INTEREST DEVELOPMENT AND THE 5E MODEL

by

John Eric Nilsen

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John Eric Nilsen

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ABSTRACT

This action research project investigated the effectiveness of the 5E model at increasing student interest in the study of electromagnetic induction, and examined factors thought to be associated with interest development. Using lesson-specific surveys, as well as pre and post-treatment surveys and assessments, the 5E model was shown to be effective at increasing students' situational and personal interest. The factors of enjoyment and meaningfulness most strongly correlated with students' perceptions of interest. Current theories of interest development were supported, but more robust and rigorous research is still needed.

INTRODUCTION AND BACKGROUND

This action research took place at the Dhahran School, one of six Saudi Aramco Schools owned and operated by the Saudi Arabian Oil Company. Our school mission is to provide each student with an excellent education in support of attracting and retaining an international workforce. I teach Conceptual Physics to grade 9 students. Our school currently has 142 students in grade 9; I teach roughly half of this group in four blocks of Physics classes: one block of 20 students, one block of 19 students, one block of 17 students, and one block of 16 students. I have a physics teaching colleague with whom I coordinate closely.

Saudi Aramco Schools is based on a North American school model of K-5 elementary, Grades 6-8 middle school, and Grade 9 high school. Education beyond ninth grade is not provided by Saudi Aramco Schools. During the first trimester of their ninth grade year, students apply to the high schools they wish to attend for Grades 10-12.

Our students come from every continent except Antarctica, and they bring a highly diverse set of cultural backgrounds, language skills, and learning styles to each classroom. The longer our students have been in Saudi Aramco Schools, the more assimilated they become in terms of culture and language. Most of the students I teach in Grade 9 Conceptual Physics have attended Saudi Aramco Schools for several years, some since Kindergarten, but a few students are new to Saudi Aramco and our school as well.

The students in each of my classes represent a broad spectrum of intelligences and capabilities, ranging from students in need of significant support to gifted students. Each student is worthy of my best effort to help them learn.

As a teacher, I am witness to the effects a lesson has on my students. Most lessons begin with eager, energetic students, some who become quite absorbed in the lesson's activities, some who attempt to convert the lesson into a personal play time or recess, and some who become quite subdued and lethargic. My aspiration is to create an environment in which each student becomes so engrossed in the lesson that s/he becomes momentarily annoyed or upset when alerted that the class period is ending. How realistic is this aspiration? How much influence do I have on the factors necessary for this to occur? What are the factors necessary for this to occur? Which factor would I begin with?

In this action research project, a deliberate attempt is made to increase each student's situational and personal interest in the study of electromagnetism, using the 5E model and the perspectives of interest-development and self-determination theory. The focus question is: Is the 5E model, as used in this study, effective at increasing students' situational interest? Sub-focus questions are: What factors correlate most strongly with students' situational interest? Does increasing students' situational interest increase students' personal interest? Is there a positive correlation between students' level of situational interest and their level of conceptual understanding?

CONCEPTUAL FRAMEWORK

In this section I review research in Interest Development, factors associated with increased situational interest, and Self-Determination Theory. I review primary research for methods of measuring situational interest and associated factors within educational settings. I review the historical development of the 5E model, make connections between the 5E model phases, Interest Development, and Self-Determination Theory, and review research on the effectiveness of the 5E model at increasing interest.

Interest Development

Interest is a psychological state that is characterized by an affective component of positive emotion and a cognitive component of concentration (Hidi & Renninger, 2006). When people experience interest, their actions acquire an intrinsic quality; they are driven by enjoyment (Krapp, 2002; Tobias, 1994). Interest is strongly and positively associated with motivation, attention, and cognitive functions (Deci, 1992; Hidi & Harackiewicz, 2000; Schraw, Flowerday, & Lehman, 2001). Interest in the extreme is termed “flow”, the state of being completely absorbed or engrossed in one’s surroundings or endeavors (Csikszentmihalyi, 1975). Interest increases learning (Dewey, 1913; Schraw, et al).

Interest arises through an interaction between a person and his or her environment (Krapp, Hidi & Renninger, 1992). The degree of interest a person takes in his or her surroundings is thought to be a function of both ‘personal interest’ and ‘situational interest’ (Krapp, 2002). Personal interest, also known as individual interest, comes from that person’s characteristics: stable features such as gender, prior knowledge, experiences, and relatively stable preferences for certain content areas. Situational interest emerges in response to features in the person’s environment, and is less stable in nature than personal interest (Hidi & Harackiewicz, 2000).

Situational interest is further differentiated into triggered situational interest, or ‘catch’, and maintained situational interest, or ‘hold’ (Mitchell, 1999; Hidi & Harackiewicz, 2000). Triggered situational interest refers to a psychological state of interest which results from short-term changes in affective and cognitive processing. Maintained situational interest refers to a psychological state of interest that is subsequent to a triggered state, involves focused attention and persistence over an extended episode in time and/or reoccurs and again persists (Hidi & Renninger, 2006).

Individual interest is further differentiated into emerging individual interest and well-developed individual interest. Emerging individual interest refers to a psychological state of interest as well as to the beginning phases of a relatively enduring predisposition to seek repeated reengagement with particular classes of content over time. Well-developed individual interest refers to a psychological state of interest as well as to a relatively enduring predisposition to reengage with particular classes of content over time (Hidi & Renninger, 2006). In their four-phase model of interest development, Hidi and Renninger hypothesize that environmental factors can trigger situational interest, which if maintained over time can develop into more enduring states of individual interest. More recent research (Linnenbrink-Garcia, et al, 2010) suggests further differentiating maintained situational interest based on the extents to which the triggering material was enjoyable and engaging (maintained situational interest-feeling) and whether the material was viewed as important and valuable (maintained situational interest-value).

Because situational interest is thought to precede and facilitate the development of personal interest and because situational interest can be partially controlled by teachers through task design and teaching strategies (Hidi & Renninger, 2006; Linnenbrink-Garcia, et al, 2010; Mitchell, 1993, Schraw, Flowerday, & Lehman, 2001), research has focused on situational interest, with the intent of learning how to measure and increase students' situational interest inside the classroom (Chen, Darst, & Pangrazi, 2001; Kang, Scharmann, Kang, & Noh, 2010; Linnenbrink-Garcia et al; Rotgans & Schmidt, 2010; Schraw, et al; Tsai, Kunter, Ludtke, Trautwein, & Ryan, 2008).

Factors associated with increased situational interest

Many factors and strategies have been identified which increase students' situational interest. Researchers also note, however, that attempts to only enhance student interest can be irrelevant to learning, and may even undermine it (Dewey, 1913; Bergin, 1999). Bergin identifies hands-on activities, discrepancy/cognitive conflict, novelty of learning stimuli, social interaction by means of group work, modeling experts, food, games, puzzles, narratives, and humor as ways to increase students' situational interest.

Schraw, et al (2001) identify providing meaningful choices to students in what and how they study, selecting well-organized, structured, and vivid texts that promote interest, and providing the background knowledge needed to fully understand a topic. They also stress that encouraging students to be active learners, by means of predicting and summarizing what they already know, want to know, and have learned, can increase situational interest.

Chen et al (2001) identify offering students ample exploratory opportunities during student-task interaction that can lead to instant enjoyment.

Rotgans and Schmidt (2010) identify the teaching characteristic of cognitive congruence, defined as the ability of teachers to express themselves in a language the students can understand, using concepts the students use, and explaining concepts in ways easily grasped by students, with increased student situational interest.

Hidi and Renninger (2006) identify providing support so that students can experience a triggered situational interest or feedback that allows students to sustain attention so that they can generate their own curiosity questions, provide opportunities for students to ask curiosity questions, and select or create resources that promote problemsolving and strategy generation. Curiosity questions refer to the type of verbal or nonverbal questioning that a learner generates in the process of organizing and accommodating new information. They also identify the importance of positive feelings about the activity and solid content knowledge in the early phases of interest development.

Self Determination Theory

One theory that attempts to explain these findings is the Self-Determination Theory (SDT) (Deci, Vallerand, Pelletier, and Ryan, 1991; Tsai, et al, 2008). According to SDT, intentional behaviors can be motivated by either autonomous or controlled forms of regulation. Autonomous forms of regulation include both intrinsic motivation, defined as behavior energized by its inherent satisfactions, and identified or integrated forms of extrinsic motivation. The individual identifies with the personal importance of a behavior or assimilates its regulation to the self (Ryan & Deci, 2000), meaning that regulation is autonomous, volitional, and valued by the self (Deci, et al, 1991). Research in SDT has repeatedly confirmed that autonomously regulated behaviors are characterized by the experience of interest (Deci, 1992; Grolnick & Ryan, 1987). By contrast, behaviors experienced as controlling, such as externally regulated or interjected regulations, are typically not associated with either interest or task enjoyment (Ryan & Deci, 2000).

The level of autonomy support in the classroom is a key factor for understanding students' interest (Reeve, 2002). Teachers can create an autonomy-supportive climate by attempting to understand students' feelings and thoughts about learning tasks and by supporting students' personal growth (Assor, Kaplan, & Roth, 2002). Specific autonomy-supportive instructional strategies include listening to students, asking questions about students' wishes, responding to students' questions and acknowledging the students' perspectives, allowing students to work on their own, using praise as informational feedback, and offering encouragement (Reeve & Jang, 2006).

Cognitive autonomy support is proposed as another dimension of autonomy support (Stefanou, Perencevich, DiCintio, & Turner, 2004). Cognitive autonomy support emphasizes the support provided for students' engagement in cognitive activities. Students experience a sense of personal control at the cognitive level when teachers explain the purposes of the task at hand and its links to the learning concepts and scaffold students' understanding by activating prior knowledge or increasing personal relevance (Schraw, et al, 2001; Stefanou, et al; Tsai, et al, 2008).

Methods of measuring situational interest and associated factors

In the five primary research investigations cited (Chen, et al, 2001; Kang, et al, 2008; Linnenbrink, et al, 2010; Rotgans & Schmidt, 2010; and Tsai, et al, 2008), methods of measuring students' situational interest and/or the factors which support it involved the use of student surveys. These surveys ranged from 6 to 33 items using 5 to 7 point Likert scale responses intended to take 5 minutes or less to complete. Items varied in their target factors, and results were analyzed for statistical agreement/best fit with theorized models of interest development. These investigations ranged from n=181 to 858 students ranging from 12 to 19+ years of age, in subjects ranging from middle and high school science, physical education, math, native language, and foreign language to undergraduate psychology and polytechnic studies, in classroom settings ranging from lecture-based to computer aided instruction, active learning, problem-based instruction, to basketball courts, in countries ranging from South Korea, Singapore, and Germany, to the United States. Table 1 summarizes these situational interest measurement methods.

Table 1
Summary of situational interest measurement methods

Investigators	Setting	n	# items	# points (Likert scale)	Survey frequency
Chen, et al 2001	SW U.S.A. metro middle school P.E. grades 7-9	472	24	5	1 x post lesson
Rotgans & Schmidt, 2010	Singapore polytechnic mean age 19.43 years	498	9 6	5 5	1 x post treatment (end of semester) 6 x one day
Tsai, et al, 2008	German gymnasium 7th grade math, German, foreign language	261	19	6	1 x pre treatment 1 x post lesson for 3 weeks
Kang, et al, 2010	South Korea 7th grade science	183	20	5	1 x post treatment
Linnenbrink, et al, 2010	USA university undergrad psych courses	858	17	7	1 x post 13 weeks instruction
Linnenbrink, et al, 2010	Western USA urban area grades 7-12 math	181	12	5	1 x post treatment fall and 1x spring
Linnenbrink, et al, 2010	Western USA urban area grades 7-12 math	246	12	5	1 x post treatment spring

Kang et al's (2010) investigation used a modified version of the Melbourne Curiosity Inventory (MCI) State form to measure students' situational interest in response to a discrepant event. There is also an MCI Trait form, which has been developed to measure an individual's capacity to experience curiosity (Naylor, 1981). Curiosity has been studied as a method to measure interest in learning (Buckley, Hasen, and Ainley, 2004), and researchers have used the measurement of curiosity as a feeling of interest in learning (Ainley, et al, 2002; Litman & Jimerson, 2004). The MCI Trait form seems adaptable for use in measuring students' levels of personal interest.

Rotgans and Schmidt's (2010) and Tsai, et al's (2008) studies involve the use of lesson-specific measures of students' situational interest and factors thought to influence interest. Rotgans and Schmidt used a six-item computer-based situational interest scale which students took at six critical occasions during courses they attended in a single day. In addition, they used a nine-item teacher-characteristic questionnaire within a semester-end program evaluation. Tsai, et al used a 33-item questionnaire to assess the emotional and value components of situational interest as well as assessing perceived autonomy and cognitive autonomy support, administered during the last five minutes of up to three lessons per day per student for three weeks. The use of lesson-specific measurements of students' situational interest and factors which may support it seem very suitable to my action research project.

The 5E Model

"Do not then train youths by force and harshness, but direct them to it by what amuses their minds so that you may be better able to discover with accuracy the particular bent of the genius of each." – Plato

Interest has long been acknowledged by educators to be an important condition for learning. Instructional strategies, models, and learning cycles have been designed which intend to engage students in learning activities through which students construct their understanding of specific learning objectives. One such strategy is the Biological Science Curriculum Study (BSCS) 5E Instructional Model, also known as the 5E Inquiry cycle and the 5E Learning cycle, and hereafter referred to as the 5E model. The 5E model has been used over the past three decades at all levels of science and teacher instruction (Bybee, et al, 2006). In their report to the National Institutes of Health Office of Science Education, Bybee et al trace the development of the 5E model back more than a century, identifying four earlier instructional models.

The Herbart model (Table 2) is based on two principles: interest and conceptual understanding. The first principle of effective instruction consists of students' interest in the subject. Herbart suggests two types of interest, one based on students' direct experiences with the natural world and the second based on social interactions (Bybee, et al, 2006).

Table 2
Herbart Instructional Model

Phase	Summary
Preparation	The teacher brings prior experiences to the students' awareness.
Presentation	The teacher introduces new experiences and makes connections to prior experiences.
Generalization	The teacher explains ideas and develops concepts for the students.
Application	The teacher provides experiences where the students demonstrate their understanding by applying concepts in new contexts.

The Dewey model (Table 3) utilizes the concept of the discrepant event, an experience in which the students feel thwarted and sense a problem (Bybee, et al, 2006). Dewey's emphasis on students' interest in their learning cannot be overstated. His term "genuine interest" from Interest and Effort in Education (1913) reads very much like Hidi and Renninger's well-developed individual interest, and "When a person is absorbed, the subject carries him on" from How We Think (1910) sounds very much like flow.

Table 3
Dewey Instructional Model

Phase	Summary
Sensing Perplexing Situations	The teacher presents an experience where students feel thwarted and sense a problem.
Clarifying the Problem	The teacher helps the students identify and formulate the problem.
Formulating a Tentative Hypothesis	The teacher provides opportunities for students to form hypotheses and tries to establish a relationship between the perplexing situation and previous experiences.
Testing the Hypothesis	The teacher allows students to try various types of experiments, including imaginary, pencil-and-paper, and concrete experiments, to test the hypothesis.
Revising Rigorous Tests	The teacher suggests tests that result in acceptance or rejection of the hypothesis.
Acting on the Solution	The teacher asks the students to devise a statement that communicates their conclusions and expresses possible actions.

Heiss, Obourn, and Hoffman's Learning Cycle (Table 4) is based on Dewey's complete act of thought (Bybee, et al, 2006). Student interest is important. "The teacher must stimulate interest." "…if the teacher wishes to keep interest in her class at top pitch she must have interest and enthusiasm herself" (Heiss, Obourn, & Hoffman, 1950).

Table 4
Heiss, Obourn, and Hoffman's Learning Cycle

Phase	Summary
Exploring the Unit	Students observe demonstrations to raise questions, propose a hypothesis to answer questions, and plan for testing.
Experience Getting	Students test the hypothesis, collect and interpret data, and form a conclusion.
Organization of Learning	Students prepare outlines, results, and summaries; they take tests.
Application of Learning	Students apply information, concepts, and skills to new situations.

The Atkins-Karplus Learning Cycle (Table 5), also known as the Science Curriculum Improvement Study (SCIS) learning cycle, connects Piaget's cognitive constructivism to the design of science instructional strategies. Cognitive conflict or disequilibrium produced during students' initial experiences with a phenomenon forms the basis for engaging students in inquiry (Bybee, et al, 2006).

Table 5
Atkins-Karplus (SCIS) Learning Cycle

Phase	Summary
Exploration	Students have an initial experience with the phenomena.
Invention	Students are introduced to new terms associated with the concepts that are the object of study.
Discovery	Students apply concepts and use terms in related but new situations.

The 5E model (Table 6) expands on the SCIS learning cycle, with added engagement and evaluation phases. The engagement phase makes connections to students' prior knowledge, may employ discrepant events or demonstrations, asks questions, and defines a problem to engage students and focus them on the instructional task (Bybee, et al, 2006).

Table 6
Summary of the BSCS 5E Instructional Model

Phase	Summary
Engagement	The teacher or a curriculum task accesses the learners' prior knowledge and helps them become engaged in a new concept through the use of short activities that promote curiosity and elicit prior knowledge. The activity should make connections between past and present learning experiences, expose prior conceptions, and organize students' thinking toward the outcomes of the current activities.
Exploration	Exploration experiences provide students with a common base of activities within which current concepts (i.e. misconceptions), processes, and skills are identified and conceptual change is facilitated. Learners may complete lab activities that help them use prior knowledge to generate new ideas, explore questions and possibilities, and design and conduct a preliminary investigation.
Explanation	The explanation phase focuses students' attention on a particular aspect of their engagement and exploration experiences and provides opportunities to demonstrate their conceptual understanding, process skills, or behaviors. This phase also provides opportunities for teachers to directly introduce a concept, process, or skill. Learners explain their understanding of the concept. An explanation from the teacher or the curriculum may guide them toward a deeper understanding, which is a critical part of this phase.
Elaboration	Teachers challenge and extend students' conceptual understanding and skills. Through new experiences, the students develop deeper and broader understanding, more information, and adequate skills. Students apply their understanding of the concept by conducting additional activities.
Evaluation	The evaluation phase encourages students to assess their understanding and abilities and provides opportunities for teachers to evaluate student progress toward achieving the educational objectives.

More recently, the 7E model expands on the 5E model, differentiating the engagement phase into separate elicit and engage phases, and adding an extend phase to emphasize transfer of learning (Eisenkraft, 2003). The 5E and 7E models are identical in their actions. The differentiations into separate elicit and extend phases serve to ensure that actions intended to elicit students' prior knowledge and have students transfer learning are not under-attended to or omitted. The instructional model used in this action research will acknowledge and use the important strategies of eliciting students' prior knowledge and providing opportunities for student transfer of knowledge, but will retain the nomenclature of the 5E model.

Connections between 5E model phases, interest development, and SDT

Each phase of the 5E model as described by Bybee, et al (2006), correlates to instructional strategies identified by researchers as capable of supporting interest development, autonomy, and cognitive autonomy.

The engagement phase elicits students' prior knowledge, a necessary condition for interest development (Schraw, et al, 2001; Hidi & Renninger, 2006) and for cognitive autonomy support (Stefanou, et al, 2004; Tsai, et al, 2008). This phase also engages and promotes curiosity through activities such as discrepant events or novel situations, which can trigger situational interest (Bergin, 1999; Schraw, et al; Chen, et al, 2001). This phase also organizes students' thinking toward learning objectives, an important step in autonomy and cognitive autonomy support (Schraw, et al; Stefanou, et al; Tsai, et al).

The exploration phase provides students with a common base of activities within which students connect new knowledge to prior knowledge to facilitate conceptual change. Novel equipment and tasks, hands-on activities, encouraging students to be active learners, problem solvers, and strategy generators are all identified as effective at triggering and maintaining situational interest (Bergin, 1999; Schraw, et al, 2001; Hidi & Renninger, 2006).

The explanation phase focuses students' attention on a particular aspect of their engagement and exploration experiences. This phase represents a critical transition from more novel, enjoyable, fun engagement and exploration phases, which have triggered students' situational interest, to a more focused attention-a maintained situational interest. Using active learning strategies such as lab activities to focus on a particular concept can both continue to trigger and begin to maintain situational interest (Bergin, 1999; Chen, et al, 2001; Hidi & Renninger, 2006). This phase also provides opportunities for students to demonstrate their conceptual understanding, process skills, and/or behaviors. Connecting new experiences and knowledge to students' prior knowledge, connecting present activities to the larger learning objectives, and connecting the concept's relevance to the students, can both continue to maintain situational interest and support cognitive autonomy (Schraw, et al, 2001; Hidi & Renninger, 2006; Stefanou, et al, 2004; Tsai, et al, 2008). This phase also provides opportunities for the teacher to directly introduce a concept, process, and/or skill. Cognitive congruence, the teacher's ability to explain concepts in ways easily grasped by students, can contribute to maintaining situational interest (Rotgans & Schmidt, 2010). Creating an autonomy supportive climate can make the teacher's direct instruction more effective, in the sense that students might perceive the direct instruction as less about teacher control and more about supporting their personal growth (Reeve, 2002; Assor, et al, 2002).

The elaboration phase provides opportunities for students to develop deeper and broader conceptual understanding and/or skill. Opportunities for both near and far transfer of knowledge are provided (Eisenkraft, 2003). This phase presents the challenge of maintaining student interest in a concept or topic that is no longer novel. In this phase the providing of meaningful choices in how they investigate deeper and communicate their understanding can contribute to maintain situational interest and can support the development of personal interest (Schraw, et al, 2001; Hidi & Renninger, 2006). The challenge of transfer can be initiated by the students autonomously, which could be evidence indicative of personal interest (Hidi & Renninger), or teacher initiated, which, if within the context of an autonomy supportive climate, could be perceived by the students as less about teacher control, and more about supporting their personal growth (Reeve, 2002; Assor, et al, 2002).

The evaluation phase encourages students to assess their understanding and abilities. Self-assessment is a crucial component of autonomous personal growth. When students are provided with meaningful choices of how to demonstrate their conceptual understanding, process skill, and/or behavior, situational and personal interest can be fostered and/or maintained (Schraw, et al, 2001; Hidi & Renninger, 2006). This phase also provides opportunities for the teacher to evaluate student progress towards achieving the learning objectives. From the perspective of interest development and SDT, it can be predicted that teacher-initiated assessments of student progress, under standardized conditions, might be perceived as more teacher control and not associated with either interest or task enjoyment (Ryan & Deci, 2000). Assessments involving student activity, such as a project or performance, with meaningful choices provided, within an autonomy supportive climate, can foster and support interest development (Schraw, et al; Hidi & Renninger; Reeve, 2002).

Throughout these phases, listening to students, to acknowledge and understand their thoughts, feelings, and perspectives of the activities, responding to their questions, allowing students to work on their own, and offering them praise and encouragement, can serve to create an autonomy supportive climate (Assor, et al, 2002; Reeve & Jang, 2006).

Effectiveness of the 5E model at increasing interest

Due to the relative youth of the 5E model compared with earlier learning cycles, such as the SCIS learning cycle, there are fewer published studies which compare the 5E model with other instructional strategies (Bybee, et al, 2006). There is, however, a growing body of work whose findings indicate that the 5E model has a positive effect on interest and attitudes toward science (Akar, 2005; Boddy, Watson, & Aubusson, 2003; Ergin, Kanli, & Unsal, 2008). Findings from America's Lab Report (National Research Council, 2006) also indicate that the 5E model has greater evidence of increased interest in science compared with alternative instructional models.

Akar (2005) found high school chemistry students in a 5E-based course experienced positive changes in attitudes towards science that were significantly higher than those in a course where traditional approaches were used. Boddy, et al (2003) found that elementary school students taught with a learning cycle-based approach experienced positive changes in attitudes towards science. Ergin, et al (2008) found that high school physics students in a 5E-based unit on projectile motion experienced positive changes in attitudes toward science that were significantly higher than a control group of students taught in a more traditional method.

METHODOLOGY

In this section I describe the setting, measurement instruments, and treatments used in this action research project. The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained.

Setting

A three week investigation of electromagnetic induction was the context for this research. Four sections of 16 to 19 students met every other day for ninety minutes. There were seven sessions for each class during this investigation. Students had just returned from a three-week break from school, and it was the start of the third week of the second trimester. Students investigated forces and motion in the first trimester, through a case study of cats falling from New York skyscrapers, an extended 5E model inquiry of factors affecting falling, a projectile motion project, analysis of student chosen and performed motion events using Newton's Laws, and an investigation of impulse and momentum. The first two weeks of this second trimester were spent investigating gravitational potential energy and kinetic energy transformations, and formally introducing the four fundamental forces of our universe.

Measurement Instruments

Since the beginning of this school year, students had been tasked each session with posing a research question to find the answer to, as best they can, for sharing with their classmates the beginning of the next class session. There were no restrictions on the question's topic, and the students could change their mind and/or experience serendipity to arrive at a different question and answer. Frequently, but not every session, I added one or more questions for all students to research. The students left a copy of their questions with me at the end of each session, which I read and returned to them at the beginning of the next session. I used the questions they posed as evidence of how interesting/provoking the session's activities were by noting whether or not their questions connected to the session's activities. I continued this practice during this project, and refer to this instrument as research questions (RQs).

On Day 1 and Day 7 of this project the MCI Trait form (Appendix B) and Personal Interest (Appendix D) surveys were administered. The MCI Trait form was used for pre- versus post-treatment comparisons of students' self-perceived general curiosity level. The Personal Interest survey was used for pre- versus post-treatment comparisons of students' declared interests in magnetism and/or electricity. The MCI Trait and Personal Interest survey results were also compared to determine a relative personal interest level in magnetism and/or electricity.

A pre-treatment conceptual understanding assessment (Appendix C) was given on Day 1, and given again post-treatment on Day 7. This open-ended, short to medium-length explanation of the observed falling of two neodymium magnets through a copper tube was used to assess their understanding of electromagnetic induction.

Each session's activities ended roughly ten minutes before dismissal, to administer the Lesson Specific Measure (Appendix A). This 19-item, 6-point Likert scale survey was modified from Tsai, et al (2008) and used to measure student's level of interest in each session's activities, as well as measure student's perceptions of factors associated with interest development, autonomy support, and cognitive autonomy support. This survey also includes an optional free response.

I also kept a journal, where classroom observations, thoughts, and interviews made during and/or after each session were recorded.

The Data Triangulation Matrix below summarizes how each measurement instrument's data connects to the focus and sub-focus questions.

Table 7
Data Triangulation Matrix

Focus Questions	Data Source 1	Data Source 2	Data Source 3
Focus Question: Is the 5E Model, as used in this project, effective at increasing students' situational interest?	Lesson-Specific Measures	Classroom Observations	Research Questions
Sub-Focus Question 1: What factors correlate most strongly with students' situational interest?	Lesson-Specific Measures	Classroom Observations	Student Interviews
Sub-Focus Question 2: Does increasing students' situational interest increase students' personal interest?	Pre and Post-Treatment Personal Interest Survey	Pre and Post-Treatment Melbourne Curiosity Inventory	Classroom Observations
Sub-Focus Question 3: Is there a positive correlation between students' level of situational interest and their level of conceptual understanding?	Pre and Post-Treatment Personal Interest Survey	Pre and Post-Assessment Conceptual Understanding	Classroom Observations

<u>Treatments</u>

Day 1 began with a brief recap of the highlights of each student's three-week break. This served to re-establish teacher cognitive congruence and an autonomy supportive climate. The MCI Trait and Personal Interest surveys were administered, and then students' prior knowledge was elicited as we reviewed what we had been investigating just before the break.

In the context of eliciting the students' prior knowledge, I demonstrated the discrepant event of neodymium (Nd) magnets falling through a copper (Cu) tube, in an attempt to trigger students' situational interest and engage them in inquiry. After the students took over, and performed the demonstration themselves several times each, the pre-treatment conceptual understanding assessment was administered. This pre-assessment assisted with identifying the investigation's learning objectives.

Next, we transitioned into an exploration phase. The students were tasked with discussing, in small groups, their explanations for their observations and then designing and conducting preliminary experiments to test their early hypotheses, which tended to center on air resistance and friction, from their prior knowledge. The results of their preliminary experiments clearly ruled out air resistance and friction, which left them struggling with the conflicting observations that the magnets neither attracted nor repelled the copper tube when stationary, yet the abnormal falling of the magnets through the tube clearly indicated a force opposing gravitation at work.

Students were tasked with identifying, in writing, what new information they would like to have, and planning steps for the next session's investigations. This served as an opportunity for students to transfer this day's new knowledge to the task of hypothesis construction. Magnets and magnetism, neodymium and copper were popular ideas for further investigation. Students were tasked with posing their research questions, and I added two questions to be researched: What makes something magnetic or magnetized? What are magnets used for? These questions were intended to assist in focusing students' attention in the next session's explorations. The lesson-specific measure (LSM) was administered, research questions (RQs) collected, and class was dismissed. The research questions provided opportunities for students to generate their own curiosity questions. Classroom observations were recorded.

Day 2 started with students in small groups discussing their research question findings and transitioned into a whole-class discussion of their findings related to magnets and magnetism. This served to establish an autonomy-supportive climate and to elicit and connect new knowledge to prior knowledge. I had organized the lab into stations; the novelty of new equipment triggered students' situational interest. The format for this and all sessions during this investigation was intended to allow students to work at each station for as long as they needed. Other students were at each station as well. Students were encouraged to collaborate and share their ideas with each other, but cautioned not to get distracted by each other, and to make sure that each was attempting to construct her/his own understanding of what's going on at that station. This format was intended to support students' interest development, autonomy, and conceptual development. At one station globes were set up so that their axes were aligned, along with other models to represent the electron-spin and domain theories of magnetism. Other stations had permanent magnets, including the neodymium magnets used in the discrepant event, which students repeated and were reminded of the larger objective of this investigation. The session's tasks and objectives were clarified to support autonomy.

Students were tasked with using compasses and/or iron filings to map the magnetic field lines around isolated bar magnets and the Nd magnets. Students also explored the attractive and repulsive forces between magnets, and mapped the magnetic field lines between magnets that were attracting or repelling each other. The hands-on, active nature of this session supported students' interest development, while the self-paced nature of this session supported their autonomy. At one station a coil of copper wire was attached to a galvanometer. Students were tasked with observing what happens when they moved a magnet around and through the coil of wire, and when they moved the coil of wire around a magnet.

Students were able to work through two to three of the different stations during this session. We regrouped and shared what we had discovered so far. Students were tasked with summarizing their individual observations. The lesson-specific measure (LSM) was administered, research questions (RQs) collected, and class was dismissed. Classroom observations were recorded.

Day 3 started with students in small groups discussing their research question findings and transitioned into a whole-class discussion of magnets and magnetism, as well as a review of the lab format. Students then resumed their explorations.

As the students completed this exploration phase we regrouped and transitioned into the explanation phase. Students shared the observations they made at each station. They demonstrated a clear ability to recognize an area of force surrounding a magnet, described the orientations of field lines in the near vicinity of magnets, recognized the attractive and repulsive forces acting between magnets, and could distinguish the field lines between attracting and repelling magnets. They were also able to recognize that the galvanometer needle moved when the magnet was moved through the coil and when the coil was moved around the magnet, and that the needle moved in opposite directions when the magnet or coil were moved in opposite directions.

I added to their discussion the conventions of direction of magnetic field lines, the use of spacing between field lines to indicate field strength, and verified their suspicion that the lines form loops. I also assisted the students in expanding their two dimensional models of these magnetic fields into three dimensions. This scaffolding served to support their cognitive autonomy as well as their conceptual understanding. The galvanometer has the word milliammeter on its face, so we broke this word down and discussed what a milliammeter might do. This connected to prior knowledge students have about electricity.

Students were now provided with time to make further observations using the equipment in ways they thought up. We then reconvened as a whole class to re-summarize the session's findings, which served to support students' interest development and cognitive autonomy as well as providing me with formative assessment information. Students were asked to formulate their current hypothesis to explain the Nd magnets' fall through the Cu tube, ask what they still needed or wanted to know, and propose further inquiry steps. This served as an opportunity for students to transfer their new knowledge to the task of hypothesis construction. I added one question to be researched: What moves in an electric current? This question was intended to assist in focusing students' attention in the next session's explorations. The LSM was administered, RQs were collected, and class was dismissed. Classroom observations were recorded.

Day 4 started with discussions of research question findings and transitioned into a whole-class discussion of electric currents and the conventions for describing their direction, resistance, and voltage--these latter two terms were brought into the discussion by the students. This served to establish an autonomy supportive climate and to elicit and connect new knowledge to prior knowledge.

I had organized the lab into new stations; the novelty of new equipment triggered students' situational interest. At several stations students used compasses to map the magnet field lines around current-bearing wires arranged in straight lines, loops, and coils. At one station there were two re-magnetizers, one intact which students used on bar magnets, and one partially disassembled, which they examined to see how it works.

At another station an open-constructed, permanent horseshoe magnet, hand-powered electric generator was analyzed to decipher how it works, and was used to make a bulb glow or if desired, deliver a tingling shock, in which the students eagerly partook. At the same station there was another open-constructed hand-powered generator which lights up a small LED. It was a nice contrast because it involves spinning its permanent magnets within a stationary coil of copper wire, as opposed to spinning coils of copper wire within stationary horseshoe magnets, and also because it was built and later donated by a former ninth grade student, as opposed to a professional scientific material manufacturer.

The hands-on, active nature of this session supported students' interest development, while the self-paced nature of this session supported their autonomy.

After ample opportunities to explore and observe at each station, the class regrouped for discussion to summarize what they learned this session, and how it connected to the previous day's investigation and to the neodymium magnets' fall through the copper tube. Through discussion, it was clear that students understood that current-bearing wires have magnetic fields around them, and that the magnetic field lines are perpendicular to the straight wire and change direction with change in circuit polarity. I assisted the students with expanding their models of the magnetic fields around the current-bearing loops and coils, and with expanding their two dimensional models into three dimensions. It was also clear that students understood that moving magnets within coils of wire, or moving conducting material through magnetic fields generates electric currents, and that electric currents generate magnetic fields around themselves. This summarizing served to support students' interest development and cognitive autonomy as well as providing me with formative assessment information.

Students were tasked with updating their hypotheses to explain the discrepant event, asking what they still needed or wanted to know, and proposing further inquiry steps. This served as an opportunity for students to transfer their new knowledge to the task of hypothesis construction. I added one question to their research question: How does an electric motor work? This question served as an additional opportunity for students to connect and transfer their new knowledge of electric generators to electric motors. The LSM was administered, RQs collected, and class dismissed. Classroom observations were recorded.

Day 5 started with discussions of research question findings and transitioned into a whole class discussion comparing and contrasting electric motors and generators. Some of the students had a good understanding of how the Nd magnets falling through the Cu tube can be explained using the concepts of electromagnetic induction; other students were at various levels of emergence. The lab was set up with supplies of materials previously used. Students were tasked with using their current hypothesis to predict an electromagnetic event they had not observed previously, and then to design and conduct an experiment to test their prediction and hypothesis. A formal lab report for this experiment was assigned, due on Day 7. When necessary, students could collaborate, such as when more than two hands were needed, or to bounce an idea off someone. Lab reports were to be written independently.

During this day my facilitation became more highly differentiated. Students with well-developed hypotheses were assisted with obtaining the lab materials suitable for their proposed experiments, and/or adapting their experiments to be capable of being performed in the lab. For these students this was an elaboration phase, and I was focused on supporting their interest development and autonomy by giving them meaningful choices with regards to their independent investigations, by listening and responding to their thoughts and feelings regarding this task, and by minimizing my input beyond encouragement, praise, and minor technical advice.

Students with less well-developed hypotheses were assisted with additional guided observations and Socratic questioning to develop their conceptual understanding and their hypotheses. For these students this was still an explanation phase, and I was focused on supporting their interest development and cognitive autonomy by first scaffolding to solidify the connections between their prior and new knowledge, and connections between the investigations we had performed over the past four days, including praise and encouragement in feedback, and giving them meaningful choices with regards to their independent investigations.

After time for explaining, elaborating and/or extending, we regrouped and constructed a common hypothesis to explain the fall of the Nd magnets through the Cu tube. This summarizing served to support students' interest development and cognitive autonomy as well as providing me with formative assessment information. Students were then tasked with updating their hypothesis, asking what they still needed or wanted to know, and proposing further inquiry steps. This served as an opportunity for students to transfer their new knowledge to the task of hypothesis construction. I added one question to their research question: How does a galvanometer work? This question was intended to serve as an informal self-assessment. The LSM was administered, RQs collected, and class dismissed. Classroom observations were recorded.

Day 6 started with discussions of research question findings and transitioned into a class discussion about galvanometers and some of their uses. This session was dedicated to students refining their hypotheses, making testable predictions, designing and conducting experimental tests, and organizing and composing their reports. I acted as facilitator, helping students to realize their experimental designs using the equipment, knowledge, and skills available. Interest development, autonomy, and cognitive autonomy were supported through hands-on, active-learning, scaffolding, meaningful choices, listening, responding, encouragement and praise all rolled into one hectic blur of student-led inquiry. Students who completed their reports were tasked with peer-reviewing each other's reports, and repeating their experiments for each other. This served to assist with students' self-assessment of their conceptual understanding and process skills. This also served to support interest development and autonomy, as students saw themselves and their peers as more independent learners and teachers in their own right. With ten minutes remaining, the LSM was administered, RQs collected, and class dismissed. Classroom observations were recorded.

Day 7 started with discussions of research question findings. The MCI Trait and Personal Interest surveys were re-administered, as was the conceptual understanding assessment. For the remainder of the session students shared their experiments with each other. Students turned in their reports, the LSM was administered, RQs collected, and class dismissed. Classroom observations were recorded.

DATA AND ANALYSIS

In this section I define the thresholds for statistical significance and correlation strength. I report how data was selected and prepared for analysis. I report the results and critically assess them.

Statistical significance p-value and Correlation Coefficient r

The Microsoft Excel spreadsheet TTEST statistical formula was used to determine p-values for two-tailed, paired-sample tests. For this project, p-values less than 0.05 ($p < 0.05$) represented an acceptable level of confidence that the results obtained were not due to random chance. P-values greater than 0.05 ($p > 0.05$) represented too great a possibility that the results obtained could have been due to random chance for conclusions to be drawn from them.

The Excel spreadsheet CORREL statistical formula was used to determine the correlation coefficient r for the paired-sample tests. For this project, absolute r-values less than 0.30 were considered weak correlations, absolute r-values from 0.30 to 0.60 were considered moderate correlations, and absolute r-values above 0.60 were considered strong correlations. Positive r-values represented proportional relationships; negative r-values represented inversely proportional relationships. It was important to note that correlations do not mean causalities.

Data Selection

For the Melbourne Curiosity Inventory, Personal Interest Survey, and Conceptual Understanding Assessment, only data for students who took both pre and post treatment surveys and assessments were used, to enable paired-sample testing. For the Lesson Specific Measurements and Research Questions, data from each student present that day was used.

Data Analysis and Results

For the pre and post-treatment Melbourne Curiosity Inventories, 64 student's scores were averaged to create individual curiosity scores. These scores were collated and entered into a Microsoft Excel spreadsheet and analyzed for whole group pre and post-treatment averages, two-tailed, paired-sample p-value, and correlation coefficient r. The pre-treatment average was 2.98 (SD = 0.38), post-treatment average 3.07 (SD = 0.38). This small increase in students' overall curiosity was statistically significant $t(62) = 2.37$, $p = 0.02$ and had a strong correlation $r(62) = 0.70$, $p = 0.02$.

For the pre and post-treatment Personal Interest Surveys, students' responses were quantified to a one to six scale (1 = strongly disagree, 2 = disagree, 3 = slightly disagree, 4 = slightly agree, 5 = agree, 6 = strongly agree). Scores for each student and item were collated and entered into an Excel spreadsheet and analyzed for averages, two-tailed paired-sample p-values, and correlation coefficient r.

Substantial, statistically significant increases were observed for students' personal interest in magnets (Table 8). Smaller, often not statistically significant increases were observed for students' personal interests in electricity (Table 9).

Table 8
Personal Interest Survey Results: Magnets (N = 64)

	Magnets interest me.	I often play with magnets.	I want to learn more about magnets.	Understanding magnets is important to me.	Understanding magnets can be useful outside of class.
Pre-treatment average	4.33	3.90	4.11	3.32	4.27
Post-treatment average	4.97 $p < 0.05$ $r = 0.47$	4.44 $p < 0.05$ $r = 0.51$	4.70 $p < 0.05$ $r = 0.39$	4.41 $p < 0.05$ $r = 0.46$	4.84 $p < 0.05$ $r = 0.34$

Table 9
Personal Interest Survey Results: Electricity (N = 64)

	Electricity interests me.	I often play by building electric circuits or devices.	I want to learn more about electricity.	Understanding electricity is important to me.	Understanding electricity can be useful outside of class.
Pre-treatment average	4.78	2.92	4.49	4.40	5.25
Post-treatment average	4.86 $p = 0.58$* $r = 0.46$	3.19 $p = 0.06$* $r = 0.78$	4.60 $p = 0.40$* $r = 0.55$	4.71 $p = 0.05$ $r = 0.51$	5.22 $p = 0.80$* $r = 0.35$

(*Not statistically significant for $p > 0.05$)

For the Conceptual Understanding pre and post-assessments, 64 students' responses were scored using a one to five point rubric. Scores were collated and entered into spreadsheet for averaging, and analyzed as two-tailed paired-samples ($p < 0.05$). A substantial increase in students' level of conceptual understanding of electromagnetic induction was observed (Figure 1).

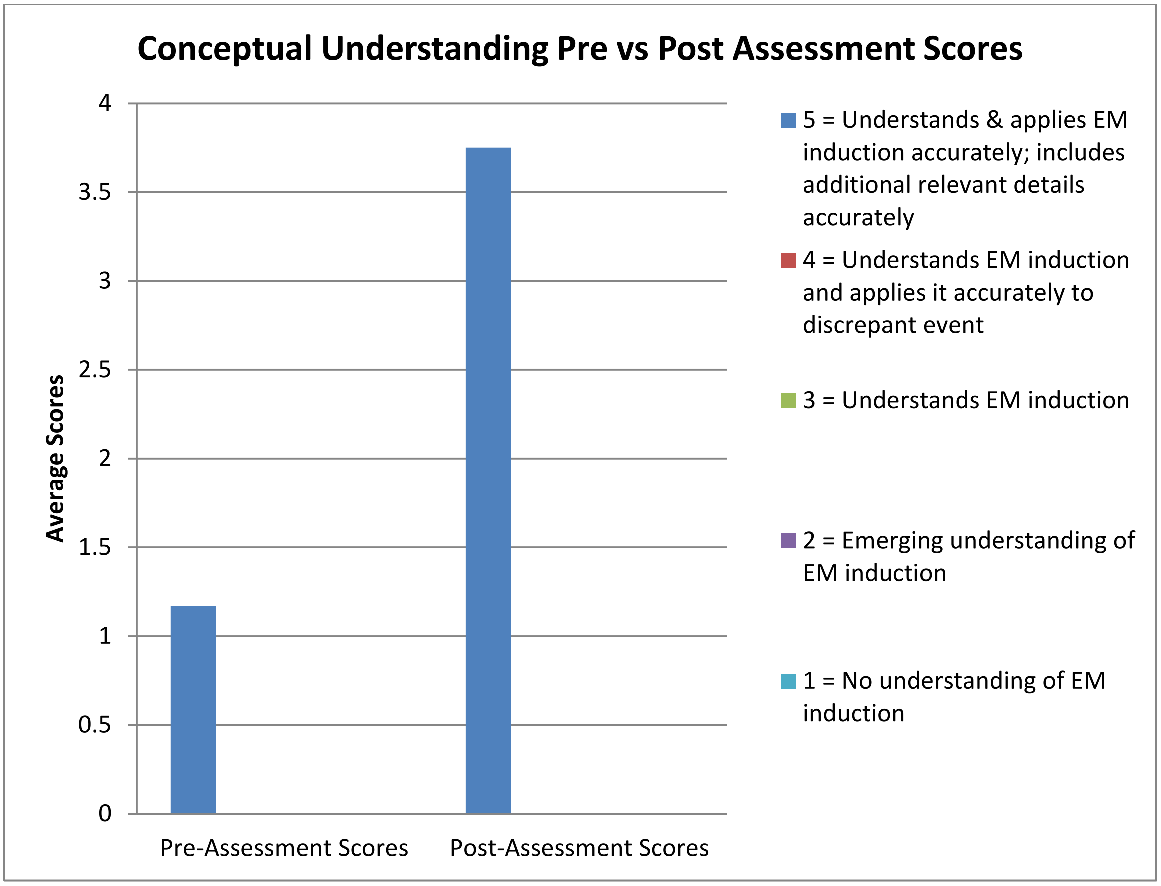

Figure 1. Conceptual understanding assessment results, (*N* = 64).

Students' research questions were compared to the day's activities and the percentage of questions relating to the day's lesson computed. The research questions provided evidence supporting the four-phase model of interest development (Hidi & Renninger, 2006). Situational Interest triggers abound in the environments of my students, as evidenced by the wide variety of research question topics. Many students began a strand of related questions, evidence of a maintained situational interest, which often faded out. A few students have developed an enduring predisposition to reengage with a particular content over time—an emerging individual interest.

The initial maximum of students' research questions relating to the day's lesson, followed by a declining trend, suggests a triggered situational interest which was not maintained (Figure 2).

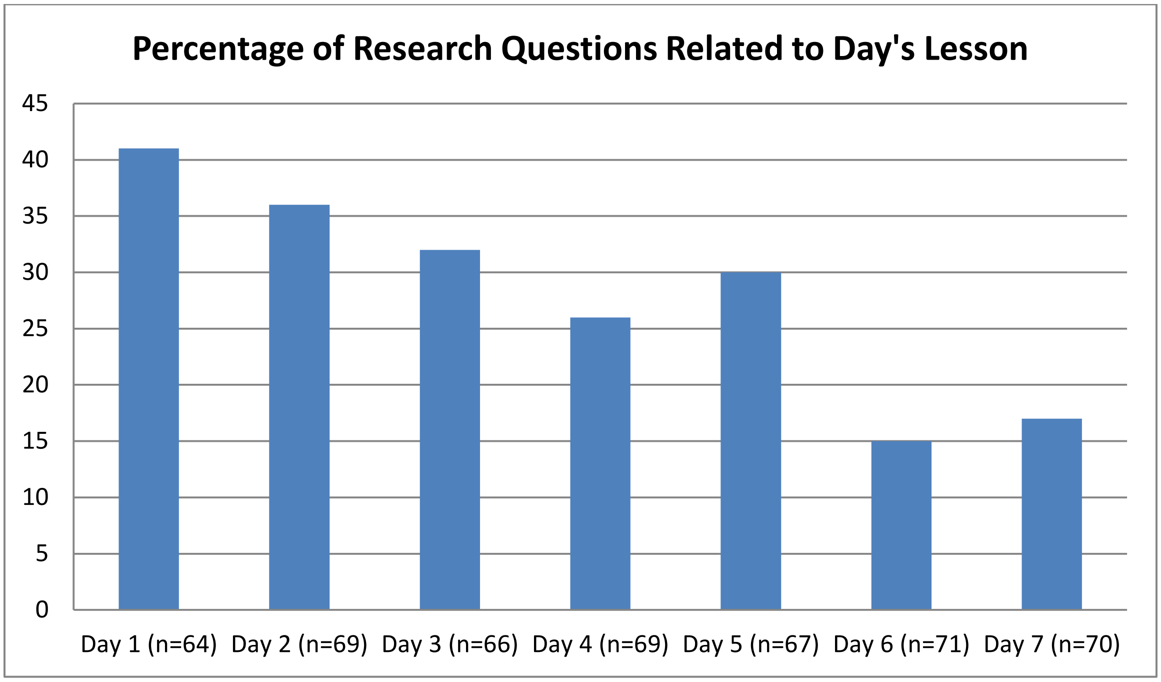

Figure 2. Percentage of research questions related to day's lesson

For the lesson-specific measures (LSM), students' responses were quantified to a one to six scale (1 = strongly disagree, 2 = disagree, 3 = slightly disagree, 4 = slightly agree, 5 = agree, 6 = strongly agree). Scores for each day, student, and item were collated and entered into spreadsheets, averaged, analyzed as two-tailed paired-samples for p-values, and correlation coefficient r-values determined. The analyses made were intra-student comparisons of their reported interest in the day's lesson (LSM Item "Today's lesson was interesting to me.") with the other LSM items for the same day. These results were organized by the Interest Development and Self-Determination Theory hypotheses of maintained situational interest (SI)-feeling (Table 10), maintained SI-value (Table 11), controlling factors (Table 12), autonomy support (Table 13), and cognitive autonomy support (Table 14).

Students agreed that each day's lesson was interesting and enjoyable (Table 10). The correlations between interest and enjoyment were the strongest calculated in this study. This is in agreement with Chen et al (2001) and supports the concept of maintained situational interest-feeling (Linnenbrink-Garcia, et al 2010).

Table 10
LSM Results: Interest and Enjoyment

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
	N = 64	N = 69	N = 66	N = 69	N = 67	N = 71	N = 70
Today's lesson was interesting to me.	5.16	5.19	4.94	5.04	4.91	4.99	4.79
I enjoyed today's lesson.	4.98 r = 0.72 p <0.05	5.17 r = 0.58 p =0.84*	5.05 r = 0.74 p =0.16*	5.13 r = 0.78 p =0.22*	4.97 r = 0.79 p =0.35*	5.06 r = 0.70 p =0.36*	4.94 r = 0.82 p <0.05

(*Not statistically significant for p >0.05)

Students agreed that it was important that they thoroughly understood the material studied (Table 11). The students saw the lessons as increasingly meaningful and useful as the investigation progressed. The correlations between interest and meaningfulness were the second highest calculated in this study. This supports the concept of maintained situational interest-value (Linnenbrink-Garcia, et al 2010).

Table 11

LSM Results: Interest and Value Factors

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
	N = 64	N = 69	N = 66	N = 69	N = 67	N = 71	N = 70
Today's lesson was interesting to me.	5.16	5.19	4.94	5.04	4.91	4.99	4.79
The topic was meaningful to me.	4.21 r = 0.54 p <0.05	4.38 r = 0.59 p <0.05	4.36 r = 0.43 p <0.05	4.74 r = 0.58 p <0.05	4.60 r = 0.75 p <0.05	4.72 r = 0.58 p <0.05	4.67 r = 0.34 p =0.44*
It was important that I thoroughly understood the material studied.	4.74 r = 0.27 p <0.05	5.03 r = 0.35 p=0.11*	5.00 r = 0.36 p=0.60*	5.12 r = 0.35 p=0.56*	5.06 r = 0.48 p=0.17*	5.15 r = 0.44 p=0.10*	5.00 r = 0.23 p =0.12*
I saw that the content of today's lesson can be useful in real life.	4.15 r =0.01 p <0.05	4.75 r = 0.28 p <0.05	4.71 r = 0.15 p=0.12*	4.83 r = 0.39 p=0.07*	4.73 r = 0.54 p=0.08*	4.80 r = 0.54 p <0.05	4.91 r = 0.47 p =0.28*

(For Tables 10-14, Correlations listed are for comparisons between the interest average at the top of each column with each factor's average listed below it in the same column.*Not statistically significant for p >0.05)

Students disagreed that controlling factors were employed during the lessons (Table 12). The negative r-values indicate that less controlling correlates with more interest, and vice versa. These negative correlations are weak, but support the concept of autonomy support (Ryan & Deci, 2000).

Table 12

LSM Results: Interest and Controlling Factors

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
	N = 64	N = 69	N = 66	N = 69	N = 67	N = 71	N = 70
Today's lesson was interesting to me.	5.16	5.19	4.94	5.04	4.91	4.99	4.79
My teacher expected split-second answers.	2.73 r = 0.05 p <0.05	2.64 r = -0.01 p <0.05	2.32 r = -0.19 p <0.05	2.41 r = -0.07 p <0.05	2.31 r = -0.02 p <0.05	2.34 r = 0.04 p <0.05	2.17 r = 0.22 p <0.05
My teacher's instructions were so vague that nobody knew what to do.	1.90 r = -0.14 p <0.05	1.68 r = -0.13 p <0.05	1.80 r = -0.16 p <0.05	1.75 r = -0.24 p <0.05	1.73 r = -0.10 p <0.05	1.58 r = -0.17 p <0.05	1.66 r = -0.15 p <0.05
My teacher assigned so many tasks that we had difficulty keeping up.	1.68 r = -0.08 p <0.05	1.61 r = -0.20 p <0.05	1.52 r = -0.18 p <0.05	1.80 r = -0.25 p <0.05	1.72 r = -0.17 p <0.05	1.49 r = -0.12 p <0.05	1.51 r = 0.03 p <0.05
My teacher was mean to a student.	1.29 r = -0.04 p <0.05	1.42 r = -0.16 p <0.05	1.52 r = -0.04 p <0.05	1.57 r = -0.10 p <0.05	1.42 r = -0.14 p <0.05	1.38 r = -0.13 p <0.05	1.41 r = -0.11 p <0.05

Students agreed that autonomy supporting factors were employed over the course of the lessons (Table 13). Their agreements increased to maximums by Days 5 and 6, which coincided exactly with the progression of the extended inquiry into the student independent investigation phase. The correlations between these autonomy support factors and interest were moderate, and are in agreement about choices and options with Schraw, et al (2001), encouraging to ask questions (Hidi & Renninger, 2006), and listening to and trying to understand students (Reeve & Jang, 2006).

Table 13

LSM Results: Interest and Autonomy Supporting Factors

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
	N = 64	N = 69	N = 66	N = 69	N = 67	N = 71	N = 70
Today's lesson was interesting to me.	5.16	5.19	4.94	5.04	4.91	4.99	4.79
I felt that my teacher provided me choice and options.	4.44 r = 0.34 p <0.05	4.58 r = -0.06 p <0.05	4.55 r = 0.48 p <0.05	4.64 r = 0.43 p <0.05	5.33 r = 0.37 p <0.05	5.20 r = 0.40 p =0.05	4.86 r = 0.49 p =0.55*
I felt understood by my teacher.	4.63 r = 0.50 p <0.05	4.88 r = 0.26 p <0.05	4.80 r = 0.62 p =0.13*	4.78 r = 0.45 p <0.05	4.81 r = 0.43 p =0.35*	4.90 r = 0.27 p =0.50*	4.94 r = 0.35 p =0.20*
My teacher conveyed confidence in my ability to do well in this lesson.	4.81 r = 0.34 p <0.05	4.81 r = 0.35 p <0.05	4.88 r = 0.52 p =0.58*	4.78 r = 0.41 p <0.05	4.82 r = 0.46 p =0.40*	5.06 r = 0.30 p =0.56*	4.93 r = 0.32 p =0.27*
My teacher encouraged me to ask questions.	4.68 r = 0.54 p <0.05	4.77 r = 0.10 p <0.05	4.71 r = 0.39 p =0.09*	4.77 r = 0.59 p <0.05	4.84 r = 0.47 p =0.52*	4.80 r = 0.29 p =0.16*	4.79 r = 0.50 p = 1*
My teacher listened to how I would like to do things.	4.13 r = 0.07 p <0.05	4.17 r = 0.04 p <0.05	4.24 r = 0.30 p <0.05	4.41 r = 0.35 p <0.05	4.58 r = 0.37 p <0.05	4.72 r = 0.28 p <0.05	4.59 r = 0.39 p =0.13*
My teacher tried to understand how I see things before suggesting a new approach.	4.60 r = 0.18 p <0.05	4.38 r = 0.07 p <0.05	4.47 r = 0.41 p <0.05	4.59 r = 0.39 p <0.05	4.67 r = 0.26 p =0.07*	4.70 r = 0.34 p <0.05	4.54 r = 0.43 p <0.05

(*Not statistically significant for p >0.05)

Students agreed that cognitive autonomy supporting factors were employed over the course of this project's lessons (Table 14). Their levels of agreement remained relatively stable. One notable increase for students presenting their findings to the same investigation coincided exactly with the students sharing their independent investigations on Day 7.

The correlations between these cognitive autonomy support factors and interest were weak, but are in agreement with Stefanou, et al (2004).

Table 14
LSM Results: Interest and Cognitive Autonomy Supportive Factors

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
	N = 64	N = 69	N = 66	N = 69	N = 67	N = 71	N = 70
Today's lesson was interesting to me.	5.16	5.19	4.94	5.04	4.91	4.99	4.79
We worked through investigations that helped us understand the topic.	4.79 r =0.16 p <0.05	5.04 r = 0.27 p=0.12*	5.17 r = 0.34 p <0.05	5.04 r = 0.41 p = 1*	5.00 r = 0.12 p=0.53*	4.92 r = 0.34 p=0.54*	4.66 r = 0.20 p=0.36*
Different students presented their findings to the same investigation.	4.13 r =0.02 p <0.05	4.46 r = 0.17 p <0.05	4.53 r = 0.15 p <0.05	4.52 r = 0.35 p <0.05	4.37 r = 0.26 p <0.05	4.37 r = 0.07 p <0.05	4.86 r = 0.33 p=0.61*
My teacher set tasks that required time to reflect.	4.76 r =0.28 p<0.05	4.33 r = 0.10 p <0.05	4.76 r = 0.30 p=0.15*	4.86 r = 0.24 p=0.12*	4.78 r = 0.34 p=0.27*	4.90 r = 0.26 p=0.48*	4.79 r = 0.07 p = 1*
My teacher emphasized the relationships between the topics investigated.	4.74 r =0.07 p <0.05	4.87 r = 0.15 p <0.05	4.89 r = 0.44 p=0.66*	4.87 r = 0.31 p=0.13*	4.85 r = 0.20 p=0.63*	4.90 r = 0.51 p=0.37*	4.91 r = 0.27 p=0.33*

(*Not statistically significant for p >0.05)

<u>Student Interviews</u>

Student interviews began after I observed some seemingly anomalous responses to the LSM item in Table 12 "My teacher expected split-second answers." To try to understand, why without influencing students' scoring, I asked students about this question within the context of casual conversations during student self-directed lab time.

Three students revealed that they interpreted the item to mean "Did the teacher expect students to know the answer to a question asked?" They felt that I had high expectations of their abilities.

Two students who have only recently started learning English reported that sometimes questions and answers happen too fast for them to follow—but not always, which showed in their varied responses.

Most students interpreted the item to judge whether or not I had provided sufficient time after asking a question for them to think before answering. I did not correct any perceptions, and the students continued to respond to the item as before our conversations.

The LSM item, "It was important that I thoroughly understood the material studied", was one of the highest scored items of the LSM (Table 11). The items immediately above ("Meaningful") and below ("Useful") this "Important" item on the LSM were usually within one degree of agreement, most likely one less. I suspected the "Important" item was being interpreted to relate to getting high marks and grades. Casual interviews with students who consistently scored this item highly supported this conjecture; this was especially clear from students whose scores for "Important" were 2 or more degrees of agreement higher than their scores for "Meaningful" or "Useful".

From determining r-values, however, I noticed that the correlations between "Meaningful" and "Interesting" were consistently higher than the correlations between "Important" and "Interesting" (Table 11). These conversations and observations led me to examine the intra-student correlations between these three LSM item responses (Table 15).

Table 15
LSM Results: Correlations between Meaningfulness, Importance, and Usefulness

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
	N = 64	N = 69	N = 66	N = 69	N = 67	N = 71	N = 70
Meaningful Important	4.21 4.74 r = 0.27 p <0.05	4.38 5.03 r = 0.28 p <0.05	4.36 5.00 r = 0.50 p <0.05	4.74 5.12 r = 0.18 p <0.05	4.60 5.06 r = 0.51 p <0.05	4.72 5.15 r = 0.45 p <0.05	4.67 5.00 r = 0.60 p <0.05
Meaningful Useful	4.21 4.15 r = 0.41 p =0.62*	4.38 4.75 r = 0.52 p <0.05	4.36 4.71 r = 0.48 p <0.05	4.74 4.83 r = 0.60 p =0.37*	4.60 4.73 r = 0.63 p =0.19*	4.72 4.80 r = 0.56 p =0.38*	4.67 4.91 r = 0.38 p <0.05
Important Useful	4.74 4.15 r = 0.20 p <0.05	5.03 4.75 r = 0.34 p <0.05	5.00 4.71 r = 0.33 p <0.05	5.12 4.83 r = 0.27 p <0.05	5.06 4.73 r = 0.58 p <0.05	5.15 4.80 r = 0.47 p <0.05	5.00 4.91 r = 0.43 p =0.46*

(*Not statistically significant for p >0.05)

The strongest, statistically significant correlations occur between “Meaningful” and “Important”, just before and on the day that the Conceptual Understanding Post-Assessments occur and Lab Reports are due, both of which count towards students’ grades. The correlations between Useful and Important show a similar pattern.

What this suggests is that meaningfulness and usefulness may have represented “bridges” between interest in the lesson and importance of getting a good grade.

Other casual conversations revealed that the question, “What makes something interesting to you?” was very difficult to answer, some examples of student responses were: “I don’t know; I’ve always been interested in…”, “I’ve always liked…”,“It’s fun.” However, it seemed easy for students to decide if something is interesting to them or not.

Classroom Observations

My classroom observational notes consistently supported the students’ LSM data throughout this project. The discrepant event was very effective at triggering students’ situational interest. “Students enjoyed and were intrigued by the Nd magnets falling through the Cu tube and are very curious to know why it happens.”

The novelty of new equipment set up in the laboratory-half of the classroom never failed to trigger students’ situational interest. Most students, upon entering the classroom each day, walked through the lab and played with the equipment before choosing their seats.

The hands-on nature of the lab activities both triggered and maintained students’ situational interest. “Fun lab” is stated by quite a few students during Days 2, 3, and 4.

As the project progressed (Days 5 through 7), the introduction of the student independent lab investigation and reminders of the post-assessment changed the complexion of students’ situational interest. The atmosphere in the classroom changed from “playful engagement punctuated by bouts of focus” to “engagement and focus separated by bouts of playfulness.”

A parallel progression from more teacher-centered inquiry during Days 1-4 to more student-centered inquiry during Days 5-7 also influenced students’ situational interest. As I began to talk less and listen more, explain less and ask more, the students began to engage at deeper levels. They started to accept the challenge of demonstrating their understanding of electromagnetic induction by predicting and creating events they had not previously observed. The appearance of their interest and enjoyment changed from having fun to seeking understanding. “Watch this” and “I get it” were the expressions overheard these later days.

Critical Assessment of Data

The use of this six-point Likert scale forced students to choose either a degree of agreement or disagreement; there was no neutral option. This was not an issue for the students, but scores of 3 or 4 were ambiguous, and averages needed to be significantly above 4 or below 3 to increase confidence.

As I scored and quantified student responses, I was reassured that the data was conscientiously generated by my students. There were no “bulk entries”. Students circled, underlined, highlighted, or otherwise indicated their survey item choices one at a time. Sufficient time was allotted each day for survey completions.

Students’ responses to different surveys were consistent. On the MCI, item # 3 (I enjoy taking things apart to “see what makes them tick.”) received by far the most scores of one (1 = almost never). This was consistent with the Personal Interest Survey items (I often play with magnets/ I often play by building electric circuits or devices) which also received the most scores of one (1 = strongly disagree).

As previously reported, the classroom observations consistently supported the survey and assessment data.

To improve this study there needs to be a larger sample size. Some of the trends observed were less certain due to a lack of statistical significance. It is also important to acknowledge that this action research project lacked a comparison group.

INTERPRETATIONS AND CONCLUSIONS

The 5E model, as used in this project, is effective at increasing students' situational interest.

Students agreed that the lessons conducted throughout the course of this project were interesting (Table 10). Students' ratings of their interest in magnets increased substantially and significantly (Table 8). Classroom observations found students to be actively engaged in each day's investigations.

Research question data provides a qualifying perspective (Figure 2). Within the context of carefully planned and executed investigations, students' situational interest was focused. The effects of this focusing were quickly diluted outside the classroom.

As shown earlier, the 5E model was built to trigger and maintain students' situational interest. Within its phases are the structures for employing enjoyment and hands-on learning, meaningful choices and options, as well as supporting autonomy and cognitive autonomy, for achieving the goals of making conceptual understanding meaningful and useful.

When combined with an expert application of interest development and self-determination theories, it should be guaranteed that students will be interested. I hope to find out.

Enjoyment and meaning correlate most strongly with students' situational interest.

The correlations for interest and enjoyment (Table 10) and for interest and meaning (Table 11) were the strongest determined. The autonomy supporting factors of providing students with choice and options, conveying confidence in students' ability to do well, listening to how students would like to do things, and trying to understand how students see things (Table 13) also correlate significantly with interest.

Classroom observations strongly supported the correlation between interest and enjoyment. It was fairly easy to observe/infer levels of enjoyment. Engagement, which was also easy to observe/infer, was often used to judge interest. When levels of student engagement appeared high, but their levels of enjoyment appeared moderate, I inferred that other factors in addition to or instead of enjoyment were influencing student interest. When I provided students with choice and options regarding how to conduct their investigations, when I listened to students to hear how they wanted to investigate, and when I tried to understand how students saw things, I observed that students were interested, and interesting.

Student interviews strongly supported the correlation between interest and enjoyment, and suggested possible correlations between interest, meaningfulness, importance, and usefulness. These interviews also reinforced the need for clarity about correlations and causalities.

As previously mentioned correlations do not mean causalities. Very often things that are interesting to us are enjoyable, and things that are enjoyable to us are interesting. But is something interesting because it is enjoyable? Is something enjoyable because it is interesting? These are not always clear.

Students who are interested in getting high grades are examples of integrated forms of extrinsic motivation (Ryan & Deci, 2000). This idea was definitely on my mind when I examined the correlations between interest, importance, meaningfulness, and usefulness (Tables 11 and 15). One possible interpretation of this data is that some students were more motivated to get high grades but did not have strong personal interest in the topic studied. For these students, the interest they felt in the day's lesson correlated stronger with the lesson's meaningfulness or usefulness at helping them achieve a high grade than with the importance of the topic for the students personally.

Increasing students' situational interest increases students' personal interest.

The Personal Interest Survey showed a substantial increase in students' interest in magnets (Table 8). I interpreted the smaller increases in students' personal interest in electricity (Table 9) to be influenced by the relatively high level of interest students already had in electricity before this project began, and by the increased focus of the investigations on the magnetic field components of electromagnetic induction; we did not examine the electric field components with as much depth—that will come.

Classroom observations made during and after this project showed an increased and enduring predisposition to seek reengagement with magnets and getting shocked by the hand-cranked electric generator. The small increase in students' MCI post-treatment ratings of their curiosity levels was statistically significant, and the results provide weak support.

There is a positive correlation between students' level of situational interest and *students' level of conceptual understanding.*

The Personal Interest Survey results show an increase in students' interest in magnets and electricity (Tables 8 and 9). The Conceptual Understanding Assessment results show a substantial increase in students' level of conceptual understanding of electromagnetic induction (Figure 1).

Classroom observations showed that regardless of whether it was a discrepant event catching the students' attention as they began focusing their observational skills towards magnets and electricity, or whether it was their growing understanding of electromagnetic induction which made them more engaged in their independent investigations, there was strong supporting evidence for a positive correlation between students' levels of situational interest and their levels of conceptual understanding.

The results of this project support the theories of interest development and self-determination, and show the 5E model to be effective at increasing students' situational interest.

The biggest insight I gained from this project is that the interest I want my students to have in the knowledge and skills I am trying to impart to them can only come about if my students identify these knowledge and skills with their own wants and needs. This means that I need to be continuously listening and trying to understand what my students' needs and wants are, as I attempt to help them learn.

VALUE

The value of this research project is the focus on the actions I can take to increase students' situational interest in the topics presented in the classroom and to support students' interest development. The values of increasing students' situational interest and supporting students' interest development are increasing students' conceptual understanding and developing self-determined learners.

I have benefitted greatly from having read a plethora of research articles. I have developed an emerging personal interest in interest development, self-determination theory, Interest and Effort in Education by John Dewey, and the 5E model.

My pedagogy continues to benefit from the process of research, critical self-assessment, collegial interaction, and reform which has been spurred by this action research project.

One measure of this project's value will be if, in the future, ratings on my students' LSMs average over 5.00 each day for:

My teacher listened to how I would like to do things.

My teacher tried to understand how I see things before suggesting a new approach.

REFERENCES CITED

Ainley, M., Hidi, S., and Berndorff, D. (2002). Interest, learning, and the psychological processes that mediate their relationship. *Journal of Educational Psychology*, *94*(3), 545-561.

Akar, E. (2005). Effectiveness of 5E learning cycle model on students' understanding of acid-base concepts. *Dissertation Abstracts International.*

Assor, A., Kaplan, H., and Roth, G. (2002). Choice is good, but relevance is excellent: Autonomy-enhancing and suppressing teacher behaviors predicting students' engagement in schoolwork. *British Journal of Educational Psychology, 72*, 261-278.

Bergin, D.A. (1999). Influences on classroom interest. *Educational Psychologist*, *34*(2), 87-98.

Boddy, N., Watson, K., and Aubusson, P. (2003). A Trial of the Five Es: A referent model for constructivist teaching and learning. *Research in Science Education*, *33*(1), 27-42.

Buckley, S., Hasen, G., and Ainley, M. (2004). Affective engagement: A person-centered approach to understanding the structure of subjective learning experiences. *Paper presented at the Australian Association for Research in Education, Melbourne, Australia.*

Bybee, R.W., Taylor, J.A., Gardner, A., Van Scotter, P., Powell, J.C., Westbrook, A., and Landes, N. (2006). The BSCS 5E instructional model: origins and effectiveness, Colorado Springs:BSCS.

Chen, A., Darst, P.W., and Pangrazi, R.P. (2001). An examination of situational interest and its sources in physical education. *British Journal of Educational Psychology*, *71*(3), 383-400.

Csikszentmihalyi, M. (1975). *Beyond boredom and anxiety: Experiencing flow in work and play*. San Francisco: Jossey-Bass.

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

Deci, E.L., Eghrari, H. Patrick, B.C., and Leone,D.R. (1994). Facilitating internalization: the Self-determination theory perspective. *Journal of Personality*, *62*, 119-142.

Deci, E.L., Vallerand, R.J., Pelletier, L.G., and Ryan, R.M. (1991). Motivation and education: The self-determination perspective. *Educational Psychologist, 26*, 325

Dewey, J. (1913). Interest and effort in education. Boston: Riverside Press.

Ergin, I., Kanli, U., and Unsal, Y. (2008). An example for the effect of 5E model on the academic success and attitude levels of students':"Inclined Projectile Motion."*Journal of Turkish Science Education*, *5*(3), December 2008, 47-59.

Grolnick, W.S., and Ryan, R.M. (1987). Autonomy in children's learning: An experimental and individual difference investigation. *Journal of Personality and Social Psychology, 52*, 890-898.

Heiss, E.D., Obourn, E.S., and Hoffman, C.W. (1950). Modern Science Teaching. New York, NY: MacMillan.

Hidi, S. and Harackiewicz, J.M. (2000). Motivating the academically unmotivated: a critical issue for the 21st century. *Review of Educational Research*, *70*(2), 151-179.

Hidi, S. and Renninger, K.A. (2006). The four phase model of interest development. *Educational Psychologist*, *41*, 111-127.

Kang, H., Scharmann, L.C., Kang, S., and Noh, T. (2010). Cognitive conflict and situational interest as factors influencing cognitive change. *International Journal of Environmental and Science Education*, *5*(4), 383-405.

Krapp, A. (2002). Structural and dynamic aspects of interest development: theoretical considerations from an ontogenetic perspective. *Learning and Instruction*, *12*, 383-409.

Krapp, A., Hidi, S., and Renninger, K.A. (1992). Interest, learning and development. In K.A. Renninger, S. Hidi, and A. Krapp (eds). The role of interest in learning and development (pp 3-25). Hillsdale, NJ: Lawrence Erlbaum Associates.

Linnenbrink-Garcia, L., Durik, A.M., Conley, A.M., Barron, K.E., Tauer, J.M., Karabenick, S.A., and Harackiewicz, J.M. (2010). Measuring situational interest in academic domains.*Educational and Psychological Measurements*, *XX*(X), 1-25.

Litman, J.A., and Jimerson, T.L. (2004). The measurement of curiosity as a feeling of deprivation. *Journal of Personality Assessment*, *82*(2), 147-157.

Mitchell, M. (1993). Situational interest: Its multifaceted structure in the secondary-school mathematics classroom. *Journal of Educational Psychology*, *85*, 424-436.

National Research Council (NRC). (2006). America's Lab Report: Investigations in High School Science. Committee on High School Science Laboratories: Role and Vision, S.R. Singer, M.L. Hilton, and H.A. Schweingruber, Editors. Board on Science Education, Center for Education, Division of Behavioral and Social Sciences and Education. Washington, D.C: The National Academies Press.

Naylor, F.D. (1981). A state-trait curiosity inventory. *Australian Psychologist*, *16*(2), 172-183.

Reeve, J. (2002). Self-determination theory applied to educational settings. In E.L. Deci and R.M. Ryan (Eds.) Handbook of self-determination research (pp183-203). New York: University of Rochester Press.

Reeve, J. and Jang, H. (2006). What teachers say and do to support students' autonomy during a learning activity. *Journal of Educational Psychology, 98*, 209-218.

Rotgans, J. and Schmidt, H.G. (2010). The role of teachers in facilitating situational interest in an active-learning classroom. *Teaching and Teacher Education*, *27*(2011), 37-42.

Ryan, R.M. and Deci, E.L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology, 25*, 54-67.

Schraw, G., Flowerday, T. and Lehman, S. (2001). Increasing situational interest in the classroom. *Educational Psychology Review*, *13*(3), 211-224.

Stefanou, C.R., Perencevich, K.C., DiCintio, M., and Turner, J.C. (2004). Supporting autonomy in the classroom: Ways teachers encourage student decision making and ownership. *Educational Psychologist, 39*, 97-110.

Tobias, S. (1994). Interest, prior knowledge, and learning. *Review of Educational Research*, *64,* 37-54.

Tsai, Y., Kunter, M., Ludtke, O. Trautwein, U., and Ryan, R.M. (2008). What makes lessons interesting? The role of situational and individual interest factors in three school subjects. *Journal of Educational Psychology*, *100*(2), 460-472.

APPENDICES

APPENDIX A

LESSON SPECIFIC MEASUREMENT

Name_______________________________________ Date________________

Lesson Specific Measurement

Participation is voluntary, and you can choose to not answer any question that you do not want to answer, and you can stop at any time. Your participation or non-participation will not affect your grade or class standing.

Directions: Please circle the word(s) that best describe your response to each of the following statements.

I enjoyed today's lesson.
Disagree strongly/Disagree/Disagree slightly//Agree slightly/Agree/Agree strongly

Today's lesson was interesting to me.
Disagree strongly/Disagree/Disagree slightly//Agree slightly/Agree/Agree strongly

The topic was meaningful to me.
Disagree strongly/Disagree/Disagree slightly//Agree slightly/Agree/Agree strongly

It was important to me that I thoroughly understood the material studied.
Disagree strongly/Disagree/Disagree slightly//Agree slightly/Agree/Agree strongly

I saw that the content of today's lesson can be useful in real life.
Disagree strongly/Disagree/Disagree slightly//Agree slightly/Agree/Agree strongly

I felt that my teacher provided me choice and options.
Disagree strongly/Disagree/Disagree slightly//Agree slightly/Agree/Agree strongly

I felt understood by my teacher.
Disagree strongly/Disagree/Disagree slightly//Agree slightly/Agree/Agree strongly

My teacher conveyed confidence in my ability to do well in this lesson.
Disagree strongly/Disagree/Disagree slightly//Agree slightly/Agree/Agree strongly

My teacher encouraged me to ask questions.
Disagree strongly/Disagree/Disagree slightly//Agree slightly/Agree/Agree strongly

My teacher listened to how I would like to do things.
Disagree strongly/Disagree/Disagree slightly//Agree slightly/Agree/Agree strongly

My teacher tried to understand how I see things before suggesting a new approach.
Disagree strongly/Disagree/Disagree slightly//Agree slightly/Agree/Agree strongly

My teacher expected split-second answers.
Disagree strongly/Disagree/Disagree slightly//Agree slightly/Agree/Agree strongly

My teacher's instructions were so vague that nobody knew what to do.
Disagree strongly/Disagree/Disagree slightly//Agree slightly/Agree/Agree strongly

My teacher assigned so many tasks that we had difficulty keeping up.
Disagree strongly/Disagree/Disagree slightly//Agree slightly/Agree/Agree strongly

My teacher was mean to a student.
Disagree strongly/Disagree/Disagree slightly//Agree slightly/Agree/Agree strongly

We worked through investigations that helped us understand the topic.
Disagree strongly/Disagree/Disagree slightly//Agree slightly/Agree/Agree strongly

Different students presented their findings to the same investigation.
Disagree strongly/Disagree/Disagree slightly//Agree slightly/Agree/Agree strongly

My teacher set tasks that required time to reflect.
Disagree strongly/Disagree/Disagree slightly//Agree slightly/Agree/Agree strongly

My teacher emphasized the relationships between the topics investigated.
Disagree strongly/Disagree/Disagree slightly//Agree slightly/Agree/Agree strongly

Please add any additional comments regarding today's lesson and /or this survey here:

APPENDIX B

MELBOURNE CURIOSITY INVENTORY

Name_________________________________Date______________

Melbourne Curiosity Inventory-Trait Form

Participation is voluntary, and you can choose to not answer any question that you do not want to answer, and you can stop at any time. Your participation or non-participation will not affect your grade or class standing.

Directions: A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you generally feel.

There are no right or wrong answers.

Do not spend too much time on any statement, but give the answer which seems to describe how you generally feel.

1=Almost never 2=Sometimes 3=Often 4=Almost always

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1. I think that learning "about things" is interesting and exciting 1 2 3 4
2. I am curious about things……………………………………...1 2 3 4
3. I enjoy taking things apart to "see what makes them tick"……1 2 3 4
4. I feel involved in what I do……………………………………1 2 3 4
5. My spare time is filled with interesting activities……………..1 2 3 4
6. I like to solve problems that puzzle me………………………..1 2 3 4
7. I want to probe deeply into things……………………………..1 2 3 4
8. I enjoy exploring new places…………………………………..1 2 3 4
9. I feel active…………………………………………………….1 2 3 4
10. New situations capture my attention…………………………..1 2 3 4
11. I feel inquisitive………………………………………………..1 2 3 4
12. I feel like asking questions about what is happening………….1 2 3 4
13. The prospect of learning new things excites me……………….1 2 3 4
14. I feel like searching for answers……………………………….1 2 3 4
15. I feel absorbed in things I do…………………………………..1 2 3 4
16. I like speculating about things………………………………...1 2 3 4
17. I like to experience new sensations…………………………….1 2 3 4
18. I feel interested in things………………………………………1 2 3 4
19. I like to enquire about things I don't understand………………1 2 3 4
20. I feel like seeking things out…………………………………...1 2 3 4

APPENDIX C

CONCEPTUAL UNDERSTANDING PRE AND POST-ASSESSMENT

Name____ Date________________

Conceptual Understanding Pre- & Post-Assessment

Please carefully observe and perform the demonstration.

Briefly describe what you observe. (Tell me what you saw).

Explain, as best you can, what you have observed. (Tell me what you think is causing this to happen).

APPENDIX D

PERSONAL INTEREST SURVEY

Name____ Date_____________

Personal Interest Survey

Participation is voluntary, and you can choose to not answer any question that you do not want to answer, and you can stop at any time. Your participation or non-participation will not affect your grade or class standing.

Directions: Please circle the word(s) that best describe your response to each of the following statements.

Magnets interest me.
Strongly disagree/Disagree/Slightly disagree/Slightly agree/Agree/Strongly Agree

I often play with magnets.
Strongly disagree/Disagree/Slightly disagree/Slightly agree/Agree/Strongly Agree

I want to learn more about magnets.
Strongly disagree/Disagree/Slightly disagree/Slightly agree/Agree/Strongly Agree

Understanding magnets is important to me.
Strongly disagree/Disagree/Slightly disagree/Slightly agree/Agree/Strongly Agree

Understanding magnets can be useful outside of class.
Strongly disagree/Disagree/Slightly disagree/Slightly agree/Agree/Strongly Agree

Electricity interests me.
Strongly disagree/Disagree/Slightly disagree/Slightly agree/Agree/Strongly Agree

I often play by building electric circuits or devices.
Strongly disagree/Disagree/Slightly disagree/Slightly agree/Agree/Strongly Agree

I want to learn more about electricity.
Strongly disagree/Disagree/Slightly disagree/Slightly agree/Agree/Strongly Agree

Understanding electricity is important to me.
Strongly disagree/Disagree/Slightly disagree/Slightly agree/Agree/Strongly Agree

Understanding electricity can be useful outside of class.
Strongly disagree/Disagree/Slightly disagree/Slightly agree/Agree/Strongly Agree