



## Self-Directed Activity-Based Learning and Achievement in High School Chemistry

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The effects of student-directed activity-based learning (SDABL) were examined in two high school chemistry classes. Students in the SDABL class were given pretest results, a list of standards to be mastered, and a chart of learning activities categorized by difficulty level. They selected activities to meet their needs and preferences. Significantly greater achievement gains and more consistent participation were found in the teacher-led instruction class. Overall, most students believed they learn better by teacher-led instructional methods. SDABL may have the potential to be effective in high school chemistry classes if more student preparation is part of the strategy.

### Introduction

Historically, education has maintained teachers as purveyors of knowledge and students as absorbers of information. Such passive learning can lead to factual regurgitation of new material rather than interpretation and application of acquired knowledge. According to Petress (2008), passively learned content is easily forgotten and ineffectively utilized. In contrast, synthesis of facts with prior knowledge, through active learning, creates a partnership between student and teacher that can lead to authentic achievement.

In the state where this research took place, completion of four science classes was a graduation requirement (Governor's Office of Student Achievement, 2010). A wide variety of science courses are offered in the state's high schools to provide students of different interests and abilities the chance to fulfill graduation requirements.

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Some courses offered include biology, physical science, chemistry, physics, earth systems, and environmental science. To make graduation a possibility for all students, teachers of science content could benefit from finding methods of encouraging active learning in the science classroom to ensure genuine science achievement.

In addition to fulfilling graduation requirements, science achievement is vital to the financial stability of the nation. The deficiency of technically trained people in the U.S. can be linked to inadequate science instruction, which affects the global economic standing of the U.S. (National Academies, 2005). Mathematics, engineering, technology, and science skills are increasingly more valuable in the workforce.

A deficiency in U.S. students' science achievement is evidenced by low test scores. In 2009, almost 500,000 students from 65 countries took the comprehensive Programme for International Student Assessment (PISA) test (Organisation for Economic Cooperation and Development, 2010), which measured students' ability to apply mathematics, reading and science concepts to real-life situations. PISA science scores of U.S. students ranked 17 out of 34 nations (Organisation for Economic Cooperation and Development, 2010). If U.S. students increased the average PISA score by 25 points over the next 20 years, the U.S. economy could gain \$41 trillion (Stanton, 2011). Improving science achievement is essential to the nation, as well as to the individual student.

In the state where this study took place, the Governor's Office of Student Achievement (GOSA) is responsible for reporting public school system data. The state administers End of Course Tests (EOCTs) after certain identified high school courses, including Biology and Physical Science, and these data provide evidence of problems with science scores. As shown in Table 1, a significant percentage of students failed the Biology and Physical Science EOCTs. Large discrepancies existed between failing rates of all students as compared to Hispanic students, students with disabilities (SWD), and economically disadvantaged students.

*Table 1. The Research School's Percentage of Failing Scores on the Biology and Physical Science EOCTs*

School Year		All Students	Hispanic Subgroup	SWD Subgroup	Economically Disadvantaged Subgroup
2009-2010					
	Biology	19	14	48	36
	Physical Science	15	21	31	24
2008-2009					
	Biology	24	43	53	45
	Physical Science	40	No data <sup>1</sup>	No data <sup>1</sup>	45
2007-2008					
	Biology	20	65	58	46
	Physical Science	21	36	57	38

<sup>1</sup> GOSA does not report on subgroups composed of fewer than 10 students.

Between 2008 and 2010, the percentage of failing scores for Hispanic students on Biology and Physical Science EOCTs significantly decreased, and in 2010, Hispanic students had a lower rate of failing scores than all students who took the Biology EOCT. There was a moderate decrease in percentage of failing scores for SWD and economically disadvantaged students on the physical science EOCT. There was minimal change in percentage of failures in biology for SWD and economically disadvantaged students. The percentage of all students who failed either EOCT fluctuated between 2008 and 2010.

The school where the research was conducted was in a suburban neighborhood near a southern metropolitan area. For the 2011-2012 school year, a goal of the school improvement plan for the research school included increasing the course passing rate to 95.5% for all students in all content areas. The school system in which the research school was located had recently increased the impact of summative (test) grades on final course grades. In previous years, summative grades had accounted for 60% of an overall course grade. Starting with the 2011-2012 school year, summative grades accounted for 75% of the final course grade. The school system had

increased the weight of summative grades to ensure that final course grades were indicative of true concept mastery.

Without concept mastery, facts could be merely memorized, true learning may not have taken place, and passing rates on high-stakes tests could not improve. Authentic learning lends itself to concept mastery, which is an important component of education. In February 2012, the state where this research was conducted received a waiver from the requirements of the No Child Left Behind (NCLB) legislation, which allowed teachers to focus on preparing students to become successful members of society, and reduced focus on test scores.

## **Review of the Literature**

### ***Understanding the Problem: Teachers***

The most recent National Survey of Science and Mathematics Education (NSSME), conducted in 2000, highlighted a great discrepancy at the elementary level in quantity of science instructional time in comparison to instructional time allocated to other subject areas (National Science Foundation, 2000). The NSSME report indicated that at the elementary level, science instruction averaged 23 to 31 minutes per day, mathematics instruction averaged 52 to 60 minutes per day, and language arts/reading instruction averaged 96 to 115 minutes per day (National Science Foundation, 2000). Lack of priority placed on science education at an early age reduces the perceived importance of science, and leads to deficiencies in knowledge that affect successive science classes (National Science Foundation, 2000).

Minimal emphasis on science education in elementary and middle school is frequently caused by lack of teacher training, confidence, and resources. According to NSSME, many elementary level teachers have taken few classes in science education. Of the elementary teachers surveyed, 56% completed six or fewer semester hours in science education, and only 4% earned a degree in science or science education (National Science Foundation, 2000). Statistics for teachers at the middle school level were similar.

At the high school level, teacher possession of in-field certification and college major are positively correlated to student achievement in mathematics and science (Morton, Peltola, Hurwitz, Oslofsky, & Strizek, 2008). The School and Staffing Survey conducted by the U.S. Department of Education during 2003–2004 assessed teachers' major and certification, and found that only 70% of high school science classes were taught by a teacher with both a major and certification in science (Morton et al., 2008). Furthermore, the same study found the following:

Among students in the subfields of science, only a majority of students in biology/life sciences classes were taught by teachers who were dually qualified in biology/life sciences (57 percent). A lower percentage of students in physical science (34%) and its further subdivisions (chemistry – 31%, Earth sciences – 27%, and physics – 30%) were taught by a teacher with both a major and certification in the specific subfield (Morton et al., 2008, p. 33).

### ***Understanding the Problem: Students***

Science achievement is also affected by circumstances outside of school. Sastry and Pebley (2010) indicated that parental education and socioeconomic status (SES) had a clear impact on science achievement. Poorly educated and lower SES families were frequently segregated into neighborhoods that lacked funds for quality recreation, day care, and public schools, which negatively impacted school achievement (Sastry & Pebley, 2010). At the research school, economically disadvantaged students had the lowest science achievement based on science EOCT scores.

In addition to having low SES, many Hispanic families have the added disadvantage of being uninformed about public schools (National Research Council, 2006), and public schools often lack resources to compensate for language barriers. The result of these deficiencies is that Hispanics are among the least educated people in the U.S.; over 25% of Hispanic adults have not been educated beyond ninth grade (National Research Council, 2006).

At the research school, SWD also had low science achievement based on science EOCT scores. Cawley, Hayden, Cade, and Baker-Kroczyński (2002) conducted a study of 114 junior high school

students to compare achievement in a general education science classroom containing on-level students versus a general education classroom with SWD inclusion. The researchers provided training to the teachers in implementation of “hands-on” learning in the science classroom, and teachers were instructed to utilize the methods for the duration of the school year. At the end of the school year, researchers measured achievement using a district benchmark and final class grades, and found achievement of SWD in a general education class was hindered by limited social skills, off-task behavior, and limited attention span; however, SWD were most successful when they worked collaboratively with general education students in the inclusion class (Cawley et al., 2002).

Nasr and Soltani (2011) found that general education students’ attitudes and achievement were also affected by peer interaction within the class. The research was conducted by studying the correlation between students’ attitudes toward biology and their biology achievement. In this study, attitudes were defined as students’ emotional responses to science, including whether or not they liked and enjoyed the subject (Nasr & Soltani, 2011). Surveys of attitudes and analysis of student achievement indicated that students tended to have more positive attitudes toward science when they were motivated to succeed in school, had a good self-concept, had an optimistic view of their school environment, were positively influenced from peer and parental perceptions of science, and enjoyed collaboration with peers during class (Nasr & Soltani, 2011).

A second study by Köse, Sahin, Ergün, and Gezer (2010) compared the effectiveness of cooperative learning versus direct instruction by analyzing attitude surveys and achievement scores of 68 eighth-grade science students. In contrast to direct instruction, in which the teacher organizes and presents the material, cooperative learning often begins with a teacher-provided knowledge base followed by student completion of various group-based learning tasks. Köse et al. (2010) found increased positive attitudes and achievement for students who learned collaboratively versus receiving direct instruction.

***Relevant Practices from the Research: Potential Strategies***

Until 2011, teachers were pressured to produce increasingly higher test scores to meet Adequate Yearly Progress and NCLB legislation. As a result there was a shift toward teaching with a focus on test results. With the state's waiver from NCLB, schools will now be assessed according to core content achievement data. To improve achievement, educators are expected to eliminate passive lecture and presentation style learning, which require only recall and recognition, and they must transition to using active learning tasks to improve thinking skills, concept mastery, and achievement (Pang, 2010). Active learning involves minimal passive listening and more engagement in activities that emphasize skill development and deeper thinking, with meaningful feedback being provided by the teacher (Bonwell & Eison, 1991). Two methods of active learning that are conducive to science education include self-directed learning (SDL) and activity-based learning (ABL).

In SDL, students take more responsibility for their own learning. After assessment of their prior knowledge, students are given the content standard goals, and they choose their own learning tasks. The small amount of large-group instruction in SDL serves mainly as introduction of new concepts. Teacher time is predominantly used for one-on-one and small-group instruction, as well as for facilitation of SDL. Chou and Chen (2008) analyzed quantitative data from six studies to determine the relationship between achievement and SDL. They consistently found a positive correlation between self-directed learning and academic success (Chou & Chen, 2008).

Orawiwatnakul and Wichadee (2011) analyzed the achievement of students with different learning styles using SDL. Over a 12-week period, 80 undergraduate college students from Business Administration and Communication Arts were taught English proficiency using SDL. Additionally, students took a survey to determine their learning style. Students of all learning styles scored significantly higher on the posttest than the pretest after learning the content by SDL in comparison to students who learned from traditional teacher-led instruction.

Activity-based learning is an applied approach to learning that interconnects with SDL. In ABL, students are permitted a choice among activities suited to their abilities and interests. Upon completion of an activity, the teacher can determine if further activities are necessary prior to assessing concept mastery. Hussain, Anwar, and Majoka (2011) randomly divided physics students into two groups to determine the impact ABL had on high school physics achievement. One group was assigned to ABL, and the other learned from teacher-based instruction. Results indicated that achievement was significantly higher for the ABL group (Hussain, et al., 2011).

### ***Limitations of previous research***

Although studies have been conducted to evaluate the effect of SDL or ABL on achievement, there is no specific research to compare the effectiveness of a combination of SDL and ABL, called student-directed activity-based learning (SDABL) in the high school science classroom. Most research of SDL spotlights college level students, which may stem from a belief that high school students may not be capable of directing their own learning. Very little research on ABL focused on high school science classes.

### ***Purpose of the Study***

The purpose of this study was to examine the relationship between student-directed activity-based learning, and student achievement in high school science classes. Specifically, student achievement was compared using student-directed activity-based learning versus teacher-led instruction. Students' participation and attitudes toward learning method in science courses were also examined. It was hypothesized that student-directed activity-based learning would improve science achievement.

### ***Research Questions***

*Research question 1.* Will there be a significant difference in achievement for high school science students when using student-directed activity-based learning as compared to teacher-led instruction?



*Research question 2.* Will attitudes toward student-directed activity-based learning be more positive than toward teacher-led instruction?

*Research question 3.* Will there be greater participation during student-directed activity-based learning or during teacher-led instruction?

### ***Definition of variables***

*Student-directed activity-based learning.* Student-directed activity-based learning (SDABL) is a fusion of delivery methods in which students choose their own progressively challenging learning activities to reach pre-stated goals. The teacher serves as facilitator, and provides minimal whole-class instruction; instructional time is generally reserved for small-group or one-on-one instruction.

*Teacher-led instruction.* Teacher-led instruction is a delivery method that is teacher-focused. A majority of class time is spent on teacher delivery of information, and the teacher determines learning tasks for all students. Usually tests are utilized to assess student comprehension.

*Achievement.* Achievement demonstrates content mastery and ability to apply knowledge to real-life situations. In this study, achievement was evaluated by comparing pretest and posttest scores on a content test.

*Attitude.* Student attitude refers to a student's opinion of the effectiveness of the instructional method applied to a class. In this study, student attitudes were measured by comparing results of surveys taken after the intervention.

*Participation.* Participation refers to the level of engagement of students who are involved in learning activities. In this study, participation was measured with an observation checklist.

## **Methods**

### ***Participants***

This study took place at a suburban high school. According to the U.S. Census Bureau (2012), the population of the county in which

the school was located was 175,511; the median household income in 2010 was \$87,605, with 6% of the population below the poverty level. Of adults over 24 years old, approximately 91% had graduated high school, and 44% had graduated with a Bachelor's degree or higher (U.S. Census Bureau, 2012). As Sastry and Pebley (2010) indicated, low SES and low parental education have a negative impact on science achievement.

According to the Governor's Office of Student Achievement (2010), the high school had a student population of 2,165 students in 9th through 12th grade. Roughly 14% of the students qualified for gifted services, and 11% of the students were served by the special education staff. Of the population, 87% were White, 9% were Hispanic, 2% were Multiracial, 1% was Asian, 1% was Black, and 1% was Native American/Alaskan Native (Governor's Office of Student Achievement, 2010).

The student-directed activity-based learning class contained 24 students, and the teacher-led instruction class also contained 24 students. The gender and subgroup breakdowns for each class, as well as previous achievement scores, are shown in Table 2. Analysis of the demographic data led to the conclusion that the composition of the two research classes was similar to that of the school, and that the student populations in the two classes were similar to each other.

Students were randomly assigned to the teacher-researcher by the counseling department, using an automated class scheduling program. It was expected that relevant variables would be approximately equal between the classes in the intervention and control groups; however, because convenience sampling was used, and randomization of individuals was not possible, information was collected on each child to determine whether the classes were similar enough for comparison. Data gathered for each student included gender, grade level, race/ethnicity, eligibility for free or reduced-price lunch, disabilities, eighth-grade Criterion-Referenced Competency Test (CRCT) scores for both Mathematics and Science, and End of Course Test scores for a previous science course, Biology.

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All students were required to master the same standards during the study. Chemistry is very mathematics-intensive; therefore, the most recent individual student scores on the CRCT for Science and Mathematics were obtained. The CRCT is a state-mandated test for first through eighth-grade students to assess student acquisition of content knowledge as defined by state standards. Both classes were taught by the teacher-researcher, the only adult participant in this study. The teacher-researcher had 13 years of teaching experience, including 8 years at the high school level, and all of that teaching experience had been in science.

*Table 2. Demographic Data for Student-Directed Activity-Based Learning Class and Teacher-Led Instruction Class*

Demographic	Student-Directed Activity-Based Learning Class (n = 24)	Teacher-Led Instruction Class (n = 24)
Gender		
Male	12	11
Female	12	13
Grade		
10	14	16
11	7	8
12	3	0
Race/Ethnicity		
White	17	19
Hispanic	4	4
Multiracial	2	1
Asian	0	0
Black	1	0
Native American/Alaskan Native	0	0
Subgroup		
Economically Disadvantaged	0	0
Students with Disabilities	1	0
Gifted	5	3
Achievement		
Mean Biology EOCT Score	88%	87%
Mean Science CRCT Score	847	847
Mean Mathematics CRCT Score	853	851

### ***Intervention***

Participants in this study were high school Chemistry students. A quasi-experimental design was chosen for this study because use of existing class assignments minimized potential for educational disruption (Creswell, 2007). The intervention for this study was the different instructional method utilized to teach the same content to both classes.

All students received the same test on the same days before and after the intervention. The teacher-researcher administered the multiple-choice Chemistry of Matter Test before instruction to determine baseline data for both groups at the beginning of the 9 weeks. The topics covered during the 9-week period included introductory science concepts, matter classification, atomic structure, and electron configurations.

After a brief introduction to the central ideas of the unit, students in the student-directed activity-based learning (SDABL) class were given the results of their pretest and a list of standards they were expected to master using SDABL techniques. Using SDABL, students were responsible for monitoring their own learning and selecting appropriate learning activities for their needs and preferences. For the Chemistry of Matter unit, students received a chart that provided a variety of learning activities categorized by level of difficulty. Students were instructed to choose progressively more complex activities according to which seemed most enjoyable and beneficial to the individual student.

Students in the teacher-led instruction class were taught the standards using traditional, teacher-centered lecture and demonstration. Students were given once-a-week opportunities to practice skills in teacher-chosen laboratory activities. In addition, individual and group assignments were selected by the teacher. Students were not given choice of activities, and activities were not differentiated based on students' prior knowledge indicated by pretest scores.

At the end of the 9 weeks, students took the same Chemistry of Matter Test as a posttest. In both classes, the teacher-researcher also utilized the Attitude of Instructional Delivery Method Questionnaire,

which students completed after the intervention to assess attitudes toward the instructional method used with their class. An Observation Checklist was utilized to record student participation and to document student behaviors during the various instructional methods.

### ***Data Collection***

To determine the effectiveness of self-directed activity-based learning on science achievement, the teacher-researcher used three data collection instruments.

*Chemistry of Matter Test.* At the beginning of the 2012-2013 school year, and prior to week 1 of the research, the Chemistry of Matter Test was administered as a pretest to students in both the SDABL class and teacher-led instruction class. The same Chemistry of Matter Test was administered as a posttest at the end of the intervention. The test consisted of 32 multiple-choice questions covering analysis of data, properties and changes of matter, atomic structure, and electrons. The test was scored according to the percentage of questions answered correctly. The Chemistry of Matter Test was created using ExamView Test Builder database that accompanied the Chemistry textbook (McGraw-Hill, 2007). The results of the changes in score from the pretest to the posttest for both classes were compared using a two-tailed t-test and the accompanying descriptive statistics. The results were used to determine whether or not the method of instruction made a significant difference in the students' achievement.

*Attitude of Instructional Delivery Method Questionnaire.* After the intervention, all study participants took the Attitude of Instructional Delivery Method Questionnaire (AIDMQ). The purpose of the survey was to measure students' attitudes about the effectiveness of the instructional delivery method used in their class. The survey consisted of 10 Likert-scale questions, with 1 = strongly agree and 5 = strongly disagree. Survey questions were adapted from the Perceptual Learning Style Preference Questionnaire, developed by Reid (1984). Content validity was established by three field studies conducted by Wintergest, DeCapua and Verna (2002). Percentages of students who chose responses were computed and used to

compare student attitudes toward instructional method between the SDABL class and the teacher-led instruction class.

*Observation Checklist.* The teacher-researcher used the Observation Checklist to record participation by students in both classes throughout the intervention. The observation checklist was taken from Township High School (2011). Student comments, attitudes, and behaviors that were documented in the checklist were coded and interpreted. Patterns of participation were the focus of analysis of the actions of all students. Actions of students in the SDABL class were compared to actions of students in the teacher-led instruction class to compare the levels of participation.

## **Results**

Test scores, attitudinal surveys, and observation checklists were utilized to determine if student achievement in high school science classes was higher when student-directed activity-based learning (SDABL) was implemented as the instructional method in comparison to teacher-led instruction (TLI). Students in both the SDABL and TLI classes were administered the same pretest. The SDABL class used the results of the pretest, and a list of standards they were expected to master, to guide their selection of progressively more complex learning activities based on their needs and preferences. The TLI class was taught in the traditional manner, with the teacher providing whole-class instruction and choosing learning activities for the entire class. Learning activities were not differentiated based on pretest results in the TLI class. At the end of the study, the scores from the Chemistry of Matter Test, administered as a pretest and posttest, were compared to determine if student achievement was higher with use of the SDABL instructional method. Students in both the SDABL and TLI classes took the same attitudinal survey at the end of the study. Observation checklists were the data instrument used to help the researcher analyze student participation in both groups of participants.

### ***Achievement data analysis***

First, pretest and posttest scores for both the SDABL class and the TLI class were compared to determine whether both classes made

significant gains during the study. The mean scores for the pretests were compared to mean posttest scores, and in both classes, the posttest scores were significantly higher than the posttest scores (see Table 3). Significant gains in content knowledge were made for both the student-directed activity-based learning class ( $p < 0.0001$ ) and the teacher-led instruction class ( $p < 0.0001$ ). The conclusion drawn from these data is that both instructional methods provided for a statistically significant gain in student achievement. That growth should be expected when comparing pretests and posttests on content to which students have not been previously exposed.

*Table 3. Pre-Post Scores for SDABL and TLI Classes*

Class	Test	<i>M</i>	<i>SD</i>	<i>t</i> -value	<i>p</i>
Student-directed Activity-based Learning	Pre	54.04	12.73	-13.37	<.0001**
	Post	92.88	6.36		
Teacher-led Instruction	Pre	43.58	9.42	-20.33	<.0001**
	Post	92.54	7.11		

\*\* $p < .01$

Cohen's *d* was calculated to determine the effect size of SDABL on students' science achievement. The SDABL instructional method had a large effect on the posttest performance of students ( $d = 3.94$ ). This finding does indicate significant growth in science achievement for students in the SDABL class. Cohen's *d* was also calculated to determine the effect size of TLI on students' science achievement. The TLI instructional method also had a large effect on the posttest performance of students ( $d = 5.99$ ). Students in classes with both instructional formats made significant growth in science achievement; both instructional formats had a very large practical effect on achievement scores.

Mean changes in scores from pretest to posttest assessment for both SDABL and TLI classes were then compared to determine whether either of the classes made significantly greater gains than the other, and those results are reported in Table 4. The mean increase in test scores for the TLI class ( $M = 48.95$ ,  $SD = 9.42$ ) was significantly higher ( $p = 0.0038$ ) than the mean increase in test scores for the SDABL class ( $M = 38.83$ ,  $SD = 12.73$ ).

Table 4. Pre-Post Gain Scores: SDABL vs. TLI Classes

Class	<i>M</i>	<i>SD</i>	<i>t</i> -value	<i>p</i>
Student-directed Activity-based Learning	38.83	12.73	-3.04	.0038**
Teacher-led Instruction	48.95	9.42		

\* $p < .05$ ; \*\* $p < .01$

Cohen's *d* was used to calculate the effect size of TLI instruction on test score gains. In comparison to SDABL, use of the TLI instructional method had a large effect ( $d = 0.92$ ) on gains in test scores. An average student (normally scoring at the 50th percentile) in the TLI class would be expected to have greater test score gains than approximately 82% of students in the SDABL class. Results of the comparison of pretests and posttests for the two groups revealed significantly greater gains in knowledge of chemistry for the teacher-led instruction group than for the student-directed activity-based learning group.

### ***Student Attitudes***

A survey was administered to both classes at the end of the study to measure students' attitudes toward the instructional delivery method applied to their class, as well as toward the instructional delivery method they did not experience. The first three statements measured attitude toward SDABL instructional methods, and the last three statements measured attitude toward TLI type of instructional methods. For analysis, the categories of agree and strongly agree were collapsed into one group of positive responses, and the categories of disagree and strongly disagree were collapsed into a group of more negative responses. Results from the survey are reported in Table 5.

Examination of the responses to the first three questions leads to the conclusion that students in the SDABL class were more likely to agree with statements indicating preference for teacher-led instructional activities rather than SDABL-type of learning activities. Students in the SDABL class, who had experienced a choice of learning activities, were uncertain (61%) or disagreed (26%) with the statement that they preferred to learn by choosing from a list of learning activities. Only 13% of students who were able to choose learning activities were positive toward that learning opportunity, while 59% of students who had not experienced choice responded that they would prefer that method.



*Table 5. Percentage of Students in Both Classes Choosing Each Rating on Student Surveys*

Statement	SDABL Ratings			TLI Ratings		
	SA/A	UC	SD/D	SA/A	UC	SD/D
I prefer to learn by choosing from a list of activities to do in class.	13%	61%	26%	59%	33%	8%
I learn more by reading things than by listening to lectures.	17%	57%	26%	8%	46%	46%
I learn more when I can make or build something.	61%	35%	4%	79%	21%	0%
I understand material more by reading what the teacher writes on the board.	39%	48%	13%	13%	50%	37%
I learn better in class when the teacher lectures or explains things.	74%	22%	4%	67%	25%	8%
I understand things better when the teacher has the class do a lab activity.	53%	30%	17%	58%	42%	0%

Only a few students in each group (17% of SDABL and 8% of TLI) agreed or strongly agreed that they learned more by reading than by listening to lectures, but there was strong support from SDABL (61%) and from TLI (79%) groups for the effectiveness of active (making or building) learning. Additional student support for teacher explanations was shown in the fifth item. Over half of the SDABL respondents indicated that they learn better when the teacher explains things, and when the class completes a teacher-chosen lab activity. Most students in both classes agreed that they learn better when the teacher explains things, and disagreed that they learned more by reading than by listening to lectures. Students who had experienced SDABL expressed a preference for a more teacher-directed style of learning. Students in the TLI class did not indicate a clear preference for either type of learning activity, but did lean toward the descriptions of the method that they had not experienced.

### ***Student Participation***

The researcher used observation checklists during the study to evaluate student participation in both classes. Students were

observed to determine whether their talking and writing were on-task, and whether they were listening or distracted (daydreaming or with their heads down). The researcher initially noticed more on-task behavior in the SDABL class in comparison to the TLI class. After the first week, the off-task behavior in the SDABL class gradually increased, while the on-task behavior in the TLI class remained consistently high. By the end of the 9-week study, data showed student participation in the SDABL class to be minimal in comparison to participation in the TLI class.

### **Discussion and Conclusions**

To determine if student-directed activity-based learning (SDABL) improved science achievement of high school students in comparison to teacher-led instruction (TLI), the researcher evaluated test score gains from a pretest and posttest. Analysis of data from the pretest and posttest did not support the idea that SDABL would improve science achievement for high school students. Although the SDABL class had a higher mean pretest score ( $M = 54.04$ ) than the TLI class ( $M = 43.58$ ), the mean posttest score for the SDABL class ( $M = 92.88$ ) was almost the same as the mean posttest score for the TLI class ( $M = 92.54$ ). Test score gains for the SDABL class ( $M = 38.83$ ) were compared with test score gains of the TLI class ( $M = 49.85$ ), and statistically significantly higher gains were made by students in the TLI class. Results of this study did not match findings of the study conducted by Hussain et al. (2011), in which activity-based learning led to significantly higher achievement than that of students assigned to teacher-based instruction, nor does it agree with the study conducted by Chou and Chen (2008), which found a positive correlation between self-directed learning and academic success.

Based on survey results, students who had experienced student-directed activity-based learning were less positive about independent learning activities than were students who had not experienced that instructional format. Students in both classes agreed that they learn better when the teacher explains things and has the class perform a lab activity. This finding was different from the study conducted by Köse et al. (2010), in which increased positive attitudes and greater

achievement were observed for students learning by methods other than direct instruction.

As shown by data from observations, the researcher noticed a decline in student participation for those in the SDABL class. These results may be attributed to the fact that high school students lacked the ability to accurately self-assess and select appropriate learning activities.

Often, high school students are most familiar with passive learning, in which the teacher delivers content while students quietly listen. This approach to teaching “has been used for many years...because it provides a convenient and expeditious mode to impart knowledge” (Michel, Carter & Varela, 2009, p. 400). Consequently, several studies have been conducted to examine the effectiveness of alternative, more active teaching methods. According to Michel, et al. (2009), although studies have generally reported results in favor of active learning methods, the data in support of these findings is mainly qualitative and fails to measure student learning outcomes.

By implementing student-directed activity-based learning (SDABL) in a high school science class, it was quantitatively determined that, for these students, achievement was greater with teacher-led instruction (TLI). The test score gains were significantly higher for students in the TLI class ( $M = 48.95$ ) when compared to test score gains of students in the SDABL class.

A factor that may have influenced results was the researcher’s lack of training in facilitating a student-directed method of instruction. Overcoming students’ tendencies to rely on the teacher for continuous step-by-step guidance was a challenge for the teacher-researcher and may have affected the achievement of the SDABL class.

### ***Implications and Limitations***

The implications of this study are important for the research school because the intervention was found to have a less positive impact on science achievement than traditional teacher-led instruction. In this study, the higher achievement with teacher-led instruction provides quantitative data that should be compared to the qualitative research

in support of student-directed activity-based learning method of instruction. Results of the attitudinal survey indicated that many students preferred teacher-led instructional methods over student-directed activity-based learning method. Furthermore, researcher observation logs indicated more consistent participation during the teacher-led instruction class when compared to student-directed activity-based learning. Although there is a wide variety of teaching methods, the findings of this study support teacher-led instruction, as opposed to student-directed activity-based learning, in these high school science classes.

The restricted time in which this study was conducted, the limited content that was covered, and the small sample size allowed for minimal data collection. Future studies could be conducted over a longer period of time, over a wider variety of content, and with a larger sample size to yield more reliable results. Additionally, the pretest and posttest only assessed content knowledge acquisition, and did not take into consideration the difficult-to-measure science process skills that may have been more powerfully developed during the student-directed activity-based learning.

### ***Future Research***

While the results of this study indicate that teacher-led instruction was more effective in terms of achievement and participation in these high school science classes than student-directed activity-based learning, more research is needed to determine the most effective teaching methods in upper level science classes. Present findings that conflict with some of the contemporary studies would suggest the need for ongoing review and it is understandable that there is a need for further discourse. As Pang (2010 ) points out, it is possible that “The learner has adapted to a passive learning environment where...information is imparted through lecture and PowerPoint presentations rather than interpretive and application skills developed through activity-based learning” (p. 38). As for what is known now, it remains difficult to determine the specific best practice, yet the current work clearly speaks to the continued need for multi-faceted instruction strategies in which there is no one-size-fits-all teaching method.

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