ENGAGING DISINTERESTED MIDDLE SCHOOL SCIENCE STUDENTS

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Abstract

Engaging Disinterested Middle School Science Students

Students are at many times not focused on certain areas of study. I hypothesized that there would be middle school-aged students who claim to be disinterested in their science class. Additionally, I thought that these disinterested students might best be engaged in scientific learning by the use of more physically active, fun classroom exercises to teach science concepts and skills. I used qualitative student surveys to assess self-perception of science interest, enjoyment, and success in science classes both before and after lessons uniquely-designed to either be more or less physically engaging. I show by these surveys and through quantitative assessment of student learning that 1.) there were students who self-identified as disinterested in science and 2.) overall test scores went up on average following one of two more active science lessons on human body systems. I show that student self-perception of enjoyment of their science class is closely associated with their interest in the class, and that students claimed to be more interested in the more physically engaging lessons in post-lesson surveys given following assessment. There is incentive to make science lessons physically engaging and thus more enjoyable and interesting to middle school science students, as this perception can bear academic fruit if lessons are designed appropriately.

Table of Contents

List of Figures

List of Tables

Introduction

Sarah, whose name is changed here, was not interested in her junior high science class. She was focused on deepening her understanding of the basics: reading, writing and arithmetic. While Sarah understood science was important, she wasn't interested in science class mostly because she didn't see how it applied to her personally. Her prior instruction had primarily been informational lecture and experimental observation; there was no active participation. What if her teacher could better engage her in the lessons to motivate her to want to learn related concepts, such as scientific inquiry? Moreover, Sarah might learn critical thinking skills that are important in any class or field if she were better engaged in science class.

Even if Sarah does not wish to pursue further scientific studies or a science-related career, it could serve to deepen an interest in other important subjects used in these classes, such as mathematics. It is important that educators engage students in fields such as science, as research indicates U.S. students are being outpaced in other parts of the world, in particular in Asia and parts of Europe, per Trends in International Mathematics and Science Study for eighth graders (TIMSS, 2007).

I observed Sarah grow from a disinterested, quiet participant in one of my small, discovery-based science classes to an enthusiastic member of her cohort. What was it that Sarah didn't like about this subject before she joined my class? How was she engaged in such a way that moved her from disinterest to enthusiasm? Sarah now claims that she enjoys the field of science, and is interested in possibly becoming a doctor one day. What more could a science teacher want but to actively move disengaged students –

whether it be because of negative preconceptions about science, learning challenges or special needs, or distraction and boredom – to a place of enthusiasm and learning?

I am interested in moving disinterested or disengaged science students from a place of inaction to action, triggering active and motivated learners. Parker Palmer (1997) in his book *The Courage to Teach* describes a teacher's tendency to mischaracterize students as "brain-dead patients" when it appears many students are, among other things, "… bored and passive in situations calling for action…", while also saying

> our assumption that students are brain-dead leads to pedagogies that deaden their brains. When we teach by dripping information into their passive forms, students who arrive in the classroom alive and well become passive consumers of knowledge and are dead on departure when they graduate. But the power of this self-fulfilling prophecy seems to elude us: we rarely consider that our students may die in the classroom because we use methods that assume they are dead. (1997, p. 42)

We must actively engage these students. However, for those students who are engaged in their science classes, we must make it more than just an exciting experience. In an environment where science has been popularized over the past several years on television and in music by *Sid the Science Kid*, Bill Nye, *MythBusters*, the band They Might Be Giants, or in local science museums where more and more activities look to wow children with the "whiz-bang factor" of science, there are students who need other forms of engagement in order to elevate science education to more than just a fun project. A science teacher must find a balance where fun equals effective learning. In this study I considered ways science teachers can engage students who claim to be disinterested in science at the junior high level.

I first hypothesized that there would be students who were not interested in junior high science. Secondly, I believed those students least interested in science would most effectively learn the subject when taught using methods that actively engaged them (while also having addressed the needs of the rest of the class). It was supposed that these students would likely enjoy the "hands-on" or more active science most, and that science would become more personal with active participation in aspects of lessons. These disinterested students were thought to be more likely to perform better during assessments based upon their newfound interest and enjoyment of the science lesson.

Literature Review

It was important to understand why junior high students may or may not be interested in science classes by becoming familiar with research focused on factors affecting student interest in those classes. I first reviewed research of student learning styles that related to my hypothesis that more active teaching styles may better engage these students. I also used educational research literature to examine ways of adding "active learning" to lessons, as well as sample lessons from education researchers who have sought to better engage students in classes, science or otherwise. Assessment of what was done regarding student interest in junior high science classes was performed. This included studying literature that evaluated student interest in science classes, an exploration of student attitudes about science in and out of the classroom, as well as a final section on adding active interest in science classes.

Learning Styles and Assessment

There was little research available dedicated specifically to the physical or active learning aspect of teaching junior high science. Most of the research appeared to be dedicated to more traditional active learning styles derived from constructivist teaching methodologies, and therefore traditional teaching methods that might best meet the specific needs of disinterested science students was examined along with common learning styles. The importance of different styles of student assessment became a common theme in these studies, and thus was also reviewed.

There was some controversy as to the relevance of more traditional teaching styles. Merri Lynn Casern (2006) stated that "active learning" is typically defined as student-centered instructional design using frequent assessment to provide both student and instructor with a measure of student achievement and comprehension of course concepts. This study examines how frequency of assessment impacts learning in an undergraduate biology course employing a student-centered, active learning pedagogy. This research indicated that student performance during assessments was slightly better under the high-frequency versus traditional examination schedule. Frequent assessment also appeared to have altered the predictive relationship between the GPA of a student and their performance in this course. The conclusion from this study was that the most effective pedagogy is one that combines student-centered, active learning with frequent assessment. There was no mention of laboratory experimentation or other "hands-on" activity adding interest to the educational process, however as undergraduate college students they likely did not need this stimulus.

Assessment was further explored in *Assessment for Learning in Biology Lessons* (Gioka, 2007). Overseas secondary science teachers were observed for this study and conclusions recommended that these teachers utilize elements of assessment more frequently during their lessons. This would be easy to employ in a science class as the teacher moves throughout the classroom when a project is underway. Gioka argued that for science teachers to use assessment for learning in biology education, a clear understanding of the intended quality of performance on investigations is a prerequisite. Additionally, a conclusion was that teachers must understand the subject matter well. Furthermore, it is explained how teachers may develop good questions and written feedback while grading tests. It is clear assessment is a valuable component to any lesson that is meant to engage the student well, and if science students are truly bridging fun with learning during their bench work then the moment of discovery and learning must be captured as it happens.

Kirschner, Sweller, and Clark contribute more to this discussion in their research *Why Minimal Guidance During Instruction Does Not Work: An Analysis of the Failure of Constructivist, Discovery, Problem-based, Experiential, and Inquiry-based Teaching* (2006). Kirschner et al.'s review, while not focused on science, is telling in that one cannot teach with minimal guidance alone; that is to leave the students to primarily their own devices to discover how a concept or skill should work is not effective. Evidence for the superiority of guided instruction is explained in the context of knowledge of human cognitive architecture, expert–novice differences, and cognitive load. The authors demonstrate that unguided or minimally guided instructional approaches are very popular and intuitively appealing, because these approaches ignore both the structures that constitute human cognitive architecture and evidence from empirical studies over the past half-century that consistently indicate that minimally guided instruction is less effective. Furthermore, their research shows approaches that place a strong emphasis on guidance of the student learning process are more effective. The advantage of guidance begins to recede only when learners have sufficiently high prior knowledge to provide "internal" guidance.

Richard Mayer supports the notion that "discovery learning" and "discovery teaching" leave a great deal to be desired (2004). In this context, along with terms such as "inquiry-based learning," "discovery learning" or "discovery teaching" is the act of teaching students with minimal guidance. The prevalent thought is that students learn better without rote memorization, and without receiving the answer or expected outcome before trying to learn it for themselves. Mayer finds that constructivist-based discovery learning styles of teaching suffer from a lack of student guidance. Piecing this with the assessment component examined above, it is clear that the science teacher must be present in order to shape and analyze student progress during active learning.

I learned from Mehmet Bahar that it is difficult to tie learning styles to classroom work performance (2009). Effective teaching and learning of science depends on the selected teaching method appealing to as many students' learning styles as possible, but this is difficult to accomplish without an accurate assessment of actual learning styles. According to Bahar, in a summary of the past two decades of several studies related to learning styles in all fields of education, there are many tests and many learning styles – more so than it would be feasible to determine fully in a classroom environment without the use of such testing models and scales as the Gregorc Model, Myers-Briggs Type Indicator, the Felder-Silverman Learning Style Model, and so on. Just the Gregorc and Felder-Silverman models alone describe learning styles such as concrete sequential, abstract sequential, abstract random, sensing/intuitive, visual/verbal, inductive/deductive and active/reflective. One learning style model reviewed by Bahar (2009), the Grasha-Riechmann Model, is unique in that it is based on students' responses to actual classroom activities rather than a more general assessment of personality or cognitive traits. Bahar demonstrates a correlation of certain learning styles based upon the Grasha-Riechmann Model with student participation in mini science projects, and ascertained that certain learning styles were stimulated by these projects and had higher degrees of achievement, and that student enjoyment of the projects correlated with achievement.

Lastly, while the study *The Active Classroom* (Mulrine, Prater & Jenkins, 2008) focuses on learning using physically active methods to engage students, it does so in the context of teaching Attention Deficit Hyperactivity Disorder (ADHD) children. These children are already quite active by nature. The authors note that all teachers face challenges related to promoting success of a diverse group of students and they explore some of the most common problems teachers face when dealing with students who have ADHD and discuss the benefits that exercise (physical activity) offers all students. They also offer suggestions on how to incorporate exercise into daily classroom activities. Many of the tips described in this article are beneficial in any classroom, to maximize an active learning environment. Some of these ideas include the teacher moving around the classroom while teaching, having students standing up and moving around – e.g. giving them the job of collecting and handing out papers and moving classroom activities outside. These ideas could be applied to making a junior high science class more engaging, by simply getting the students more physically involved in their lessons.

Student Interest in Science

The comprehensive study *Factors Affecting Junior High School Students' Interest in Biology* (Trumper, 2006), conducted in Israel, is very relevant to my project given the junior high study population and the examination of the population's interest in biology. This research showed that the students' overall interest in learning biology was relatively positive but not high and girls showed greater interest than boys. Students' interest in learning biology correlated closely with their negative opinions of science classes.

Edwin Vineyard conducted a historical study of interest in 1959. Vineyard describes how personal differences may account for student personalities that are more interested in science, or better suited to studying science when comparing non-science and science majors at the early college level. Vineyard's findings showed that science majors tended to be impulsive or to be moderately serious and restrained. While this study was done with an older population of students, it may be helpful to target those students' personalities who are less impulsive or less serious when attempting to garner interest in junior high science classes.

Adding Active Interest in the Science Classes

There are education research studies that demonstrate how to add interest to science classes. For example, photographs were shown in case studies to promote active learning among biology students (Krauss, Salame, & Goodwyn, 2010). These researchers state that interpreting a photograph creates an instinctive and easy way for students to develop their deductive and inductive reasoning. Krauss et al. adds that while case studies contribute to any style of teaching and help students develop a better understanding of difficult subjects, photographic case studies can be easily used to teach a wide variety of subjects in science. The personal effort exerted by educators as the most important aspect of using photographic case studies is also discussed.

Additionally, Simon Lei (2010) describes how learning is best served when students are mentally and physically (actively) participating in the process. This study reviews the benefits and drawbacks of traditional (off-campus) field trips and suggests that "on-campus" field trips may provide an ideal solution to many of the drawbacks of traditional field trips, while retaining most of the benefits of traditional field trips. This ties in well with the physically active learning principals from Mulrine's "Active Classroom" research, and would allow for more frequent inclusion in traditional life sciences curricula at reduced expense.

Lastly, while "Adventure Learning" is defined as lessons that often expose students to a certain amount of perceived risk to engage them, such as rock climbing to learn more about geology, or climbing a mountain in a far off region to learn more about social studies, Daniel Moos and Brian Honkomp's research on motivating middle school students presented a case for more physical and active student involvement in the inquiry process (Moos & Honkomp, 2011). Moos and Honkomp determined using qualitative and quantitative methods among other outcomes that adventure learning had a strong effect on student motivation, and therefore learning success.

Attitudes Toward Science

In a fascinating overseas (United Kingdom) study, Judith Bennett and Sylvia Hogarth present *Would You Want to Talk to a Scientist at a Party? High School Students' Attitudes to School Science and to Science* (2009). Because this is a UK study, junior high school students (ages 11 -14 years here) are referred to as high school students, so the ages studied are very relevant to my research. The data presented from Bennett and Hogarth's (2009) comprehensive qualitative and quantitative study reveal that these students' positive attitudes to school science declines significantly between the ages of 11 and 14 years, and contradicting Trumper's (2006) work on student interest in science, female students show less positive attitude than males. Nevertheless, the students as a whole appreciated that science was important outside of the classroom.

Finally, research demonstrating the benefits of having high school students intern in biology laboratories was explored (Roth, Eijck, Hsu, Marshall & Mazumder, 2009). While not specific to junior high students, Roth et al. describe some of the positive benefits of having students work in a laboratory setting including creating a more positive attitude towards university science, negating stereotypes about science and laboratory practice, gaining insight into what laboratory science entails and allowing students to reflect on their own academic and career goals. Some of these principals could be applied to further engaging junior high biology students.

Lessons to Engage the Science Student

Many lesson plans published in various education research journals are helpful when considering classroom activities to help engage science students. Published works such as Chandrakanth Emani's *Using the 'DNA story' to inculcate a scientific thought process in the classroom* (2010) and Anthony Curtis' *A Lesson on Evolution and Natural Selection* (2010) demonstrate ways to engage scientific thought process and active learning techniques respectively.

In summary, my literature review has revealed that little has been done to research and address the needs of junior high science students, let alone engaging disinterested junior high science students. However there are components that can be included or created to more actively engage these students as described in the lessons section. While Trumper's (2006) research is specific to this age-range of students, it does not go beyond simply establishing that these students' interest in biology class is closely tied to their opinion of science. Bahar's (2009) research is fascinating because it correlates learning success with activities in the classroom. It offers some hope to teachers, most of whom instruct a classroom full of diverse learning styles, and suggests that most student personalities can be reached with well designed, engaging lessons.

My research builds upon Trumper's study by not only establishing a similar correlation in a junior high science class in the U.S., but also by applying physically active and engaging lessons designed to potentially improve interest in the subject matter and learning of scientific concepts. I am also inspired in my research by works such as Bahar's to create lessons that engage students who may not otherwise be interested in science and encourage learning success.

Research Question

In light of this review of the literature, I was led to the following research questions. Foremost, "Would original and engaging, physically active lessons generate better opinions of classroom science and therefore increase student interest and learning in this subject?" Secondary questions that arose included: "Are there junior high students who claim to be disinterested in science in a U.S. science class?" Additionally, "If there were students who claim to be disinterested in classroom science, why did these students claim to be disinterested?" Is this because, as Trumper suggests in his study in Israel, that negative opinions about science have resulted in disinterest?

Methodology

Method/Rationale

My conclusion based upon both Mayer's (2004) and Kirschner, Sweller, and Clark's (2006) research is that physically active, "hands-on" science projects and experiments in class must be guided well to arrive at the desired teaching objective(s), to most effectively engage as many students as possible. Additionally, because of work such as that by Trumper (2006) and Bahar (2009), I was inspired to design original lessons that might prove to interest and physically engage students thereby increasing successful learning as evidenced by better quiz scores and post-lesson analysis.

This project employed a mixed-method approach, using both qualitative and quantitative methodologies aimed at my research questions. Qualitative research involves the examination of the personal side of scientific inquiry (Hendricks, 2009). In this study, participants were surveyed, seeking to better understand their perceptions of science and their interest in the subject of science in school. While outside of the scope of this study based on Bahar's (2009) review of countless student personalities and learning styles, these students were also asked for their perception of their own learning styles based upon survey choices. Subjective responses are a hallmark of qualitative study; it is a valued component given the purposeful selection of the study population and that context is examined (Hendricks, 2009).

The use of a qualitative methodology was an appropriate way to determine student interest and to examine if students who identified as disinterested in science became more interested after a lesson that served to better involve them in the lessons presented in a follow-up survey. I used Likert Scales because they are a good way to would receive the more active version of this same lesson. Then the first period received a second but more active lesson on a different day with different learning targets, while the second period received the less active version of this same lesson. The relevant quizzes for the concepts taught in each of these lessons was given immediately following the lessons on the same day per the lesson plans attached (Appendices A and B).

Pre-lesson surveys were given to these same class periods prior to the lessons and quizzes (separate day), and post-lesson surveys were delivered to these same class periods on the day following the final lesson, with the hope that the students would not be unduly biased in their opinion of the most recent lesson if the survey was given on the same day the lesson was received. Six days passed from the administration of the pre-lesson survey to the delivery of the post-lesson survey. There were two days between the two lessons.

Sample

Seventh grade secondary students in two mixed-gender life sciences biology class periods were the study groups for this research project. While these entire class populations were surveyed before and after being given more or less active lessons and assessments, student data was only used for this study if parent or legal guardian consent was obtained. These students were from a closed-campus school in the Pacific Northwest of the United States. As I am interested in better engaging middle school science students and hope to teach life sciences students in this age group, this population was appropriate for this study.

Instrumentation

Using the lens of qualitative inquiry, surveys were employed that determined various factors including science students' opinions of science and self-perception of interest in science. Example statements included, "I am really interested in learning about science in this class." A Likert Scale was used to ascertain opinions about science class to give it a quantitative component whereby number values are assigned to a scale of possible feelings, e.g. "No interest in this science class," to "Extremely interested in this science class." Pre- and post-lesson surveys used can be found in the Appendices (Appendices C and D respectively).

A quantitative component then assessed all students' performance on quizzes based on lessons that used either more "hands-on" or physically active components, or more of a lecture-based participatory and sharing model. The final student questionnaire was then used to tie students' responses from the pre-lesson questions to this post-lesson evaluation as attached (Appendix D). The two lesson plans utilized are attached (Appendices A and B).

Quantitative responses to quizzes given immediately following either more traditional lecture-based versions of the Cardiovascular System Lesson (Appendix A) and the Digestive System Lesson (Appendix B) as opposed to similar lessons using more physically active methods to better engage students (see "ACTIVE MODULE" components to lessons in both Appendices A and B) were used to correlate performance on the quizzes to student interest based upon the pre- and post-lesson surveys. Information ascertained reviewing Casern's 2006 research reinforced the importance of timely assessment. These quizzes were assigned numerical grades and compared directly with one another, using central tendency analysis including mean, and standard deviation from the mean. The quizzes used following either the less active or more active lessons per above are attached as Appendices E and F.

Analysis/Validity

Qualitatively, after the surveys were completed, each item was analyzed separately and responses were summed to create measurements within groups of "Likert items" or "statements" as described previously.

Likert responses can be quantitatively evaluated by collating them into charts, and central tendency examined by the median or mode, and/or the mean responses. Responses to several Likert statements may be summed, providing that all statements use the same Likert scale and intervals of assessment. Statistical tests such as the Student t-test or analysis of variance could be applied to evaluate the significance of the responses.

For both qualitative and quantitative methods, coding was used to ensure that observer bias did not affect the acquisition of data or data quality. Students were assigned a number identifier, and that "Student Number" was used on the surveys and quizzes related to my project. A coded data key was used to link students to their assigned number codes; this key was kept separately from the researcher. The students always used the same identifying number to tie all of the qualitative and quantitative information together, thus ensuring validity and credibility of the data. It was important to ascertain whether or not those students who at first identified as disinterested or less interested in science could be tracked accurately through the study to determine if their interest level had changed after experiencing lessons taught with or without more engaging components. One student inadvertently changed Student Number to one used by another student (no. 10) after the Pre-Lesson Survey. Any subsequent work received using Student Number 10 was not included in subsequent analyses.

When considering Cardiovascular System Quiz score data, I eliminated questions 1 and 3 from consideration of any scoring or analysis given too little time to cover the material tested consistently during lessons for both compared class periods.

I came to this research project with bias as a former scientific researcher who has learned best throughout my years as a student and scientist by a process of hands-on experience. While it is clear from both my literature review and observance of other students' personal styles that we do not all learn alike, I believed that more active, hands-on participation would spark interest and improved learning in my study population.

Data

Data collected in this multi-part study (two class periods involved, with two separate lessons, surveys, and quizzes) were both qualitative and quantitative in nature. The qualitative survey responses were semi-quantitative in that Likert scales represent them, thus numbers are reported for these responses.

Figure 1 demonstrates student responses to the Pre-Lesson Science Interest Survey (Appendix C) given to both class periods of students who consented to the study.

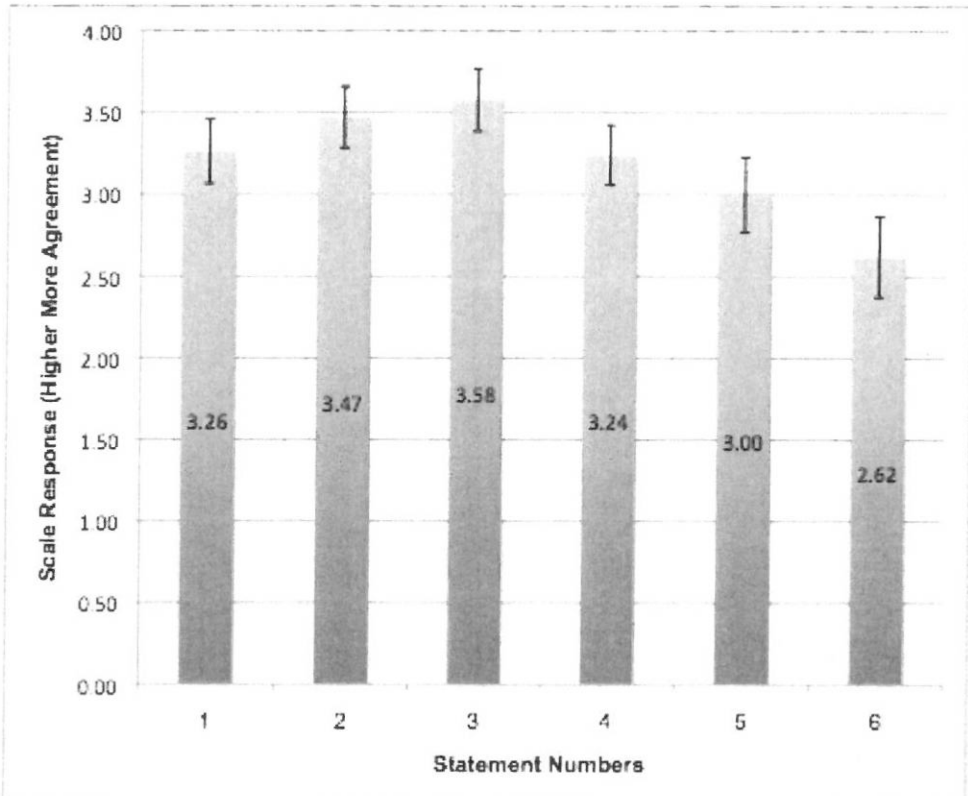

Figure 1. Mean Student Responses to Pre-Lesson Survey Statements for Both Classes Surveyed. N=38 students total. Labels within bars represent the mean Likert scale responses 1 – 5 in each group (y-axis range shows 0 – 4 since no mean response was above 4 and to facilitate comparison). Error bars represent standard deviation errors within each of these groups. Statement Numbers refer to the statements shown on Appendix C: Pre-Lesson Science Interest Survey.

Pre-Lesson Survey results were assembled to facilitate comparison for later analysis. Student-perceived enjoyment of their science class as compared with their interest in learning about science in their class is demonstrated in Figure 2.

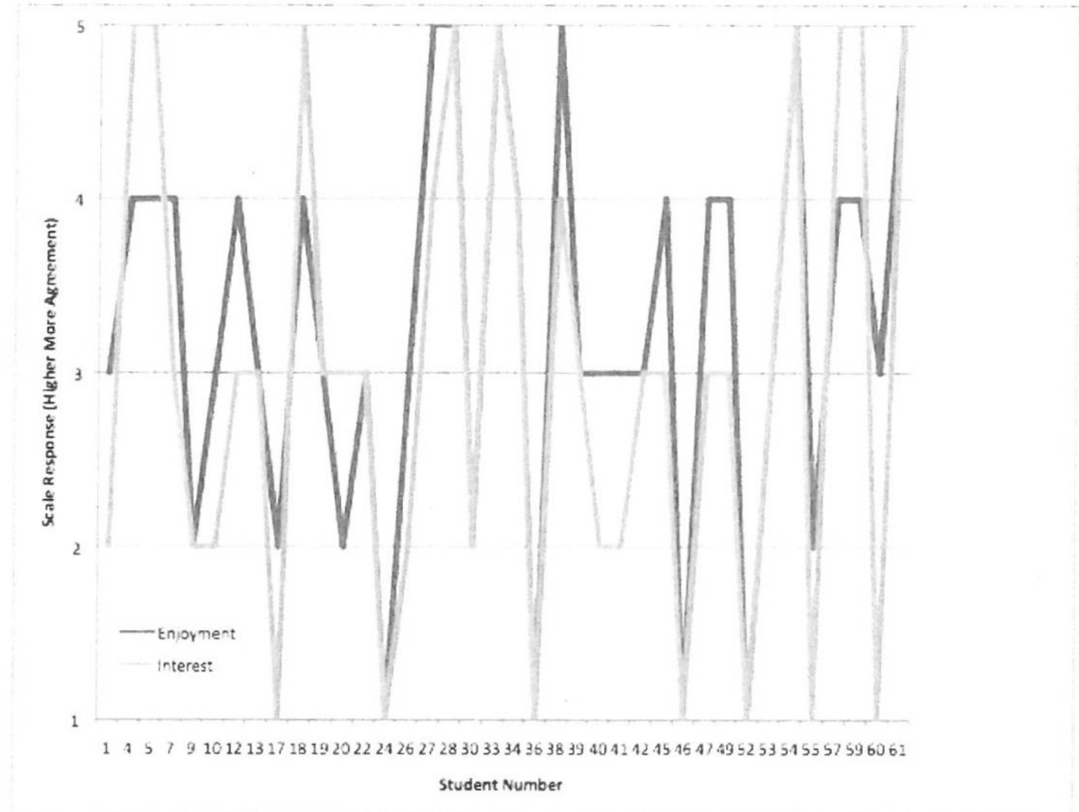

Figure 2. Pre-Lesson Survey on Student-Perceived Enjoyment of Science Class vs. Interest in Science Class. Student Likert Responses to Statements 1 and 5 (for both classes surveyed, respectively. n=38 students total. Lines connect the data points representing student responses between 1 and 5 to demonstrate similarity in student perception of enjoyment learning about science in this class (Statement 1) with perception of interest in learning about science in this class (Statement 2). See Appendix C: Pre-Lesson Science Interest Survey for full text of these statements.

Quizzes were scored following either less or more physically active and engaging lessons on the human cardiovascular and digestive systems respectively. As will be described in *Analysis*, not all of the cardiovascular system answers were scored on those quizzes. Select "Active Indicators" are presented for both the cardiovascular and digestive system quiz responses as described in *Analysis*.

Tables 1 and 2 are representative of individual student scores for the Cardiovascular System Quiz given to Period 5 (less physically active lesson) and Period 6 (more physically active lesson) respectively.

Table 1.

Less Active Class Period Cardiovascular Lesson Student Quiz Results

P.5 Student No.	Overall Score %	Active Indicator Q.2 %	Active Indicator Q.5 Correct?
1	86	100	
4	43	40	
5	71	60	+
7	71	80	+
9	14	0	
10			
12	12	0	+
13	57	60	+
17	86	100	+
18	43	20	+
19	88	100	+
20	71	60	+
22	86	100	
24	14	0	
26	100	100	+
27	40	0	+
28	43	20	+
30	86	80	+
mean	59.47	54.12	no. correct: 12/17
stDev	28.79	40.48	percent correct: 71
mode	86	100	

Note. P.5 (Period 5) was less active class period for this lesson, n=17 students scored. See Appendix E for quiz given to students. Overall Score % is representative of collective score students received on the test as graded (less questions 1 and 3). Active Indicator Q.2 % (Question 2) is percentage correct individual students received on this question (five possible answers). Active Indicator Q.5 (Question 5) was either answered correctly ("True") or not ("False"); a correct answer was given a "+" symbol. Grey bar is representative of no quiz taken by this student.

Table 2.

More Active Class Period Cardiovascular Lesson Student Quiz Results

P.6 Student No.	Overall Score %	Active Indicator Q.2 %	Active Indicator Q.5 Correct?
32	71	60	+
33	100	100	+
34	43	40	+
36	86	80	+
38	14	20	
39	43	40	+
40	29	0	+
41	71	60	+
42	71	60	+
45	100	100	+
46	43	20	+
47	57	80	
49	71	60	+
52			
53	14	0	+
54	100	100	+
55	57	40	+
57	71	100	NOT ANSWERED
59	100	100	+
60	100	100	+
61	100	100	+
mean	67.05	63.00	no. correct: 17/19
stDev	28.99	35.11	percent correct: 90
mode	100	100	

Note. P.6 (Period 6) was more active class period for this lesson, n=20 students scored. See Appendix E for quiz given to students. Overall Score % is representative of collective score students received on the test as graded (less questions 1 and 3). Active Indicator Q.2 % (Question 2) is percentage correct individual students received on this question (five possible answers). Active Indicator Q.5 (Question 5) was either answered correctly ("True") or not ("False"); a correct answer was given a "+" symbol. Grey bar is representative of no quiz taken by this student. Student No. 57 did not answer Q.5.

Figure 3 directly compares mean scores for both the less and more active cardiovascular lesson periods. Tables 3 and 4 are representative of individual student scores for the Digestive System Quiz given to Period 6 (less physically active lesson) and Period 5 (more physically active lesson) respectively.

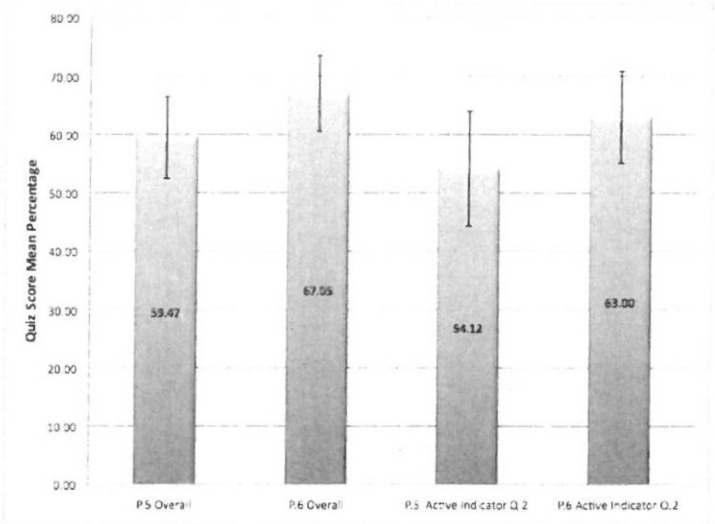

Figure 3. Mean Scores on Cardiovascular System Quiz for Periods 5 (Less Active) and 6 (More Active). P.5 (Period 5, n=17 students scored) and P.6 (Period 6, n=20 students scored) like mean data compared side-by-side. P.5 mean Overall Score is over 7 percentage points lower that P.6 Overall Score. P.5 Question 2 (Q.2) score is approximately 9 percentage points lower than the result on the same question taken by P.6 students who received the more active lesson.

Table 3.

Less Active Class Period Digestive Lesson Student Quiz Results

P.6 Student No.	Overall Score %	Active Indicator Q.1 Correct?	Active Indicator Q.3 Correct?
32	89		+
33	100	+	+
34			
36	67	+	
38			
39	89		+
40	67	+	
41	89		+
42	89		+
45	100	+	+
46	56		
47	78		+
49	67	+	
52	100	+	+
53	56	+	+
54	89	+	+
55	67		
57	100	+	+
59	100	+	+
60			
61			
mean	82.53	no. correct: 10/17	no. correct: 12/17
stDev	16.06	percent correct: 59	percent correct: 71
mode	89		

Note. P.6 (Period 6) was less active class period for this lesson, n=17 students scored. See Appendix F for quiz given to students. Overall Score % is representative of collective score students received on the test as graded. Active Indicator Q.1 (Question 1) was either answered correctly ("True") or not ("False"); a correct answer was given a "+" symbol. For Q.3 (Question 3), the Active Indicator was whether or not the student correctly understood that the Cardiac Sphincter (Valve) came before the stomach; a correct answer was given a "+" symbol. Grey bars are representative of no quiz taken by these students.

Table 4.

More Active Class Period Digestive Lesson Student Quiz

P.5 Student No.	Overall Score %	Active Indicator Q.1 Correct?	Active Indicator Q.3 Correct?
1	89	+	+
4	60		
5	78	+	
7	89		+
9	78	+	
10			
12	89	+	
13	67	+	
17	67	+	
18	67	+	
19	89	+	
20	100	+	+
22	89		+
24	22		
26	89	+	
27	100	+	+
28	100	+	+
30	100	+	+
mean	80.76	no. correct: 13/17	no. correct: 7/17
stDev	19.93	percent correct: 77	percent correct: 41
mode	89		

Note. P.5 (Period 5) was more active class period for this lesson, n=17 students scored. See Appendix F for quiz given to students. Overall Score % is representative of collective score students received on the test as graded. Active Indicator Q.1 (Question 1) was either answered correctly ("True") or not ("False"); a correct answer was given a "+" symbol. For Q.3 (Question 3), the Active Indicator was whether or not the student correctly understood that the Cardiac Sphincter (Valve) came before the stomach; a correct answer was given a "+" symbol. Grey bar is representative of no quiz taken by this student.

Figure 4 correlates student interest levels in science class before the more active cardiovascular lesson with interest following the lesson, as well as with student performance on a formative quiz following this lesson.

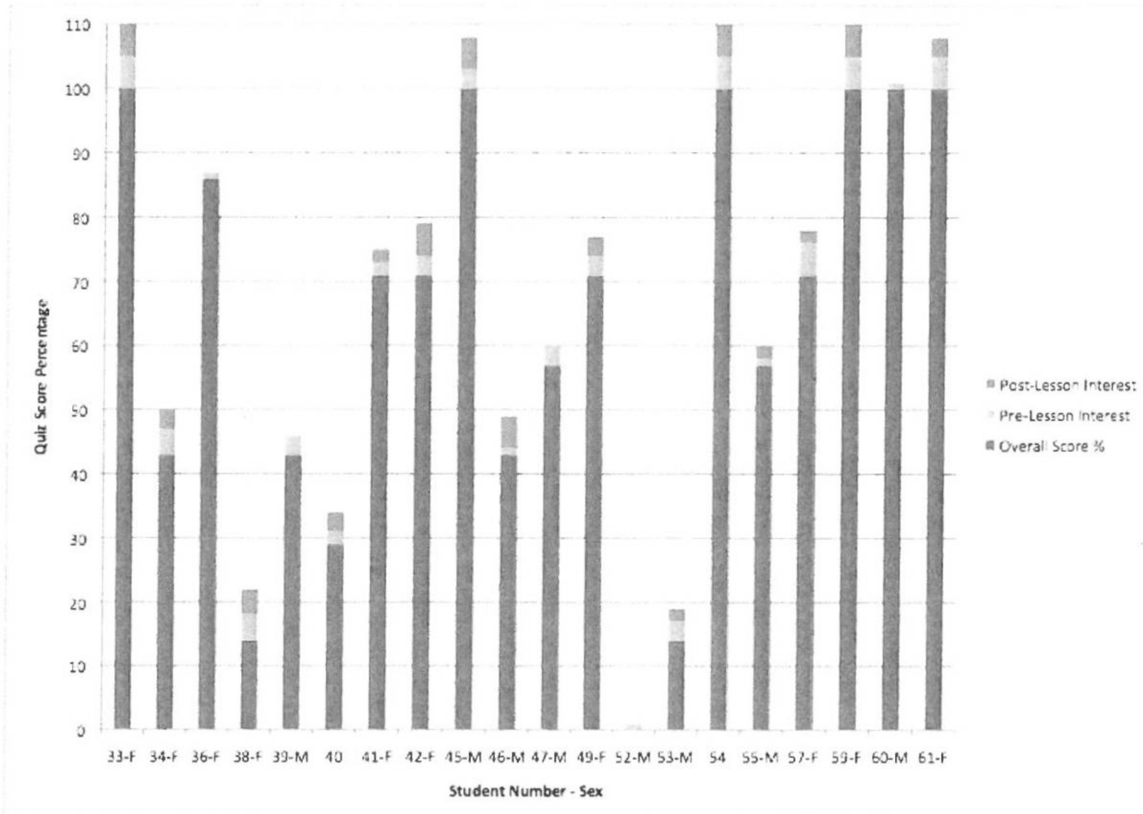

Figure 4. Active Cardiovascular System Lesson (Period 6) Interest Levels Correlated with Post-Lesson Quiz Scores. Period 6, n=20 students' data reported; Student No. 52 did not take test and had only the Pre-Lesson Interest survey data available. From bottom of figure, dark column represents overall Quiz Score Percentage as also reported in Table 2. The lightest column above this bar represents a histogram of Pre-Lesson Interest, while the topmost bar represents Post-Lesson Interest in this particular science lesson.

Figures 5 and 6 compare students' self-perception of enjoyment, learning, and interest following either a more active cardiovascular lesson and less active digestive system, or a more active digestive system lesson and less active cardiovascular system lesson respectively.

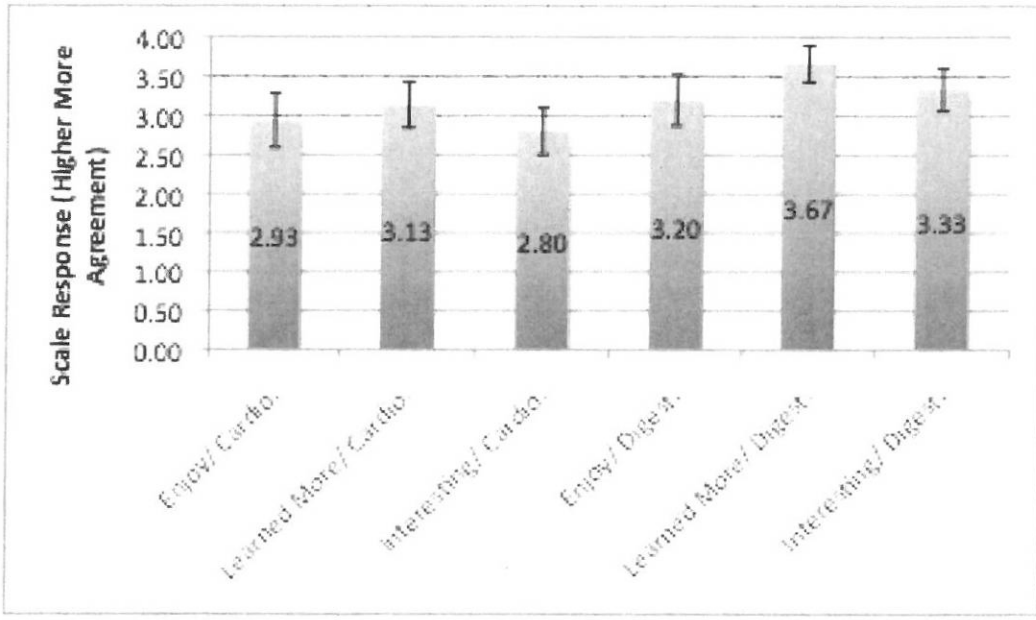

Figure 5. Period 5 Active Digestive System Lesson Post-Lesson Survey Levels Compared with Post-Cardiovascular System Lesson Impressions. Mean Student Responses to Post-Lesson Survey statements for class, n=15 students responded.

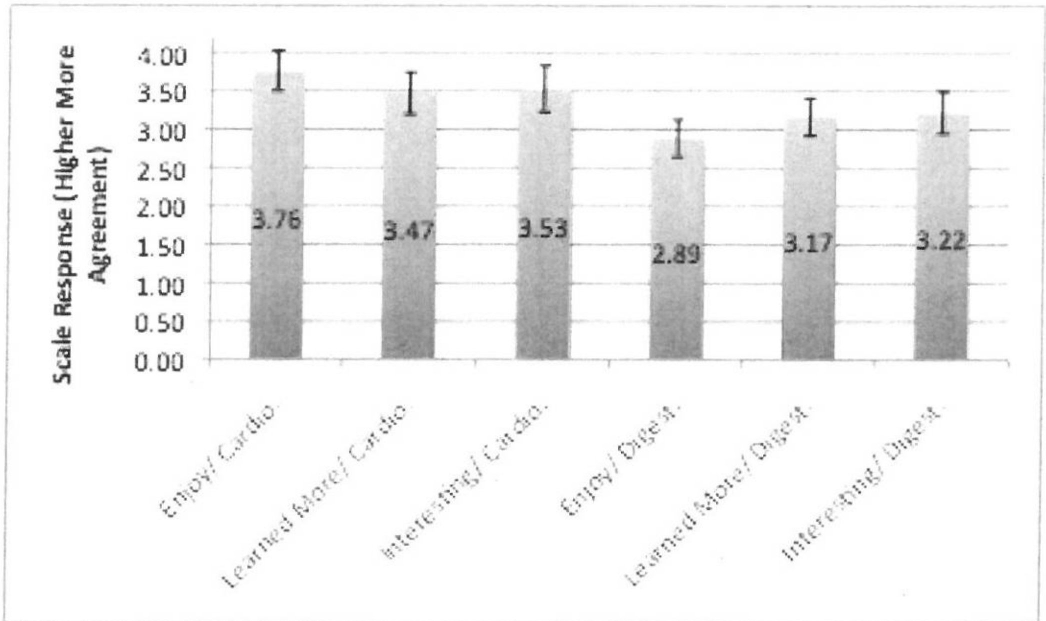

Figure 6. Period 6 Active Cardiovascular System Lesson Post-Lesson Survey Levels Compared with Post-Digestive System Lesson Impressions. Mean Student Responses to Post-Lesson Survey statements for class, n=18 students responded with one student only responding to the Digestive System half of the survey due to absence during the Cardiovascular System lesson/quiz.

Analysis

Figure 1 demonstrates data gathered from the Pre-Lesson Survey designed to give information on students' preconceived ideas and feelings about science and their middle school science class. This data shows that, on average, there are few extreme feelings in either direction when it came to the statements posed. Students agreed most with the third statement where they felt they get excellent grades in their class. Least agreement was subscribed to statement number six, indicating interest level in a future science-related field of employment. On average, feelings were generally neutral regarding all statements. The Pre-Lesson Survey did however demonstrate that there were disinterested middle school science students in the classes surveyed. Statement number six reflects an average level of "Neutral" or "No Feelings" regarding interest in science class from Figure 1, while Figure 2 demonstrates two students from the Period 5 class and five students from the Period 6 class who chose the lowest agreement rating for this statement ("Strongly Disagree"). These data support my hypothesis that there are middle school science students who self-identify as disinterested in science.

Figure 2 demonstrates a tight correlation of students' self-perceived level of enjoyment in science class with interest level in science class. The figure uses lines to connect data points within each series to better illustrate this pattern of similarity. Only a few data points diverge from one another for the same student, and when they do diverge it is only by a one-point scale rating.

Analysis of the cardiovascular quiz data is more in line with my hypothesis that there would be students who survey as interested in science lessons designed to physically engage them. For both the cardiovascular and digestive system lesson quizzes, I chose questions that might be more telling of success based on learning enhanced by more engaging activities. For example, the Cardiovascular System Quiz (Appendix E) questions 2 (Q.2) and 5 (Q.5) were enhanced by the students physically walking around the circulation pathway in the classroom and the physical reminder that only single red blood cells might pass though a capillary blood vessel when they squeezed between foam tubes to enter and exit "capillary beds" (details Appendix A), thus these questions were labeled "Active Indicators" of potential lesson influence. Likewise, the more active Digestive System Lesson was designed to demonstrate mechanical digestion in the stomach as well as to physically reinforce the name of the valve entering the stomach (details Appendix B), thus the Digestive System Quiz questions 1 and one part of question 3 (was the Cardiac Sphincter correctly identified as immediately preceding the stomach in the digestive tract?) were deemed "Active Indicators" respectively (Appendix F).

Thus when evaluating Tables 1 and 2 (Cardiovascular Lesson Quiz results), it is clear that mean overall quiz scores and Active Indicator scores are higher for the more active class period (Table 2). Comparison of overall quiz scores and Active Indicator Q.2 between the more active class lesson (Period 5) and the less active class (Period 6) is also illustrated in Figure 3, but side-by-side to see the difference more readily.

Figure 4 illustrates cases where student interest in the active lesson has increased post-lesson (Student Numbers 40, 42, 45, and 46) as compared with self-perceived interest with science in general, however only two of these students (42, 45) received scores greater than 50% on those questions evaluated.

Analysis of Digestive System lesson/student quiz results using the data assembled in Tables 3 and 4 reveal inconsistency as compared with the Cardiovascular System lesson results with regard to my hypothesis that students would be more engaged and therefore perform better on lessons designed to more actively involve them. Analysis of Variance (one-way) between overall digestive system quiz scores using data from these tables reveal a high p-value (p-level 0.78), thus there is no significant difference between overall class scores following the less active and more active lessons. What is more striking, the "Active Indicator" Question 3 (Q.3) component just assessing whether or not students understood the "Cardiac Sphincter (Valve)" is at the entrance of the stomach was only correctly answered 41% of the time following the active lesson, yet 71% of students got this indicator correct following the less active lesson. More confounding, the more active class did however get the first quiz question correct (Q.1) more often than the less active class (77% vs. 59% respectively); this was the question that asked about mechanical and chemical means of digestion (see Appendix F).

While it is evident more active lessons do not necessarily correlate with improved test scores, the reader will see with analysis of Figures 5 and 6 that student interest and enjoyment are enhanced using more active lessons. Though not that significant (standard deviation of the mean error bars overlap in some cases), all Post-Lesson Survey responses based on class averages were ranked "more agreeable" by Likert responses following both more active lessons (refer to Appendix D "Post-Lesson Survey" for detailed statements responded to). Validity of this result is enhanced due to the study of more than one class period of students.

Finally, based on these observations and analyses, it is interesting to note that students slightly preferred the active cardiovascular lesson (interest and enjoyment, Figure 6) to the more active digestive system lesson (Figure 5). The cardiovascular lesson was the more immersive and physical of the two active lessons given that there was more to do, explore, and learn (see Appendices A and B for lesson details).

Implications

Based upon the results of this study, the following is clear: there are middle school students who claim to be disinterested in their science classes, students perceive their enjoyment of science classes about the same way they perceive their interest in the same classes, physical activities such as acting out mechanical digestion in the stomach with classmates or narrowly passing between foam tubes representing close capillary walls may enhance learning as evidenced on quiz results, and overall enjoyment (correlated with interest) in individual, more active lessons can translate into better overall scores and individual concept understanding as evidenced by the data acquired from the more active cardiovascular lesson.

Less clear is the consistency with which students may respond to more physically engaging lessons. A small percentage of students, as Bahar indicated in his 2009 study, do not respond well to more involved or engaging activities, and it was unclear if this was the case in this study. It was impractical for me to test students for their individual learning style or personality profile, and I soon realized it was outside of the scope of this study to attempt to correlate survey findings or test results as compared to students' self-identified learning style based upon very limited survey choices, thus I disregarded the little learning style information I gathered.

It is difficult to explain the lack of consistency between the clear improvement students saw in the quiz results following the more active cardiovascular system lesson and the insignificant difference between overall scores when comparing the more or less active digestive system results. My feeling is that the cardiovascular system lesson was more involved and complex, thus the active components may truly have helped to reinforce concepts such as the path a red blood cell takes through the body and narrow capillary passageways. The digestive system lesson was less involved and students may not have needed the extra emphasis on concepts more active and involved lessons may offer. If anything, it seems the excitement students had to enter the stomach "mosh pit" may have distracted students from remembering the basic concept that they had stepped through a hula hoop representing the Cardiac Valve into the stomach (with a real pig heart representing a reminder to the proximity to the heart and thus a similar name – we had discussed what "cardiac" meant and its relationship to the heart)! Alternatively, even though students passed through a hula hoop representing this first valve into the stomach, only walking past the pig heart may not have been enough activity to help them to remember the name of the valve. Perhaps physical activity best reinforces physical concepts, and that the better "Active Indicator" may have been whether or not students understood a valve existed at the entrance to the stomach rather than its name.

Thus recommendations for use of this information include 1.) use more physically involved lessons to reinforce science concepts and skills because they add to student enjoyment and interest, 2.) minimize the number of learning targets during any given lesson – some targets may get lost in the excitement of the moment, and 3.) while there is evidence that suggests more physically active lessons increase learning and therefore performance during assessment, each lesson is unique and must be customized based on prior experimentation and actual student success.

A multifaceted study such as this would benefit from several more focused follow-up research projects where individual elements are examined (only tracking student interest and test results for example). Additional studies should employ larger study populations to increase validity of results, and future studies may benefit from lessons designed with fewer learning targets to better correlate student interest with more physically active lessons and learning outcomes.

Conclusion

In conclusion, the hypothesis that there would be students who self-identify as disinterested in science class was confirmed. Additionally, it was shown that student interest in science class is closely associated with their perception of enjoyment of science class. This is important to understand when teaching middle school science students, especially based on studies such as Judith Bennett's (2009) research demonstrating that it is students in this age-range who begin to lose interest in science in school. Educators must keep students engaged and enjoying science in order to help them succeed in future science classes, integrated subjects such as math classes during middle and high school, and beyond if students so choose. While I did not discuss the ramifications of the finding that students least agreed with the Pre-Lesson survey statement regarding a future science-related job, we may find that more interested science students through middle school translates into more high school graduates intent on eventual careers in the sciences.

At the outset I believed that at least some junior high students would self-identify as disinterested in their science class. My interest in bridging fun, engaging ways to bring science to life with the act of learning has demonstrated that students' enjoyment and perception of interest in science class is enhanced using appropriately designed lessons.

While I could not completely confirm my second hypothesis that those students least interested in science will most effectively learn the subject when taught using methods that actively engage them (while also addressing the needs of the rest of the class), it is clear that some students that had self-identified as disinterested in science class claimed to be more interested in lessons with more active components.

Students do in fact enjoy the "hands-on," more physically involved science most. These newly engaged and motivated students will likely stay more interested in science classes and thus have improved learning and understanding of scientific concepts and skills over time.

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Appendix A

More Active Cardiovascular Lesson (Period 6)

Curriculum Context: Within Human Body Systems Module

Short Term Learning Targets for this Lesson: Students will learn basic human circulatory pathway through the heart (including identification of its four chambers)/lungs/body from the point of view of a red blood cell and its oxygenation and de-oxygenation.

Middle School EALRs for this lesson: EALR 1 (Systems – SYS) – 6-8 SYSA (given a system, identify subsystems and larger encompassing system); EALR 2 (Inquiry – INQ) – 6-8 INQE (use model or simulation to represent the behavior of objects, events, systems, or processes); EALR 4 (Life Sciences – LS1) – 6-8 LS1C (explain the relationship between tissues that make up individual organs and the function the organ performs).

Assessment Plan: Formative Assessment (Appendix E) immediately following lesson on same day.

Student Self-Assessment/Reflection (Appendix D, "Post-Lesson Science Interest Survey" given following both Cardiovascular and Digestive System Lessons).

Teacher Tasks:

Before Class – Arrange classroom tables into four groups (two-person desks in groups of four; each group of four into quadrants for a total of four groups of four tables). From the front of the classroom, the right side two sets of table groups are covered in blue tablecloths, the left side tables are covered in red tablecloths. The right or blue side represents the deoxygenated right atrium and ventricle of the heart, the left or red side represents the oxygenated left atrium and ventricle of the heart. The left side of the room's countertop "lung station" demonstrates a "capillary bed" illustrated by blue table cloth on one side, red table cloth on the other. In the middle is a "lung model" used to illustrate negative pressure breathing. Poster boards are placed in the center of the four clusters of tables to label which chamber of the heart the students are "in" when they are at those tables. The "lung station" is labeled "lungs" as well. An audio track (loop) of a beating heart is played as students enter the room and during the active portion of the lesson. Poster board cut into strips with arrows on them are placed around the room to show the correct direction of blood flow/red blood cell travel.

During Class –

1. Show video to introduce cardiovascular system and oxygenation of blood:
    a. http://www.youtube.com/watch?v=D3ZDJgFDdk0

2. Resume heartbeat audio track. Darken room. Project picture of human brain cartoon on front wall of classroom. This has become the "head" of our classroom – thus completing the room's transformation into a simple model of the human cardiovascular system.

3. ACTIVE MODULE: Explain to the students that they will be acting the part of individual red blood cells and following the pathway of blood as it moves through the heart, lungs, and brain of our model system.

4. ACTIVE MODULE: Teacher asks for student volunteers to hold either blue WHAM-O® Pool Zone™ "Water Noodles" (long, colored foam tubes) at the entryway of the lungs (indicating deoxygenated blood in capillary bed entrance) or red foam tubes at the other end of the lung capillary bed. Likewise, pairs of students are asked to do the same with foam tubes at the entrance of the brain capillary bed and exit. Two students face each other with like-colored foam tubes

held vertically in front of them to create a narrow passage for individual blood cells (students) to pass through.

5. Teacher demonstrates the route a blood cell takes, first choosing to start in the right atrium of the heart. Walk the path the blood takes, moving from right atrium (tables) to right ventricle (tables), then to "blue side" of lungs, pass through blue foam tubes indicating entrance into the lung capillaries, pass through red foam tubes indicating new oxygenated status, return to heart via the left atrium (tables), exit heart by passing through left ventricle (tables) and proceed to "brain" at the front of the room. When entering the brain, pass through red foam tubes representing oxygenated red blood cell status upon entry into the brain cells, then pass through the blue foam tubes indicating loss of oxygen to the brain. Return to the right atrium table.

6. Show model of lung to demonstrate how the diaphragm muscle contracts to allow inhalation, and relaxes to allow exhalation. Replace this model in the "lung station" to show students where they can experiment with it while they are in the circulatory system.

7. Students are asked to return to their seats to prepare for quiz. Cardiovascular System is reviewed before giving quiz (Appendix E).

Student Tasks:

1. ACTIVE MODULE: Students form a line and act the part of red blood cells while passing though the same route the teacher demonstrated. Students pass though the entire model system circuit at least twice (depending on how many times they would like to).

2. Students stop and try out lung model while in the "lung" if they choose.

3. The students that held the foam tubes get to swap out their tubes walk through the system themselves at least twice at the end of the module.

NOTE: In the NON-ACTIVE classroom model (Period 5), the students do not take on the role of blood cells and walk the path of the circulatory system (nor do they go through the "capillaries"). Instead, they watch the teacher walk the circuit twice. The lung model is instead passed around the class.

4. The heartbeat audio track is turned off and the front screen image of the brain is turned off.

5. The circulatory route, along with the names of the four chambers of the heart, is reviewed.

6. The Cardiovascular System Quiz is given at the end of the class periods (Appendix E). The quiz should take approximately 5 minutes.

Appendix B

More Active Digestive System Lesson (Period 5)

Curriculum Context: Within Human Body Systems Module

Short Term Learning Targets for this Lesson: Students will learn basic human digestive organ system components and pathway through the body (including identification of valves entering and exiting the stomach) from the point of view of food). Students will understand the concept of mechanical vs. chemical digestion.

Middle School EALRs for this lesson: EALR 1 (Systems – SYS) – 6-8 SYSA (given a system, identify subsystems and larger encompassing system); EALR 2 (Inquiry – INQ) – 6-8 INQE (use model or simulation to represent the behavior of objects, events, systems, or processes); EALR 4 (Life Sciences – LS1) – 6-8 LS1C (explain the relationship between tissues that make up individual organs and the function the organ performs).

Assessment Plan: Formative Assessment (Appendix F) immediately following lesson on same day.

Student Self-Assessment/Reflection (Appendix D, "Post-Lesson Science Interest Survey" given following both Cardiovascular and Digestive System Lessons).

Teacher Tasks: Before class, arrange classroom such that there is space in the room to create a line of students moving into a "stomach area" such that as many students will fit as possible, but not everyone. This could be limited between a wall and a row of desks for example. Line of students should form to allow students to enter through one "valve" into the stomach, then out another valve into the rest of the classroom (the rest of the digestive system).

During Class –

1. Play audio loop of digestive/ gut noises in room as students enter for class and during active portion of the lesson. Not too loud to avoid distracting the students from the lesson, but to create a mood of anticipation and excitement about the lesson. Audio loop: http://www.freesound.org/samplesViewSingle.php?id=22134

2. Refer to students' health sciences textbook to illustrate major organs of the human digestive system. Show on front screen using document camera, figuratively walking the path of food as it is both chewed (mechanically digested) and instructing on the action of saliva/enzymes on the food (chemical digestion). Explain that the stomach also uses physical and chemical means of digestion. Move through the entire system including Cardiac Sphincter (Valve) into stomach and Pyloric Sphincter (Valve) out of stomach.

3. Students are shown two videos to illustrate the digestive system process:
   a. Video 1: http://www.youtube.com/watch?v=Uzl6M1YIU3w
   b. Video 2: http://www.youtube.com/watch?v=Z7xKYNz9AS0&NR=1

4. ACTIVE MODULE – Students are asked to form a line. Two student volunteers are requested to hold individual hula hoops, one on either "end" of the stomach area of the classroom. Students are asked to be their favorite food and pass first through the Cardiac Valve (first hula hoop) and into the stomach area once they have been swallowed. To further emphasize that this is the Cardiac Valve due to its proximity to the heart, a preserved pig's heart (vacuum packed) is placed on a stool near the "Cardiac Valve Hula Hoop." This is first explained to the students so they understand the relevance (heart = cardiac).

5. ACTIVE MODULE – Students are asked to squeeze as many can fit comfortably into the stomach area of the room. They then are encouraged to move around as if they are being mechanically digested. Not all students will fit into this stomach area, like real food. Students mosh around a bit, but this needs to be monitored to avoid too much physicality.

6. ACTIVE MODULE – Students then pass out of the stomach through the Pyloric Valve (second hula hoop), one at a time per instructions given before the line starts to move.

7. Students are asked to return to their seats to prepare for quiz. Digestive System is reviewed before giving quiz (Appendix F).

Student Tasks:

1. Per above except for class Period 6 (NON-ACTIVE model lesson). Period 6 does not perform "ACTIVE MODULE" steps, but instead teacher spends more time on traditional lecture about the path food takes in the human body. Students listen attentively during this time and take notes if they choose.

2. The Digestive System Quiz is given at the end of the class periods (Appendix F). The quiz should take approximately 5 minutes.

Appendix C

Pre-Lesson Science Interest Survey

Student Number: _______

Pre-Lesson Science Interest Survey

Scale Key
1 – Strongly Disagree
2 – Disagree
3 – Neutral (No Feelings)
4 – Agree
5 – Strongly Agree

A.) Please fill in your assigned "Student Number" above.

B.) Use the scale at right to describe your feelings about science and your science class. Circle the number that best corresponds to your feelings about each statement below. Your responses will be kept confidential.

Statement	Scale				
1.) I really enjoy learning about science in this class	1	2	3	4	5
2.) I really learn a lot in this science class	1	2	3	4	5
3.) I get excellent grades in this science class	1	2	3	4	5
4.) I will use the science I learn in this class again someday	1	2	3	4	5
5.) I am really interested in learning about science in this class	1	2	3	4	5
6.) I really want to be a scientist or medical professional someday (like a doctor, nurse, dentist or veterinarian)	1	2	3	4	5

C.) Circle the category below that best fits what you think your ideal learning style is:
1.) "Auditory" (learning by listening to your teacher)
2.) "Hands-on" (learning by doing something)
3.) "Visual" (learning by reading a book or looking at pictures on the board)
4.) "I don't know what my ideal learning style is yet."

D.) Circle whether you are: MALE or FEMALE

Appendix D

Post-Lesson Science Interest Survey

Student Number: _______

Post-Lesson Science Interest Survey

Scale Key
1 – Strongly Disagree
2 – Disagree
3 – Neutral (No Feelings)
4 – Agree
5 – Strongly Agree

A.) Please fill in your assigned "Student Number" above.

B.) Use the scale at right to describe your feelings about science and your science class. Circle the number that best corresponds to your feelings about each statement below. Your responses will be kept confidential.

Statement	Scale				
1.) I really enjoyed Lesson #1 (Heart/ Circulatory System)	1	2	3	4	5
2.) I learned more in Lesson #1 (Heart/ Circulatory System)	1	2	3	4	5
3.) Lesson #1 was very interesting (Heart/ Circulatory Sys)	1	2	3	4	5
4.) I really enjoyed Lesson #2 (Digestive System)	1	2	3	4	5
5.) I learned more in Lesson #2 (Digestive System)	1	2	3	4	5
6.) Lesson #2 was very interesting (Digestive System)	1	2	3	4	5

Appendix E

Cardiovascular System Quiz (Periods 5 and 6)

Cardiovascular System Quiz

1.) Circle: TRUE – or – FALSE

Arteries ALWAYS carry blood AWAY from the heart.

2.) Number in the correct order the path a Red Blood Cell (RBC) would take given these possible steps / location assuming the Right Atrium is first (#1):

__1__ Right Atrium

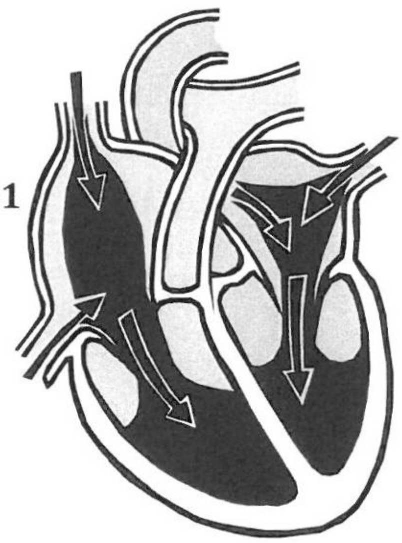
_____ Left Atrium

_____ Lungs

_____ Brain

_____ Right Ventricle

_____ Left Ventricle



3.) Fill in the blank with an underlined words about blood vessels:

Do veins or arteries tend to have valves? ____________________

4.) Fill in the blank with an underlined word: Do human lungs use positive or negative pressure to inflate? ____________________

5.) Circle: TRUE – or – FALSE

Blood vessel capillaries can be so narrow that they only let one Red Blood Cell pass at a time.

Appendix F

Digestive System Quiz (Periods 5 and 6)

Digestive System Quiz

1.) Circle: TRUE – or – FALSE

BOTH the mouth and stomach have mechanical AND chemical ways of digesting food.

2.) Think about digestion in the mouth. Write down one mechanical way and one chemical way that the mouth helps to digest food:

Mechanical: ______________________________

Chemical: ______________________________

3.) Write a number to indicate the correct order for the digestive system parts, beginning with the mouth:

__1__ Mouth

_____ Small Intestine

_____ Stomach

_____ Esophagus

_____ Rectum

_____ Large Intestine

_____ Cardiac Sphincter (Valve)