus the biological evidence to date is generally supportive of the construct.

This study aimed to investigate situational interest and its sources in a science lesson. The research questions were:

1. How much situational interest is generated during different parts of a science lesson?
2. What are the sources of situational interest?

One issue was the question of which type of science lesson would be chosen. It was decided to focus on a hands-on inquiry skills lesson, as recent curriculum documents have promoted inquiry as a favored technique for teaching science (Abd-El-Khalick et al., 2004). Hands-on inquiry can be problematic though. Very little inquiry is occurring in school science classrooms (Abd-El-Khalick et al., 2004) so many students are lacking in inquiry skills such as asking questions (Hofstein, Navon, Kipnis, & Mamlok-Naaman, 2005), designing experiments (Sandoval & Reiser, 2004), collecting data, and drawing conclusions (Kanari & Millar, 2004). As a result, inquiry tasks can bewilder many students (Haigh, France, & Forret, 2005) and many teachers feel that low achieving students in particular can struggle in inquiry lessons (von Secker & Lissitz, 1999). These findings suggest that students who are unfamiliar with hands-on inquiry may operate at relatively low skills levels, so this would need to be considered in the present study.

Method

Participants

The participants were 224 grade nine students (14- to 15-year-olds) who came from five schools in a city in south-eastern Australia. The sample was stratified in the following way. At each school in this study, the science classes had been streamed according to the achievement level of the students, so the same number of student volunteers was taken from every grade 9 science class in each school. The study aimed to include eight students (four boys and four girls) from each class, so the proportions of males and females were similar (52% and 48% respectively). The schools were located in different parts of the city and each drew students from a range of socioeconomic backgrounds.

These high schools were typical of many throughout Australia in that they catered for students from grade 7 to grade 12. In each case, science was taught by specialist science teachers, and the subject was compulsory for all students in grades 7–10. The science syllabus covered aspects of physics, chemistry, biology, astronomy and geology, and was spiralled so students were able to revisit topics and build on their understandings. Most science classes in Australia are dominated by traditional methods of teaching, utilizing teacher talk, blackboard, and textbook (Hackling, Goodrum, & Rennie, 2001).

The Lesson

Each group of about eight students participated in a single, 40-minute inquiry skills lesson. There were 28 such occasions, and each was taught by the same person (the author) in order to standardize the methodology. Due to the 40-minute time restriction and the students' expected lack of experience in inquiry, it was decided to adopt a relatively short and simple format in which students would perform a small number of skills such as proposing investigable questions, working together to carry out an experiment of their own design, observing results and verbally reporting results. The lesson was designed to facilitate these skills by using a structured sequence which consisted of four main phases: Demonstration, Proposal, Experiment and Report, as follows.

Demonstration. As the first step in the sequence, the teacher demonstrated a hands-on activity and asked students for observations and explanations. For example, on the topic of air resistance, the teacher showed a toy parachute made from a medium-sized freezer bag (which has very thin plastic) as a canopy, cotton strings and a paperclip weight. The teacher demonstrated how the parachute worked, and asked the students for observations about such things as the rate of fall, the shape of the canopy, and the amount of turning and drifting. Possible explanations for each of these were proposed. This phase lasted for about 5 minutes.

Proposal. The teacher then said, ''Look at what I have here'' and displayed a range of other materials that were available for this lesson. In the air resistance lesson, the teacher displayed medium-sized freezer bags, cotton and paperclips, as well as scissors, large freezer bags, heavy plastic, plastic shopping bags, and wire ties (which are lighter than paperclips). The teacher then asked, ''What would you like to find out about toy parachutes?'' The students then had the opportunity to brainstorm a range of simple investigable questions such as, Does a large canopy work better than a medium canopy? Does a light plastic canopy work better than a heavy plastic canopy? or Does less weight work better than more weight? If students proposed investigations that could not be carried out immediately because the materials were not available, then they were praised but advised to consider one of the other options, which could be done in that lesson. The teacher then asked the students to work in pairs to decide what they would like to investigate and how they would do it (for the purposes of this study, students were not required to plan controlled experiments). This phase took up to 5 minutes to complete.

Experiment. The students were then instructed to collect the materials they needed, carry out their experiment and observe the results. It was intended that the students' experiments would be based on the activity which they had been shown in the Demonstration phase, but with slight changes according to the different materials they chose to test. This phase lasted for about 10 minutes.

Report. As different pairs of students may have investigated different things, the sequence ended with an oral report from each pair, which would allow students to share their results with each other. To this end, the teacher asked each pair of students to report what they had wanted to find out (i.e., what their investigable question was), how they did their experiment and what they observed. Possible explanations were also proposed. This phase lasted for about 5 minutes.

Although all the lessons used the same sequenced structure, the science topic for the lesson was changed during the study to reduce the possibility that student interest was generated by the topic rather than the tasks—in one school, the topic was air resistance (the toy parachutes lesson), in two other schools the topic was buoyancy, and in another two schools the topic was static electricity. It was expected that the students in this study would already have a basic understanding of these three concepts as they are typically studied in grades 7 or 8. No attempt was made to integrate the lessons into the topics currently being studied in each school—the inquiry skills lessons were intended to be stand-alone experiences and the three topics were allocated to schools in no particular order. The buoyancy and static electricity lessons were as follows.

The buoyancy lesson started with a demonstration in which corn seeds were placed in a beaker of water and then an antacid tablet was added. This caused the corn to cyclically rise to the surface then drop to the bottom again as bubbles grew on it then burst at the surface. During the Proposal phase, the teacher displayed more corn and antacid tablets as well as soda water, peanuts, rice, dried peas, sultanas, and mustard seeds. The students thus had the opportunity to compare another type of carbonated liquid, as well as varying sizes of small seeds and fruits.

In the static electricity demonstration, the teacher rubbed a sausage-shaped balloon with paper towel then placed the balloon on the wall of the room. The balloon stuck to the wall instead of falling to the floor. In the Proposal phase, the teacher displayed more sausage balloons and paper towels, as well as other balloons of different shapes (including round balloons), plastic shopping bags and hand-sized pieces of fabric. The students thus had the opportunity to compare different shapes of balloons, different rubbing materials or different surfaces around the classroom (e.g., the windows, the wooden door or the curtains).

An additional factor that was considered was the necessity of establishing a baseline level of interest, to which any changes could be compared. Consequently, the students were also asked to copy notes at the beginning and end of the lesson. The task of copying notes was chosen as it was expected this would be a routine activity that would generate little or no interest (the results confirmed that this was the case). Two short passages were prepared for the students to simply copy from one sheet of paper to another. The passages were:

1. Scientists carry out investigations in order to find out more about the world around us. During these investigations, scientists use the skills of observing and explaining.
2. A scientist's job is to investigate the world around us. Scientists must make careful observations as they carry out their investigations.

The students copied the first passage just before the Demonstration phase and the second passage just after the Report phase. In the remainder of this paper these will be referred to as the First Copying Notes and the Second Copying Notes phases.

Data Collection and Analysis

In studies of situational interest it is preferable to use only a very brief procedure for gathering data, in order to capture the short-lived fluctuations in interest levels as they occur (Alexander, Kulikowich, & Jetton, 1994). It was decided to adopt the same approach in this study, as it was also important that the data collection during the lesson should not interfere with the flow of the lesson itself. Consequently, only one item was used to measure interest level:

	very boring		in-between		very interesting
I thought this part was:	1	2	3	4	5

Students responded to this item immediately after each of the phases, First Copying Notes, Demonstration, Proposal, Experiment, Report, and Second Copying Notes, so instantaneous interest was measured on six occasions throughout the lesson.

Analysis of student interest levels was carried out using a one-way analysis of variance (ANOVA) with post hoc comparisons using the Tukey HSD test. Where significant differences were found, effect sizes were calculated by finding the difference between the group means and dividing by the mean standard deviation. When this technique is used, an effect size of 0.8 or more is large, while 0.5 is moderate and 0.2 is small (Cantrell, Young, & Moore, 2003). Two-way ANOVAs were used to analyze the effects of the background variables of gender and achievement level.

Qualitative data about sources of interest were obtained by an audiotaped group interview that was carried out at the end of each lesson. The students were asked to reflect back to each phase of the lesson, to state whether they had been interested, and if so, to describe what it was that had interested them. Categories representing sources of situational interest were then identified from the interview transcripts. To check the reliability of the categories, a representative sample of 47 responses was independently coded by the author and a colleague. Agreement was found in 87% of cases. It was also recognized that the students' previous experiences might influence their levels of interest. Accordingly, at the end of the interview, the students were asked whether they had previously participated in any hands-on inquiry in which they had been allowed to choose what to investigate and how to do it.

The Report phase of the lesson was also audiotaped, in order to provide evidence that students did engage in inquiry skills. Analysis of the transcripts from this phase involved coding to identify examples of student statements which represented inquiry skills such as observing, explaining and proposing investigable questions.

The validity of the instrument used to measure interest levels was verified by using multiple data sources—the students' interest levels recorded on the written instrument were compared with their verbally reported interest levels obtained in the group interviews. The reliability of the instrument was verified in two ways. Firstly, within-group reliability was addressed using a test-retest comparison. This was done by comparing the students' Likert scores in the First Copying Notes phase, at the beginning of the lesson, with their scores in the Second Copying Notes phase, at the end of the lesson. Although the actual passages to be copied were different, the comparison was still valid because in each case the students were copying a short passage which they had not seen before. Secondly, across-group reliability was investigated by using multi-site data gathering. The buoyancy lesson was carried out in two schools, and these were compared using a two-way ANOVA. This procedure was repeated for the two schools in which the static electricity lesson was carried out.

Results

Students' Inquiry Skills

Figure 1 shows that students had the opportunity to engage in a range of inquiry skills including proposing investigable questions, observing, explaining and reporting. In most cases however, these skills were not of a high standard. For example, while some pairs of students were able to articulate a simple investigable question or aim (e.g., example 1 in Figure 1) others were unable to and instead just described their methodology (e.g., example 4 in Figure 1). In a very few cases the students did mention the need to control variables but most did not. The students typically attempted to describe what had happened in their experiments, but their observations were usually superficial, and in many cases quite vague (e.g., examples 1 and 2). Most of the examples in Figure 1 were chosen to show the types of explanations which the students provided, but other students were unable to propose explanations. The students' reports were typically poorly

Example 1.
Girl: Well, *we wanted to find out how it would, like, float again with the wire thing. Weight. 'Cause it's lighter than the paperclip. [And how did you make yours?] We used a small bag, big string and a little white thing for the weight. [And what happened?] *It went slower than what the paperclip did* **'cause it's lighter**. [So what did that show you?] **The less weight it has the slower it glides**. (high level class, air resistance lesson)

Example 2.
Girl: *To find out what happens when you have a bigger bag and more weight. [And what did you make yours out of?] A shopping bag, two paperclips and a long string. [And what happened?] *It went down pretty much the same* **cause it had the bigger bag, but more weight** so it's just . . . [So what did that show you?] **That the bigger bag makes it go slower, and the weight drops more with the bigger bag.** [Why might that be?] **More air might get under it**. (middle level class, air resistance lesson)

Example 3.
Girl: We used plastic and a sausage and a round balloon and we rubbed plastic bag on the balloon. [So what did you want to find out?] *If both of the balloons worked the same. [What happened?] *The sausage one like rocked and the round one kind of worked. . . Yeah it didn't work as well.* [Why wouldn't the round one have worked as well as the sausage balloon? Anyone got any ideas about that?] **'Cause the sausage balloon has a larger surface for electricity to stick to the wall whereas the round balloon didn't have it.** (middle level class, static electricity lesson)

Example 4.
*Basically we just want to see the effect the soda water and the [antacid] tablet have on the peanuts. [OK, so you have two beakers. One's got soda water and one's got antacid water, and you've got peanuts in both. And what happened?] Boy: *They both floated and the water, the one with the plain water, floated more. . .* [So which one do you think is more fizzy?] Still the soda water, **'cause the oil in the peanuts seems to be having an effect**. Girl: Do they have oil in peanuts? [OK, that's interesting. So the oil in the peanuts might be helping them float?] Girl: Yeah, **'cause oil floats on water**. (middle level class, buoyancy lesson)

Example 5.
Boy: *We got a glass of antacid water and a glass of soda water and we put sultanas in it and *sultanas work better in soda water*. [What does that tell you about soda water?] **It has . . . er more bubbles in it?** (low level class, buoyancy lesson)

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* = investigable question
italicized text = observations
bold text = proposed explanations

Figure 1. Student reports of their investigations.

structured in terms of describing their aims, methods and results, and on quite a few occasions it was necessary for the teacher to paraphrase, based on what the students were showing of their experiment (e.g., example 3 in Figure 1), and to ask prompting questions. These results suggested that the students were engaged in hands-on inquiry skills, albeit at a low level of accomplishment.

One reason for the poor quality of the students' skills may have been a lack of experience in investigating. At the end of the group interview, when students were asked the question, "In science classes at school, have you ever before done an experiment where you get to choose what you want to do and how you are going to do it?" nearly all of the students replied they had not. The only exceptions were a small number of students who reported isolated single instances which they had experienced in previous years.

Amount of Situational Interest

The ANOVA on overall interest levels (Figure 2 and Table 1) indicated there were significant differences in interest levels throughout the lesson. Post-hoc comparisons (Table 1) showed that the Demonstration, Proposal, Experiment and Report all generated significantly higher interest than the Copying Notes phases, and in each case the effect size was large. Interest was highest during the Experiment phase, the Demonstration phase was next highest, but the Proposal and Report phases were significantly lower. These results indicate that student interest levels were substantially raised during the Demonstration, Proposal, Experiment and Report, but did fluctuate from phase to phase.

Strong sources of situational interest should arouse interest in the majority of students in the class, so the proportion of students who increased their interest levels was also calculated for each phase. In the Demonstration, Proposal, Experiment and Report, 90%, 72%, 95%, and 69% respectively, of the students increased their interest by at least one point on the Likert scale, compared to copying notes. This implies that each of these four steps aroused interest in the majority of students in the study.

Validity and Reliability

The validity of the measurements of student interest levels was determined by comparison with their verbal reports of interest during the group interviews. It was recognized that the students within each group would not all always agree with each other, so it was decided to use three broad categories to summarize the comments for each group: Category 1 indicated a consensus of non-interest; Category 2 indicated either mild interest or a mixture of interest and non-interest amongst the students; and Category 3 indicated a consensus of positive interest. In the following examples of each category, the interviewer's questions are in brackets:

- *Category 1* (a negative consensus)

  [I want you to think back to the very first thing that we did which was copying notes. Did anyone find that interesting?]
  No.
  No.
  It was SO boring!

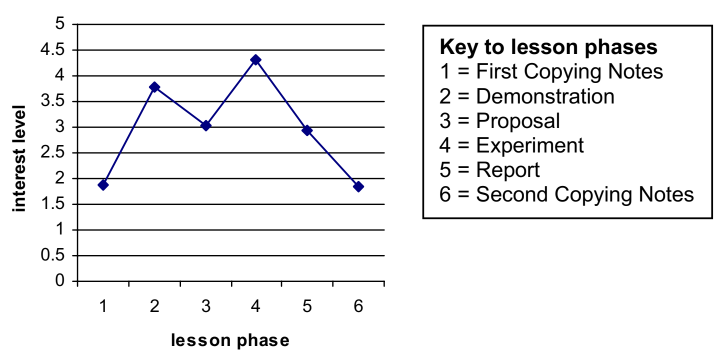

Figure 2. Interest levels throughout the lesson.

Table 1
Analysis of overall interest levels

Source	SS	df	MS	F	
A: One-way ANOVA summary table					
Between groups	1,108.13	5	221.63	315.57*	
Within groups	939.69	1,338	0.70		
Total	2,047.831343				

Groups	Groups 1	2	3	4	5	6
B: Tukey HSD tests on differences between pairs of means						
1 (Copying Notes)		1.88*	1.14*	2.44*	1.04*	0.06
2 (Demonstration)			0.67*	0.6*	0.85*	1.9*
3 (Proposal)				1.29*	0.11	1.23*
4 (Experiment)					1.4*	2.5*
5 (Report)						1.1*
6 (Copying notes)						
C: Effect sizes where differences were significant						
1 (Copying notes)		2.39[a]	1.32[a]	3.00[a]	1.18[a]	
2 (Demonstration)			0.91[a]	0.72[b]	1.01[a]	2.43[a]
3 (Proposal)				1.54[a]		1.36[a]
4 (Experiment)					1.64[a]	3.0[a]
5 (Report)						1.22[a]
6 (Copying notes)						

SS, sum of squares; MS, mean square.
$HSD_{0.05} = 0.23$. $HSD_{0.01} = 0.27$.
*$p < 0.05$.
[a]Large effect size.
[b]Medium effect size.

- *Category 2* (mixed response or mild interest)

[The next thing we did was, we went around to each group and talked about what they did and what happened (the Report). Did anyone find that interesting?]
General: Sort of.
A little bit.
Not really.

- *Category 3* (a positive consensus)

[The next thing we did then was you did it yourself. You made your parachute and tested it. Did anyone find that interesting?]
General: Oh yeaah.

Each category was allocated a score (Category 1 = 0, Category 2 = 1 and Category 3 = 2). The results indicated that the two Copying Notes phases had the lowest mean scores (1.1 and 1.1) and the Experiment phase had the highest mean score (2.9). The Demonstration (2.5), Proposal (2.4) and Report (2.3) had intermediate mean scores. This pattern of responses was similar to that obtained in the quantitative survey as both indicated that the Copying Notes phases were least interesting, and both indicated that the Experiment phase was most interesting. It can therefore be assumed that the measurements using the Likert scale had an acceptable level of validity.

Within-group reliability was addressed by comparing the First Copying Notes phase with the Second Copying Notes phase. The ANOVA and post-hoc comparisons shown in Table 1 indicated there was no significant difference between these two phases. This implies that the Likert item results were replicable within each individual lesson, implying an acceptable level of within-group reliability.

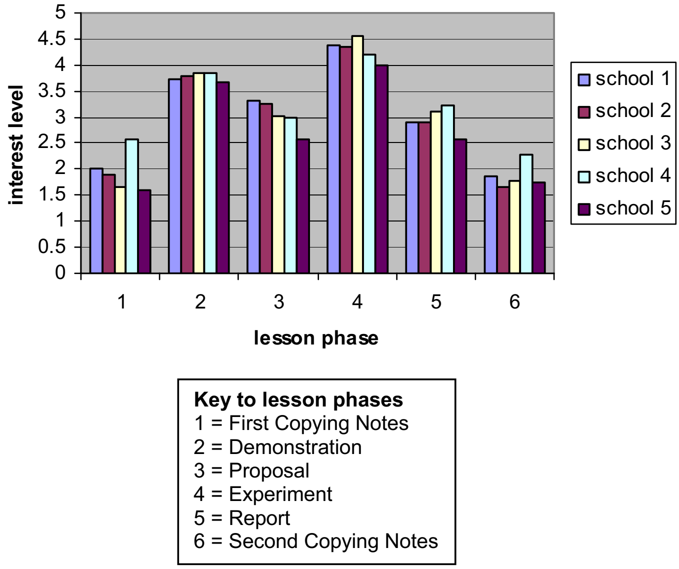

Figure 3. Interest levels at each school.

The issue of across-group reliability was addressed by comparing results for the same lesson topic done in two different schools. The results are presented in Figure 3 and Table 2. Figure 3 shows that the same general pattern of responses was replicated: in each school, the Experiment Phase had the highest interest, followed by the Demonstration Phase, then the Proposal and Report Phases, while the Copying Notes phases had lowest interest. Neither did this pattern of responses appear to be affected by lesson topics, with School 1 (air resistance), Schools 2 and 3 (static electricity) and Schools 4 and 5 (buoyancy) having very similar patterns of responses. The two-way ANOVA (Table 2) showed there was no main effect of school in the two schools which had the static electricity lesson. However, the analysis for the two schools which had the buoyancy lesson did indicate a school effect, with the results from School 5 being consistently lower. The reason for this difference was not able to be identified though, as the two schools were comparable with regard to their student characteristics and the way in which the research was carried out. In spite of this anomaly, the general pattern of responses was essentially the same as in the other schools. In summary, these results show a similar pattern of responses across all five schools, suggesting an acceptable level of across-group reliability.

Table 2
Two-way ANOVA summaries of comparisons between schools

Source	SS	df	MS	*F*
A: Schools 2 and 3 (static electricity lesson)				
School	1.69	1	1.69	2.41
Lesson phase	331.9	5	82.97	118.3^{**}
Interaction	2.935	5	0.734	1.05
Within groups	273.45	390	0.701	
Total	609.99	399		
B: Schools 4 and 5 (buoyancy lesson)				
School	24.61	1	24.61	32.76^{**}
Lesson phase	138	5	34.5	45.9^{**}
Interaction	1.538	5	0.385	0.511
Within groups	187.8	250	0.751	
Total	352	259		

SS, sum of squares; MS, mean square.
$^{**}p < 0.01$.

Table 3
Two-way ANOVA summary for effect of gender

Source	SS	df	MS	F
Gender	0.900	1	0.900	1.29
Lesson phase	1,070.12	5	214.02	308.5**
Interaction	10.146	5	2.029	2.925*
Within groups	882.39	1,272	0.693	
Total	1,963.558	1,343		

SS, sum of squares; MS, mean square.
*$p < 0.05$.
**$p < 0.01$.

Gender and Achievement Level

A two-way ANOVA was used to analyze the effect of gender. The results, presented in Table 3, showed there was no main effect of gender, but there was an interaction effect significant at the 0.05 level. A post-hoc analysis using the Tukey HSD (HSD = 0.229) indicated that in the Proposal phase, the mean for boys was higher than the mean for girls (mean difference = 0.27 > HSD); and in the Second Copying Notes phase, the mean for girls was higher than the mean for boys (mean difference = 0.28 > HSD). However, in both cases, the effect sizes were small (0.31 for the Proposal; and 0.33 for the Second Copying Notes) indicating that the difference was not substantial. Furthermore, as Table 3 shows, these interaction effects were not significant at the 0.01 level. These results suggest that gender did not have a notable effect on interest levels.

It was slightly more difficult to analyze for effect of achievement level, as different schools used different methods of streaming. Only one school streamed all the science classes from top to bottom sequentially. The other schools used various combinations of parallel streams, so it was not always possible to clearly identify a single top or bottom class. For the purposes of this analysis it was decided to only include data from the three schools in which there were either one or two top classes and one or two bottom classes. With these data, a two-way ANOVA was used to compare top classes with bottom classes. The results presented in Table 4 show that at the 0.05 level there was a significant effect for class level and a significant interaction effect. The results were graphed as shown in Figure 4, which shows that in the Demonstration, Proposal, Experiment and Report, students in the top classes had slightly higher interest than those in bottom classes. However, when post-hoc comparisons (HSD = 0.416) were carried out to identify interaction effects, it was only in the Proposal phase and Report phase that the differences were significant (Proposal phase mean difference = 0.756 > HSD; Report phase mean difference = 0.5 > HSD). The effect size was moderate (0.75) in the Proposal phase and small (0.21) in the Report phase. However, as Table 4 also shows, there was no main effect for class level, nor interaction effect, at the 0.01 level of significance. In conclusion, it is likely that there was some effect of class level, with students in top classes showing slightly more interest during most phases of the lesson, but the difference was not substantial.

Table 4
Two-way ANOVA summary for effect of achievement level (top classes versus bottom classes)

Source	SS	df	MS	F
Class level	3.803	1	3.803	5.96*
Lesson phase	287.6	5	57.52	90.2**
Interaction	9.047	5	1.809	2.84*
Within groups	221.8	348	0.637	
Total	522.33	359		

SS, sum of squares; MS, mean square.
*$p < 0.05$.
**$p < 0.01$.

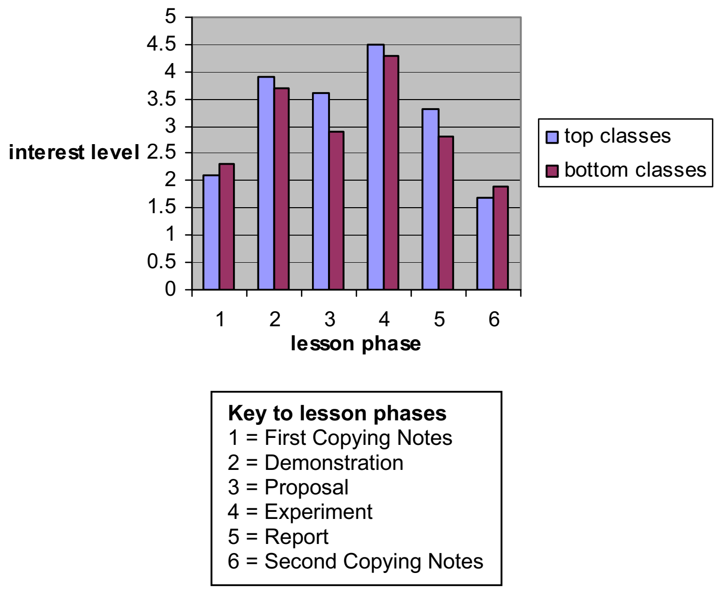

Figure 4. Effect of achievement level on interest.

Sources of Situational Interest

During the audiotaped group interview held at the end of the lesson, it was evident that the Copying Notes phases had created little or no interest, so the students were asked to explain why. Some students commented that writing notes was not interesting because it was repetitive and typical of their normal science classes:

> Boy: We do that all the time with our teacher. That's all we do. (high level class)
> [What made it boring?]
> Girl: 'Cause we do that all of the time' (low level class).

Other comments indicated that the boredom came from not learning anything:

> [Why was it boring?]
> Girl: Not really taking it in as well. You're just reading it and not learning it at the same time.
> Boy: If you asked me to remember what I wrote, I couldn't. I just remember three words at a time. Just write 'em down and go for the next three' (high level class).

However, the students' statements indicated that there were sources of interest in the other phases of the lesson. The main ones were as follows.

Learning. This was by far the most common source of interest overall. Students in 71% of groups stated it had been a source of interest in the Demonstration phase; students in 79% of groups stated it had been a source of interest in the Report phase; and students in 39% of groups stated it had been a source of interest in the Experiment phase. Responses were coded in this category if they indicated that the students had either learnt how to do the hands-on activity, or had learnt the results of the hands-on activity, or had learnt something about the concept. In some of the following examples the critical parts of the statement have been italicized; but the gender of the students is sometimes not stated if it was not recorded in the transcript:

> [Did anyone find that interesting?]
> Yeah. We learnt how it was made and how it worked properly. (boy, high level class, air resistance lesson, Demonstration phase)

[OK, why was it a bit interesting?]
I guess that you learnt something and that made it a little bit more interesting.
[So what did you learn?]
That static electricity can make balloons stick to the wall. (girl, low level class, static electricity lesson, Demonstration phase)

[Did anyone find that interesting?]
Sort of. Just *finding out* what would happen and how it would be different. (boy, high level class, buoyancy lesson, Experiment phase)

It was interesting to *see how* the different parachutes work. (girl, low level class, air resistance lesson, Experiment phase)

Everyone *found out something* different so basically it's like learning from a whole different group. 'Cause everyone does something different so you learn more than just one thing because everyone took different aspects of it, we learnt all different things about it' (girl, low level class, air resistance lesson, Report phase).

Choice. Students in 68% of groups stated that this had been a source of interest in the Proposal step. Responses were coded in this category if they indicated that choosing, picking or deciding what to do had created interest:

[What created the interest for you?]
Yeah, it was all right. Because we got to choose what we wanted to do. It was what *we* wanted to do. (girl, middle level class, buoyancy)

[Did anybody find that interesting?]
Yes, 'cause it gave us a choice of what we wanted to do instead of having to do one thing. (boy, low level class, air resistance).

Some of the students' comments suggested that there was a cognitive component to the choosing, as it offered the opportunity for them to find out things they didn't know:

I dunno, it was just fun. Just deciding what to do when we didn't know what would happen. (girl, high level class, buoyancy)

Because I was interested to see what was going to happen [with the other materials] (girl, low level class, buoyancy).

Novelty/Suspense/Surprise. These three factors were combined in one category as it was sometimes difficult to separate them. Responses were placed in this category if they indicated that interest had been aroused by something new or unusual (i.e., novelty), or not knowing what was going to happen (i.e., suspense) or something unexpected happening (i.e., surprise). These were a significant source of interest in the Demonstration phase (57% of groups) and Experiment phase (46% of groups):

I'd never seen it before so I thought that was interesting. (high level class, buoyancy, Demonstration phase)

[What made it interesting for you?]
That it stuck to the wall when you rubbed it, because I didn't think a balloon could do that. (girl, middle level class, static electricity, Demonstration phase)

[Why was that interesting?]
'Cause you didn't know what was gonna happen. (boy, low level class, buoyancy, Demonstration phase).

Some of the students' comments regarding the Experiment phase suggested that there was novelty or variety in doing an unusual type of activity:

[Why did that interest you?]
Boy: It's not what we usually do.

> Girl: It's a bit of a change. It's something new for us to do (high level class, static electricity, Experiment phase).

Physical Activity. Responses were allocated to this category if they indicated that interest had been aroused by being active, or by making something, or by doing it themselves. This was the most common source of interest in the Experiment phase—reported in 54% of groups:

> Just doing it hands-on. Being able to do it yourself (high level class, buoyancy, Experiment phase).
>
> Yep, 'cause it was hands-on. We did it instead of just watching it.' (girl, middle level class, buoyancy, Experiment phase)
>
> [What made it interesting for you?]
> We got to have the experience of doing it (girl, low level class, static electricity, Experiment phase).

Some of the students' comments indicated that physical activity combined with choice (italicized sections) had created a feeling of autonomy:

> Because we were the ones that were doing the investigating. We got to investigate *what we wanted to* with the balloons and it was interesting to see what would happen (girl, high level class, static electricity).

Social Involvement. Responses were allocated to this category if they ascribed interest to talking or working with other people. This was a minor source of interest in the Proposal step (14% of groups) and the Experiment step (14%):

> 'Cause it was like interesting—cause you get to talk to your friends and stuff. Communicate. (middle level class, air resistance, Proposal phase).

Discussion

The purposes of this study were to investigate the amount of situational interest and its sources in an inquiry skills lesson. The results indicated that the students were engaged in inquiry skills such as proposing investigable questions, making observations and explanations, and reporting. These skills were not of a high standard though—some students had difficulty articulating investigable questions, their observations tended to be superficial, it was sometimes difficult to get them to propose explanations, in most cases their experiments were not fair tests, and their reports were often lacking in clarity—all of which suggested a lack of experience in this type of inquiry lesson. This lack of experience was confirmed when the students were asked about their previous studies, and it was apparent that the majority had never had the opportunity to propose investigable questions or to design and carry out experiments based on those questions.

In spite of the students' lack of skills, the study showed that science inquiry tasks did generate situational interest. Interest levels varied substantially throughout the lesson—there was low interest in the Copying Notes phases, but the Demonstration, Proposal, Experiment and Report, each generated interest in the majority of students. Regardless of the lesson topic, there was a consistent pattern of high interest in the Demonstration, moderate interest in the Proposal, very high interest during the Experiment and then moderate interest during the Report. Each of the steps in this sequence lasted only a few minutes, so the results suggested that interest levels can fluctuate widely over relatively short time periods throughout a lesson, according to the types of tasks in which the students are involved. This reinforces the view that situational interest is a transient occurrence (Hidi, 1990).

Several sources of situational interest were identified. Of these, the one most commonly referred to by the students was *learning*, which was the main source of interest in the Demonstration phase and the Report phase, and the second most common source in the Experiment phase. This finding, that learning creates interest, was unexpected as it is in apparent conflict with other research (Laukenmann et al., 2003) which has indicated that situational interest results in better learning, rather than the other way around. This raises the question of why students in the present study stated that learning was a source of interest. One possible solution to this problem could be that the students did learn something, but the accompanying arousal of interest was actually due to another, related factor—novelty. Novelty has been identified as a source of situational interest in studies of reading (e.g., Hidi, 2001) and it is closely related to learning because when one learns something, one is learning something *new*. Novelty is therefore always present in the learning process. The following interview excerpt is an example of this idea:

> [Why was that interesting to you?]
> It's just like learning new things (girl, low level class, static electricity).

It is therefore possible that, although the students stated that learning had created interest, the actual source of interest was the novelty associated with learning something new.

Choice was another source of interest. It was only identified in the Proposal phase because this was the only part of the lesson in which students had the opportunity to decide for themselves what they wanted to investigate and how they would do it. Deci (1992) argued that humans have an inherent psychological need for autonomy and self-determination, which explains why people are more interested and intrinsically motivated when they engage in activities through choice rather than coercion. The results of the present study suggested however, that choice was probably not a powerful source of situational interest, as the levels of interest in the Proposal phase were substantially lower than in the Demonstration and Experiment. It should also be emphasized that choice is not a simple construct—Flowerday, Schraw, and Stevens (2004) argued that the choices which students make in learning situations are almost always influenced by other factors such as their previous knowledge or their individual interests. In fact, these authors provided evidence that blind choice, in which students choose between two hidden options without knowing what they actually are, had little measurable impact on student engagement in reading tasks. In the present study, students were offered meaningful choices because they could see the materials they were choosing, so it is possible that their decisions may have been influenced by their prior knowledge of those materials. As evidence for this, some of the excerpts presented in the results suggested there was a cognitive component involved as the students made their choices—they wanted to find out things they did not know—which could be interpreted as a search for novel information. Thus, the actual source of interest was probably not choice alone, but choice in combination with other factors such as their level of background knowledge and the opportunity to experience novelty.

Physical activity was identified as the main source of interest in the Experiment phase. Previous studies of mathematics students and physical education students have suggested that hands-on activities or physical tasks are only able to arouse interest if they are accompanied by a cognitive component (Chen & Darst, 2001; Mitchell, 1993). However, in the present study, responses were coded as physical activity if the students stated that simply doing the activity had created interest, without mentioning a cognitive component. It is possible though, that these students had been cognitively engaged while doing their hands-on activities but they just had not said so. This is quite a strong possibility because the experiment was not a mindless drill or practice exercise. Instead, the students had created their own experiments and observed the results, so it could be argued that there was significant cognition associated with the hands-on activity. In addition, learning was identified as the second most common source of interest in the Experiment phase, implying that these students were cognitively engaged while also being physically active. It is therefore likely that physical activity combined with a cognitive component was the source of the interest in this case.

A second issue however, is the question of why physical activity enhances interest. This is a significant issue because although previous research in science education has reported the motivational effectiveness of hands-on activities (e.g., Zahorik, 1996) the matter of *why* they are so appealing to students is still an open question. One possibility is that physical activity might have allowed a number of other sources of interest to come into play. For example, when students were physically active in their experiments, they also had an increased opportunity for: (1) social involvement, through communication and collaboration as they moved around and worked together; (2) concrete learning, and its resulting novelty component, by manipulating materials and direct experience of the results; (3) autonomy, though controlling the physical actions they performed; and (4) variety, as the task was a change from the other phases of the lesson which were more physically static. Each of these factors—social involvement, learning, autonomy, novelty and variety—was present in the Experiment phase, according to the excerpts presented in the results, so it is possible that the significance of physical activity was that it facilitated these allied factors.

Novelty was identified as a source of interest in the Demonstration and the Experiment, and it was probably the most important source of situational interest in this study. Two pieces of evidence suggested this: (1) learning was identified by the students as the most common source of interest but, as argued above, its effects were probably due to novelty; and (2) learning and novelty were both present in the two lesson phases (the Demonstration and Experiment) in which the highest levels of interest were recorded. Studies of reading have also identified novelty as an important source of interest (e.g., Hidi, 2001). Anderman et al. (2004) argued that humans have an innate need for novelty, and they referred to a number of previous studies of brain neuro-chemistry which established a biological basis for this need. This suggests that when novelty occurs, it may create interest by fulfilling this basic need.

For the purposes of this study, novelty (i.e., the new or unusual) was categorized together with *suspense* (i.e., not knowing what was going to happen) and *surprise* (i.e., unexpected or discrepant information) as it was sometimes difficult to separate them. Is it legitimate though, to group the three factors together in this way? Chen and Darst (2001) argued that novelty includes new information arising from the gap between the known and the unknown, and this would suggest that suspense, as it focuses on the unknown, could be regarded as one aspect of novelty. Surprise is also related to novelty, as Deci (1992) argued that novelty and discrepancy share a commonality in that they both refer to ideas that are not fully mastered. Thus, at least for the purposes of this paper, factors such as suspense and surprise can be legitimately considered to indicate novelty because they are associated with new information.

A further issue is whether *variety* (i.e., a change in activity) can be considered an aspect of novelty. Variety and novelty were not differentiated in the results because of the problem of reliably coding them, but there was evidence that variety did occur during the Experiment phase, as some of the student comments implied that there was interest generated because this task was different to the other phases of the lesson, which were more physically static. Indirect evidence for variety as a source of interest was also provided by the students' comments regarding the Copying Notes phases—one reason why copying notes was not interesting to them was because they often did it in science lessons. The implication is that tasks that are usual or repetitive are associated with low interest, whereas tasks that are unusual would presumably be associated with higher interest. Novelty is often defined as something new or unusual, so it could be argued that variety, which involves classroom activities that are different or unusual, is also a type of novelty.

Variety is however, different to the other types of novelty because it can refer to a simple change in activity, and does not necessarily involve any new information. Consequently, its effects on situational interest can be quite different to those of the more cognitive forms of novelty. In the present study, for example, variety would presumably have operated at the *beginning* of the Experiment phase, because this is when the change in activity occurred. On the other hand, the other types of novelty would have occurred *later* in the Experiment phase, because the students would only have learnt something new when they were able to observe results of their experiments. Thus, variety can generate initial interest when a task is first introduced, whereas the other types of novelty can generate interest at a later time when new information is recognized (or anticipated, in the case of suspense). In this way, novelty can be seen to be a multifaceted construct which can generate interest in different ways at different times.

Social involvement was a minor source of interest in the Proposal phase and the Experiment phase. Deci (1992) argued that humans have a basic need or drive for social contact, and that this explained why interpersonal involvement can arouse interest. However, Isaac, Sansone, and Smith (1999) emphasized that some individuals were high in interpersonal orientation whereas others were low. They found that those college students who were high in interpersonal orientation (about 45% of their group) were more interested in activities when working with a partner, whereas those with low interpersonal orientation provided a more mixed set of results. In the present study though, relatively few of the students (14% of groups) mentioned social contact as a source of interest, which suggests that it may have been less important than indicated by Isaac et al. (1999). However, the two studies differed not only in the types of students but also the measuring procedures, so the reasons for this difference are not clear.

In summary, it has been argued above that the situational interest experienced by students in this study was basically derived from three separate sources—novelty, autonomy (choice) and social involvement. Psychologists have proposed that humans have an inherent need for each of these factors (Anderman et al., 2004; Deci, 1992) which probably explains their propensity for generating interest. Studies in neurobiology have supported the idea of an inherent need for novelty, for example, as in rats there are believed to be common brain processes involved in novelty-seeking and food-seeking (Dellu, Piazza, Mayo, Le Moal, & Simon, 1999). Novelty was a more powerful source of situational interest than either autonomy or social involvement, and was argued to be a multifaceted construct encompassing task variety, exposure to new information, surprise and suspense.

However, there is a conundrum associated with this perspective. That is, most students regularly learn new information in science lessons, so their interest should be aroused through novelty, yet the evidence is that most secondary students are bored by science lessons. A possible explanation for this is as follows. As novelty is a multifaceted construct it is possible that some facets are working in a positive way to enhance interest, but at the same time other facets are operating in a negative way. For example, student comments in this study indicated that boredom was primarily due to repetition or lack of variety, as their normal science lessons involved tedious writing of notes. It is possible that on the occasions when students did learn something, the resulting interest was more than counterbalanced by the negative interest imposed by lack of variety.

Implications for Teaching and Learning

Situational interest is a form of motivation. However, motivation by itself only means that students are willing to engage in learning—it does not ensure that they will develop scientifically acceptable knowledge structures (Pintrich, Marx, & Boyle, 1993). For example, a student might be very highly motivated to learn in a lesson, but if the teacher does not use appropriate teaching techniques by guiding and scaffolding the direction of learning, then very little science will be learnt. For optimal learning to occur, motivational strategies need to be used in tandem with instructional strategies which focus on the development of scientific understandings.

A number of constructivist-informed models of science teaching have been developed, but these have mainly emphasized strategies for developing scientific understandings rather than strategies for motivation (Palmer, 2005). In these models, teachers are typically required to elicit students' pre-existing conceptions, present students with experiences which will challenge those conceptions, reveal the scientific perspective, and allow students to apply their new understandings and to reflect upon their change in ideas. However, the motivational processes which are required to consistently engage students in these activities are still an open question. In fact, there is evidence that large proportions of students can remain unmotivated by this approach (Banet & Núñez, 1997; Lee & Brophy, 1996). This suggests there is a need for a motivational model to be used in conjunction with constructivist-informed teaching models.

The construct of situational interest has the potential to provide such a model, for two reasons. Firstly, it focuses on classroom events and their immediate impact on students, so it is directly informative for instruction. Secondly, and more importantly, it is an extremely powerful motivator, and evidence that this is the case can be inferred in the following way. Previous studies have demonstrated that many adolescent students have negative attitudes towards science—they view it as a difficult and boring subject which fails to motivate them (e.g., Rennie et al., 2001) and this can be more marked amongst girls than boys (Miller, Blessing, & Schwartz, 2006). In addition, low achieving students have often been associated with lower levels of academic motivation and a devaluing of academic achievement (Zusho, Pintrich, & Coppola, 2003). Based on this information it could be assumed that many of the students in the present study would have had negative motivational orientations to science. Yet the evidence was that at least 90% of the students experienced interest arousal during the Demonstration and Experiment phases. This applied equally to both boys and girls, as there were no notable gender differences identified in this study. In addition, students in bottom classes had their interest raised to levels very close to those of the top class students. These data suggest that situational interest is able to temporarily over-ride any negative motivational orientations that students may have. Thus, despite its short-term nature, situational interest has the potential to arouse the interest of nearly all the students in a group, regardless of their pre-existing interests and motivational beliefs. This suggests it is a powerful phenomenon.

Consequently, situational interest could potentially be used to provide the basis for a motivational model for instruction. This would complement the existing constructivist-informed models by focusing on interest as a source of motivation for the various learning activities which teachers need to present to their students. Situational interest is a transient occurrence, which suggests that, in order for a teacher to maximize student motivation, it would be necessary to provide several sources of interest throughout the lesson. Thus, the motivational model and the constructivist-informed models would be mutually supportive and would provide an innovative and potentially powerful approach to instruction. At this stage however, there have been relatively few studies of situational interest in science, but there would appear to be value in beginning to build a critical mass of information.

One avenue for further research is the effect of students' previous experience upon their situational interest. For example, this study involved students who were inexperienced in investigating, so it is possible that their responses may have been different to those of more experienced students. Consequently, it would be useful to study the sources of interest in an inquiry skills lesson taught to students experienced in investigating, for comparison. Also, this study focused on one type of lesson, which addressed inquiry skills. However, many other types of teaching techniques can be used in science, so it is likely that other sources of interest could apply in other types of lessons. For example, meaningfulness, or relating to real life (Mitchell, 1993) was one source of interest not identified in this study, almost certainly because relating concepts to real life was not included as a planned component of these lessons. Thus, in order to fully understand the sources and effects of situational interest it would be necessary to extend this type of research to other forms of science instruction.

Conclusions and Limitations

There has been very little previous research on situational interest in school science classes. However, this study has provided evidence that situational interest can be substantially generated during an inquiry skills lesson. Novelty was probably the main source of interest, and was argued to be a multifaceted construct including new learning experiences, surprise, suspense and variety. Choice and social involvement were also identified as sources of situational interest, as was physical activity although the latter may have operated by facilitating other factors such as social involvement, autonomy and novelty. Despite the transient nature of situational interest it did have a significant impact upon the students, as it was arguably able to temporarily over-ride any pre-existing motivational orientations that the students may have had. This suggests that providing multiple experiences of situational interest in a science lesson might be one way to maintain student motivation at high levels as they participate in instructional activities.

One limitation of the study was that it was carried out with groups of eight students rather than full classes. This approach was chosen because it allowed sampling of the range of ability levels within each school, but the social and cognitive factors operating in a full class is likely to be more complex than in a group situation. In addition, this study used self-reported data only, and it is possible that some students may have been unwilling or unable to accurately describe their thoughts or feelings. A further limitation was that the lessons were unusual because student inquiry is usually developed over a longer time frame than the 40-minute procedure used in this study. In fact, open inquiry projects can last for several weeks, so it is possible there may be differences in situational interest using short interventions versus more extended inquiry units. The results should be interpreted with these limitations in mind.

Finally, there is a potentially rich variety of sources of interest that could be brought into play in science lessons. Indeed, it could be argued that science, through its emphasis on inquiry and hands-on activities, should be a fertile domain for creating situational interest. Strong sources of situational interest can be expected to arouse and motivate the majority of students in the class, irrespective of their achievement level or previous interest in the subject. By making regular use of such experiences, teachers can hopefully generate an enthusiasm for learning science in *all* students.

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