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Effects of Learning Styles on Academic Achievement in a Middle School Science Classroom

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Abstract This research was designed to investigate the relationship between learning styles, multiple intelligences, and academic achievement in a middle school science classroom. Specifically, this research addressed the following research question; Does student learning style play an important role in the academic success of students in an eighth-grade science classroom? To determine answers to these questions a careful review of the relevant psychology was performed, followed by a comparison of learning styles and academic achievement. Participants consisted of 66 eighth grade students in an urban middle school in the midwestern United States. To determine individual learning styles participants completed The Kolb Learning Style Inventory. Participants answered a set of questions using a Likert scale; results are placed along a plane in two dimensions, from concrete experience to abstract conceptualization, and from active experimentation to reflective observation. Results grouped participants into one of four quadrants: activist, pragmatist, theorist, or reflector. Academic success was measured using a summative post-test designed to measure student understanding of concepts covered during the unit. To examine the relations among academic achievement (as measured by a unit test score) and four learning styles (i.e., Activist, Theorist, Pragmatist, and Reflector), several analyses were conducted. To determine if there was a relationship among the variables, bivariate correlations were computed. It was found that Activist and Theorist were negatively correlated (p=-0.25). To determine if dominant learning style predicted academic achievement, a multiple regression analysis was conducted. The results of the regression indicated that the predictor variables of Activist, Pragmatist, Theorist, and Reflector did not predict unique variance in the dependent variable of Academic Achievement (R2=.07, F (4,61) =1.1, p<.36).

Keywords: *learning styles, multiple intelligences, experiential learning, science education*

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1. Introduction

There is survival value in diversity. Any population limited in its capability to respond to change is walking a very fine line, teetering on the cliffs of extinction. The more choices an individual or group has at their disposal to handle a situation, the more likely it becomes that they will find a successful solution to the task at hand.

Humans are wildly diverse. They aspire to a broad array of talents and perform to differing degrees along virtually every axis. The diversity of experienced traits is a product of personality and experience. Individuals are predisposed genetically to various personality traits, but education can change the range of mental experiences unlocking enough potential to negotiate a lifetime of adversity. Kolb [1] notes, "Learning is an emergent process whose outcomes represent only historical record, not knowledge of the future." As Einstein said, "truth is what stands the test of experience".

Thus, the educator is naturally concerned with diversity. I have long ascribed to the idea that we all speak a slightly different language, but good communication is similar enough the listener can translate and understand the speaker. This, I believe, is the goal of the educator; to facilitate a translation scheme to increase student understanding. The better the translation the more understanding will be imparted to the student and the more challenges they will be able to overcome. Is there any more valuable cause? It seems wise, then, to learn about the personal experiences of each student and strive to interact with them in a way which maximizes open communication and allows for the acquisition of knowledge.

Since Howard Gardner introduced his Theory of Multiple Intelligences in 1983, there has been a large focus on multiple intelligences in the classroom. Through Multiple Intelligences Theory, Gardner suggests that individuals vary in their intelligence along multiple dimensions. For example, a person who excels in verbal skills may have difficulty understanding spatial

arrangements. Multiple intelligences have been shown to be closely correlated with learning styles [2]. J. W. Keefe describes these styles as "cognitive, affective, and physiological traits that serve as relatively stable indicators of how learners perceive, interact with, and respond to learning environment" (as cited in Li, Medwell, Wray, Wang, & Liu, [3]). The ability of a teacher to adapt to a variety of learning styles is therefore considered highly beneficial and teachers should be pushed to broaden their teaching strategies; this comes to the fore through expectations of teacher differentiation which cater to a variety of different learning styles [4].

There is a plethora of learning style instruments, some utilizing sensory approaches such as the VAK Inventory (visual, auditory, kinesthetic), others grouping learners psychologically, e.g. as experiencers, conceptualizers, experimenters, and observers as does The Kolb Learning Style Inventory [3]. Li et al. [3] noted that while a learning style can be a helpful construct, it is worth realizing that few people, if any, fall into only a single category and all minds can learn in a diversity of ways. Surely, teachers often teach using methods which relate to their own learning strategies. Since this research intends to promote change in the researcher's classroom, an instrument must be chosen which focuses on the aspects of learning which will most benefit modification of instructional strategies.

Professional development time is often spent focused on ways to meet individual student learning preferences riding the assumption that being taught in ones preferred style will increase academic achievement [2,3,5]. Furthermore, it has been suggested that some teaching strategies require a specific learning style in order to be effective [6]. Sellah et al. [4] showed that teacher/student cognitive interactions play an important role in student success. However, to the contrary, other researchers show that a focus on learning styles may have no significant effect or indeed may be detrimental to student academic achievement [3,7,8]. Is a disservice committed when differentiating for learning styles; does it not seem that competence in any learning style is acquired through practice? Students likely need to be given opportunity to practice new learning strategies, even if this has a negative effect on academic performance in the short term.

2. Review of Literature

Howard Gardner wrote his seminal text, Frames of Mind: The Theory of Multiple Intelligences in 1983 and researchers have been refining the theory ever since. Gardner [9] explains that intelligence has traditionally been grounded in a single measure of general intelligence. Gardner [9] points out a tendency toward the reduction of intelligence to shorter and simpler measures, namely IQ, and suggests that a singular measure of general intelligence is of little use given the broad diversity of talents and demands found in society. He compares several occupations to explain that individuals need differing sets of intelligences in order to be successful and these intelligences are not necessarily mutually exclusive [9]. Using cultural, psychological, and physiological criterion Gardner [9] defines seven different intelligences which manifest themselves to varying degrees across individuals in the population. The primary intelligences cauterized by Gardner include linguistic intelligence which is evidenced by the ability to memorize and manipulate words as well as format stories; logical mathematical intelligence which is explained as the ability to reason with abstractions; bodily kinesthetic intelligence which involves the training of physical movements; finally, intrapersonal and interpersonal intelligence which classify our understandings of ourselves and others [9].

Prior to Gardner, most developmental psychologists had focused on general intelligence as measured by IQ and saw little flexibility when measuring intelligence [9]. To this day, the g factor measure of general intelligence is still the most powerful measure for predicting individual success [10]. Subsequently, it has been widely acknowledged in education and social science literature that multiple intelligences and learning style preferences are real and vary by individual [11]. However, many questions yet remain. How should learning styles be applied to the classroom? Are learning styles a valid and useful concept when designing lesson materials? Li et al. [3] argue that differentiation based on learning styles has become mainstream in university education departments and professional development opportunities but its value in the classroom is not yet supported by research literature. Much work is still needed to increase the validity of research in the field.

2.1. Demographics and Learning Styles

Prayekti [6] describes learning as "a process by which an individual undertakes to gain a whole new behavioral change, as a result of the individual's own experience in his interaction with his environment" (p. 2). Prayekti [6] goes on to explain that learning styles are one of many factors involved in the learning process and one of the tools necessary to design effective lesson materials; "cognitive style is an individual's characteristic in thinking, feeling, memorizing, solving problem, and making decision" (p.2). As such, it is to be reasoned that an individual is replete with their own collection of learning styles and preferences, learned and innate, which constitutes their lens for understanding the world.

Bhatnagar & Sinha [12] focus their research on this point, attempting to discover any differences between the learning styles of students in Germany and India which could be attributed to variations in culture. The subjects were selected from two populations: 40 business students from Germany and 41 business students from India. The researchers used Honey and Mumford's Learning Style Questionnaire (LSQ) to categorize students into four learning style categories: activists, who seek new experiences, reflectors who prefer a more cautious approach, theorists who value logic and rationality, and pragmatists who focus on what works in practice. These designations are based on the categories designed by Kolb in 1976 (assimilators, divergers, accommodators, and convergers) across two axes (abstract conceptualization to reflective observation, and concrete experience to active experience). LSQ scores were compared between countries. 58.54% of Indian students surveyed were found to prefer reflector style, while German students split their preferred learning styles between pragmatic (30%)

and reflective (27%) approaches [12]. Thus cultural differences in learning style seem to manifest themselves between nations.

Likewise the demographics of high-poverty communities may play a role in the distribution of various learning styles. Olivares-Cuhat [13] researched learning styles in a majority Hispanic, low-income middle school. 66 students in a midwestern city completed three surveys designed to provide insight into a variety of learning factors. Students strongly prefer kinesthetic and sensing-perceiving styles. A small preference for visual and intuitive thinking was discovered. White subjects were found to be higher in concrete global style (ANOVA F=3.43, p=0.014), while Hispanic and African American students measured higher in abstract global style (ANOVA F=2.93, p=0.028). English monolinguals were more willing to use memory aids during class (ANOVA F=5.06, p=0.028). In discussion, Olivares-Cuhat points out that the population may lag behind a normal developmental curve which would expect more visual and auditory learners when compared with cohort in areas of differing socio-economic status. This could be due in part to a lack of funding to meet the needs of all learners. Furthermore, students from high poverty areas may have trouble adjusting to the classroom environment.

Learning styles also vary by gender. Chen, Jones, & Xu [14] examined the variation in learning styles found in college accounting courses and compared that variation to success and satisfaction with the course. One hundred sixty-six students across seven accounting classes at two separate universities were surveyed for satisfaction and perceived learning effectiveness using a Likert scale. The results were analyzed against student demographics to determine broad student preferences. Students surveyed showed preference to instruction balanced between reflective and active learning (66.3%), as well as between global and sequential learning (63.3%). Likewise there was a large preference for visual learning over verbal learning (44.6% visual, 12.7% verbal). Males were largely more visual learners than females with 55.8% declaring visual preference to only 32.5% of female respondents. Conversely, 20% of female respondents preferred verbal learning compared with just 5.8% of the males surveyed showing this preference [14].

As evidenced along several dimensions in the previous studies, learning styles are real, and demographics play a clear role in their individual development.

2.2. Learning Styles vs. Teaching Styles

The foundational assumption behind learning styles research seems to be that if a student is taught in their preferred style, then they will experience greater academic success [1]. It follows that the educator can increase chances for achievement by differentiating teaching to the style of the individual learner. This means developing a set of teaching styles which relate to or mesh with the potential learning styles of each student based on their individual experiences. Developing relationships with students becomes a necessity in order to understand and correct misconceptions. A daunting task to say the least, however, findings seem to support this view.

Sternberg et al. [15] outline two broad learning style categories described in psychological literature, those that are ability based and those that are performance based. This research chooses one example from each category to support the claim that varying learning styles are real and relevant to success in knowledge acquisition. To focus on ability-based styles the researchers discuss the Theory of Successful Intelligence, which claims that teaching styles can be out of sync with learning styles at any given moment. The best way to account for this disparity is for an individual to take advantage of strengths and minimize weaknesses by balancing creative, analytical, and practical thinking. This allows the individual to generate new ideas, decide which ideas are best, and devise a plan to implement their ideas. Furthermore it suggests that teachers should allow students to develop and apply concepts independently [15].

To elucidate personality-based styles, the Sternberg et al. [15] delve into the research surrounding Sternberg's theory of Mental Self-Government. Personality based styles of learning are focused on how to use the abilities you gain. Mental self-government uses the ideas of the legislative, executive, and judicial branches to explore the function of various personality types. The legislative student, for example, will thrive while creating a strategy or plan; they are creative and independent. By contrast, Sternberg et al. illustrates, the executive student wants to focus on performing a set of tasks to the best of their ability; they need to follow a structure to maximize performance (2008). These students are the most likely to succeed in the traditional classroom environment. Students aligning with the judicial learning type excel at comparing and evaluating ideas and strategies. Finally, Sternberg et al. [15] notes that a rich variety of experiences is positively correlated with all thinking styles. Teaching and assessment strategies that put too much focus on high achievement can isolate individuals who may not be driven to earn points even when those very individuals may be likely to succeed in the field based on their non-conforming personalities [15].

Meanwhile, Sellah et al. [4] spent time directly comparing teaching style to student learning styles. The researchers focused on 330 students, six chemistry teachers, and six academic masters (N=342) from six secondary schools in Kenya. The study employed a Cognitive Styles Inventory which categorized participants cognitive style along four axes: active vs. reflective, visual vs. verbal, abstract vs. concrete, and sequential vs. global. The CSI results were then compared to student results on the Mock tests and KCSE examinations. One-way ANOVA showed there to be significant differences in Mock performance between all six schools in this study (F=18.455). Likewise, ANOVA showed significant differences in KCSE Chemistry Examination results across all six schools (F=35.244). Eighty-five percent of student learners were found to prefer concrete style, 74% preferred active styles, 74% preferred visual styles, and 82% preferred sequential styles. Teacher preferences were 83% active, 83% visual, and 83% sequential while all teachers showed preference for concrete learning style. Research indicated the highest gains are found when teaching style closely matches learning style, and teachers

should find it worthy to spend time becoming familiar with the learning styles of their students [4].

2.3. Purpose and Research Question

This research intends to apply quantitative analysis to determine if individual learning style is a significant factor in a middle school science classroom, and whether teaching style could be modified to better meet the academic needs of students. The specific research question addressed was: Does student learning style, as measured by the Kolb Learning Style Inventory, play an important role in the academic success of students in an eighth-grade science classroom? It is hypothesized that if learning style plays an important role in the classroom, some types of learners will find greater academic success with the provided style of instruction. Furthermore the learning styles that most closely mesh with the provided teaching style should perform higher academically than those of students with learning styles which differ from the provided teaching style. Finally, since the research is meant to be practical, the distribution of learning styles should give some guidance in adjusting the provided teaching style to help more students find academic success.

3. Methodology

3.1. Participants

Research was performed across a single unit of study within an eighth-grade general science classroom. This school had a total population of 547 students: 46% female, 53% male. By ethnicity, students are 38% White, 33% African American, 12% Hispanic, and 16% Other. Sixty-one percent of the students are economically disadvantaged [16]. The cohort consists of only eighth grade students and is divided daily across six individual class periods of approximately 50 minutes in length. Each class period contains between 15 and 28 students aged 14 to 15 years. 66 students completed both the survey and the summative assessment and were included in this research.

3.2. Procedures

Sudria, Redhana, Kirna, & Aini [17] describe research which will serve as the foundation for the proposed experimental design. Sudria et al. [17] addressed the effect of learning styles, as measured using The Kolb Learning Style Inventory, on student achievement during guided-inquiry lessons in chemistry class. Student learning styles were collected using The Kolb Learning Style Inventory designed by David Kolb in 1984. Students then completed a unit of study using the guided inquiry method. Student results on The Kolb Learning Style Inventory were compared to academic performance on a posttest using one-way ANOVA followed by a Scheffe's post hoc test for significance [17].

3.3. Measures

To determine individual learning styles students were asked to complete *The Kolb Learning Style Inventory*. Participants answered a set of questions using a Likert scale. The results placed respondents along a plane in two dimensions, from concrete experience to abstract conceptualization, and from active experimentation to reflective observation. As Kolb [1] explains, these categories are cyclical from testing current theories through experience, to reflection, to conceptualization, to the formulation of new theories:

> Learners, if they are to be effective, need four different kinds of abilities - concrete experience abilities (CE), reflective observation abilities (RO), abstract conceptualization abilities (AC), and active experimentation (AE) abilities. That is, they must be able to involve themselves fully, openly, and without bias in new experiences (CE). They must be able to reflect on and observe their experiences from many perspectives (RO). They must be able to create concepts that integrate their observations into logically sound theories (AC), and they must be able to use these theories to make decisions and solve problems (AE). (p. 30)

Results placed respondents into one of four quadrants: Activist, Theorist, Pragmatist, and Reflector. According to Sudria et al. [17], accommodators excel when learning through concrete experience and active experimentation, divergers through concrete experience and reflective observation, convergers through abstract conceptualization and active experimentation, and assimilators through reflective observation and abstract conceptualization.

Student academic success was measured using a summative post-test designed by the researchers to measure student understanding of standards-based concepts covered during the unit. The assessment consisted of 22 short answer questions worth 50 points.

4. Results

As modeled by Sudria et al. [17], individual results obtained from *The Kolb Learning Style Inventory* were compared with academic performance on a posttest using one-way ANOVA followed by a Scheffe's post hoc test for significance between pairs of results.

To examine the relations among academic achievement (as measured by a unit test score) and four learning styles (i.e., Activist, Theorist, Pragmatist, and Reflector), several analyses were conducted. First, descriptive statistics are reported for student scores on measures of academic achievement and on the learning styles survey (see Table 1).

Table 1. Descriptive Statistics

Variable	Mean	SD
Academic Achievement	80.2	17.5
Activist	11.3	5.4
Pragmatist	11.7	5.4
Theorist	11.3	5.7
Reflector	12.4	5.2

Note. N=66.

To determine how many students identified primarily as one dominant learning style, the category their highest score fell within was deemed their dominant learning style and coded as: 1=Activist, 2=Pragmatist, 3=Theorist, and

4=Reflector. A frequency distribution was computed to examine the distribution of the dominant learning style in this sample of students (see Table 2).

Table 2. Frequency Distribution of Dominant Learning Style

Learning Style	Frequency	Percent
Activist	12	18.2
Pragmatist	19	28.8
Theorist	18	27.3
Reflector	17	25.8

Note. N=66.

To determine if there was a relationship among the variables, bivariate correlations were computed. These findings are reported in Table 3. Results indicated that Activist and Theorist were negatively correlated (i.e., the higher the students rated themselves on Activist, the lower they rated Theorist). That is the only statistically significant relationship that emerged for the four learning styles.

Table 3. Bivariate Correlations Among Variables

Variable	Academic Ach.	Activist	Pragmatist	Theorist
1. Academic Achievement	--	0.06	0.03	0.17
2. Activist	--	--	-0.56	-0.25*
3. Theorist	--	--	-0.18	--
4. Reflector	0. 12	0.19	-0.88	-0.20

Note. *=p<.05.

Finally, to determine if dominant learning style predicted academic achievement, a multiple regression analysis was conducted. The results of the regression indicated that the predictor variables of Activist, Pragmatist, Theorist, and Reflector did not predict unique variance in the dependent variable of Academic Achievement (R2=.07, F (4,61) =1.1, p<.36). It was found that Activist did not significantly predict Academic Achievement (β = .32, p<..45). It was found that Pragmatist did not significantly predict Academic Achievement (β = .29, p<..048. It was found that Theorist did not significantly predict Academic Achievement (β = .74, p<..07). Finally, it was found that Reflector did not significantly predict Academic Achievement (β = .51, p<.24).

5. Discussion

Given the findings, one could conclude that learning style has little effect on academic achievement in the classroom, or more likely, that other factors have far more influence on student achievement in this setting. Indeed, this is the conclusion that Brunton drew in 2015. Learning is a complex organization of many factors including adverse childhood experiences, prior knowledge or experience in the topic, time since eating or sleeping, and regularity of classroom attendance.

General intelligence, though downplayed by Gardner [9], still has an impact on achievement and the training of general skills can be beneficial. McCollister & Michael [18] point out that without firm critical thinking skills students will not reach high achievement in the science classroom, regardless of learning style. Critical thinking can be realized by the inclusion of problem-solving strategies, critical analysis of questions, a focus on the evaluation of source material and decision making [18].

This research decided to take the highest category to be the dominant learning style which was then used to determine the impact of learning style on academic achievement. This eliminated much nuance exposed by the Kolb Inventory which places students on a plane defined by the interactions between all four learning styles. A study which took advantage of that nuance would yield more accurate results at the cost of increased time spent collecting and analyzing data. While appealing this approach is outside of the scope of this study, (the researcher is an active teacher with a classroom to manage). Pashler et al. made this point in 2009, when they argued that much of the research literature does not hold up to scientific scrutiny on the basis of experimental design alone. They then clearly elucidate a proper methodology for performing learning styles research. The research must group students according to learning style and randomly assigned one of several instructional methods within groups. The researcher must then show that a specific intervention caused an increase in performance as compared to out groups. The results cannot be extrapolated across learning styles.

Nevertheless, differentiating learning to align with learning preferences for all students is likely beneficial (even if just within motivation and engagement domains) and designing lessons which specifically utilize multiple learning styles can only be beneficial to individual learning as all students can practice and develop learning in multiple ways. It is a common metaphor to declare the brain is a muscle. Though not true in the concrete, in the abstract we find meaning: as we practice and use various learning skills they become more automated and accessible to daily thought. As D. C. Dennett declares in his [19] book, “You can’t do much carpentry with your bare hands, and you can’t do much thinking with your bare brain” (p. 282).

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