ELECTRONIC JOURNAL FOR RESEARCH
IN SCIENCE & MATHEMATICS EDUCATION
VOL. 27, NO. 4, 18-58

Scripted Curriculum vs. Understanding by Design: A Comparative Study of Curriculum Design Using Biology Curriculum

Masomeh Mahzoon-Hagheghi
Texas A&M University-Corpus Christi

Faye Bruun
Texas A&M University-Corpus Christi

ABSTRACT

The purpose of this study was to analyze the effectiveness of scripted biology curriculum as a means of providing students with the information required to increase content knowledge, while comparing curriculum developed by the teacher that utilizes the Understanding by Design (UbD) framework (Wiggins & McTighe, 2005). The study used a mixed method, concurrent triangulation design which revealed that there was a significant difference between student growth from the pretest to the posttest. The teacher reflection logs and student focus groups identified two themes regarding science content knowledge: instructional/learning style and using discussion within the instructional cycle for both curricula. It was evident that the increase in content knowledge was associated with the utilization of discussion during the learning cycle. The teacher reflection logs and student focus groups also identified two themes when looking at the perception of the learning environment: the effect of teacher relationship on instruction and the effect of time on the learning environment. According to the instrument used, both groups of students showed growth, however, there was a larger gain among the students receiving the Understanding by Design curriculum. A major contributing factor for the growth among all students was the relationship the teacher had with them to meet their individual academic needs.

Keywords: scripted science curriculum, Understanding by Design

Introduction

From the beginning of American education, the fundamental purpose was to "instill in students' moral values, a common cultural identity, and civic values" (Spring, 2014, p. 7). This idea has continued throughout education, but over the last decade has become more influenced by politics and federal mandates from people who are far from the realm of education. Because America is such a diverse country, the education system has had to make accommodations and broaden the spectrum of curriculum. Due to an increase of federal involvement, the government now has direct control over student learning, more specifically teachers teaching to the test (Spring, 2014, p. 225).

With the 1957 launch of the Russian Satellite Sputnik, and the fear of falling behind other nations, there was demand for innovation in technology and engineering in the United States. Following Sputnik, President Eisenhower called for action, stating that America needed scientists and it would be a collaborative effort of the federal, state, and local governments to meet these demands. Shortly after, the National Aeronautics and Space Administration (NASA) was created in 1958 and the space program began to unfold. This drove Americans to put men on the Moon, send robots to Mars (Apollo), explore the depths of the Earth, and increase the knowledge of the planet and solar system at the beginning of the Space Race. In 1983, during the Regan administration, the National Commission on Excellence in Education (1983) published *A Nation at Risk* that further reformed science and engineering programs as a means to keep the United States competitive. This initiative called for seven-hour school days and a high school curriculum that needed to include: four years of English, three years of mathematics, three years of science, three years of social studies, and a half year of computer science.

With federal agendas and grants such as No Child Left Behind (NCLB) Act and the Bill and Melinda Gates Grant, educational policies and political agendas push for stronger curriculum mandates and greater teacher accountability (Cunningham et al., 2009). These agendas have created a culture of fear and anxiety among teachers by linking scores to teacher performance and whether they keep their jobs, especially in schools with high populations of special education, English language learners, and low socio-economic groups (Ravitch, 2010, p. 269). With the implementation of high-stakes accountability and standardization, there is now a lack of teacher autonomy which has led to the adoption of reductionist notions and in turn has caused teachers to oppose their professional beliefs and values. McLaren (2007) suggests that educators must provide an education that is relevant to students in order to be critical, transformative, and to change the world to help those who suffer and need the most. Freire (2005) further explains that educators cannot teach content as if that were all there is, but they should give creative wings to the students' imaginations and demonstrate to students the importance of imagination for life, because imagination helps curiosity and inventiveness, just as it enhances adventure, without which we cannot create (p.93).

Due to the increase of federal involvement in education, teachers are not given the autonomy to teach the content but are required to cover a large body of state and federal standards. Kang (2016) explains that high stakes accountability driven times is a direct result of national, state, and district policies affecting how teachers teach. These standards are generally proposed by politicians, and based on these results, the teachers, principals, schools, and school districts are then categorized. MacGillivray et al. (2004) suggest that these curriculum mandates are a form of colonization that serve to control teachers' work by limiting their professional autonomy. Giroux (1988) explains that the dominant culture in school is organized around curricular, instructional, and evaluation experts that do the thinking while the teachers are expected to implement what they are given.

The standardization paradigm is based on the standardization of curriculum, accountability of standardized test scores, and the deskilling of the teaching profession (Spring, 2014, p. 87). Apple (2006) explains that politicians and corporate leaders believe education is a business and should be treated no differently than any other business, thereby wanting to raise standards and require more high-stakes testing that they believe will guarantee schools will return to time-honored content and more traditional methods (p. 129). With the implementation of high-stakes accountability and standardization, there is now a lack of teacher autonomy which has led to the adoption of reductionist notions and in turn has caused teachers to oppose their professional beliefs and values. According to Apple (2006), "traditional content and methods have been jettisoned as our schools move toward more trendy subjects that ignore knowledge that made us such a great nation" (p. 129).

The goal of education should be to inspire students to learn and acquire knowledge of a variety of content through various methods; "education depends on the intimate contact between a good teacher and an inquiring student" and should be a "catalyst to interest students in learning for themselves" (Ravitch, 2010, p. 284). Freire (1970) indicates that the current education system is training students to passively receive, memorize, and repeat information. Freire goes on to say that education could function in one of two ways:

> As an instrument that is used to facilitate the integration of the younger generation into the logic of the present system and bring about conformity to it, or it becomes 'the practice of freedom,' the means by which men and women deal critically and creatively with reality and discover how to participate in the transformation of their world" (Freire, 1993, p. 16).

McLaren (2007) suggests that educators must provide an education that is relevant to students in order to be critical, transformative, and to change the world to help those who suffer and need the most. Freire further explains that educators cannot teach content as if that were all there is, but they should give creative wings to the students' imaginations and demonstrate to students the importance of imagination for life, because imagination helps curiosity and inventiveness, just as it enhances adventure, without which we cannot create (Freire, 2005, p. 93).

The purpose of this study was to analyze the effectiveness of scripted biology curriculum as a means of providing students with the information required to be successful on standardized assessments, while comparing curriculum developed by the teacher that utilizes the Understanding by Design (UbD) framework. According to a review done by Roth (2007), Understanding by Design overcomes the impasse of development of coherent and cohesive curriculum by providing concise and practical guidance for experienced and inexperienced teachers. Roth (2007) goes on to explain that "UbD describes a practical and useful "backward" design process in which anticipated results are first identified; acceptable evidence for learning outcomes is established and, only then, are specific learning experiences and instruction planned" (p. 95). According to Wiggins and McTighe (2011), backward design is "an approach to designing a curriculum or unit that begins with the end in mind and designs toward that end" (p. 338).

Background Research

With the expansion of scripted curriculum across schools and the increasing importance placed on standardized testing, it is necessary to begin researching how this type of curriculum affects student achievement. Along with looking at the effectiveness of scripted curriculum, it is important to add to the research on alternative curriculum and instruction methods for teaching science, such as the use of the Understanding by Design framework. According to Amrein and Berliner (2002), high stakes or standardized test scores have come to dominate the discourse about schools and their accomplishments. The authors further explain that policymakers borrowed principles from the business sector and attached incentives to learning and sanctions to poor performance on tests, where high performing schools would be rewarded and under performing schools would be penalized and would have to improve themselves to avoid further penalties (Amrein & Berliner, 2002).

Kang (2016) explains that the high-stakes accountability times have driven national, state, and district policies to play a role in how teachers teach. The author goes on to say that the current sociopolitical climate emphasizes standardized, regimented, and prescribed curriculum and instruction in order for schools and classrooms to be controlled. Smith et al. (1989) found that pressure to improve students' test scores caused some teachers to "neglect material that the external test does not include...reading real books, writing in authentic context, solving higher-order problems, creative and divergent thinking projects, longer-term integrative unit projects, [and] computer education..." (p. 268). Problematic side effects of high stakes testing for low-income students are the narrowing of curriculum and training students to pass a test without broader notions of learning and education (Amrein & Berliner, 2002).

Science curriculum is often described as "unrelated, difficult, and boring to learn in comparison with other topics" (Alwahaibi, et al., 2019). It is important for teachers to actively engage students in the learning process and have the ability to differentiate instruction in order to meet the needs of all students. Without students' interest in science, they may not make the effort to learn and understand the concepts that they are taught (Helldén 2005). Remillard et al. (2014) explains curriculum materials can be defined as resources to guide teacher instruction that can include textbooks and supplementary units or modules. Many studies show that science curriculum materials can have positive effects on student learning, including an increase in students' attitudes and motivation toward science (e.g., Häussler & Hoffmann, 2002; Roblin et al., 2017; White & Frederiksen, 1998), an increase in student understanding of science concepts (e.g., Harris et al., 2015; Sadler, et al., 2015), and an increase in their abilities to engage in science practices. Dias, Eick, and Dias (2011) as well as Wyner (2013) suggest that curriculum materials have also shown to have an influence on teachers' beliefs about science teaching and learning, the nature of science, and about themselves as knowers of science.

The current structure of the public-school system has made both learning and teaching difficult; "Just as it is difficult to communicate the complexities of teaching to the lay public, so it will be difficult to communicate to policymakers how full of conflict, how rife with contradictions, their decisions about accomplished teaching will be" (Wineburg, 2001, p 208). According to Wineburg (2001), knowledge of a subject is central to teaching, but expert knowledge of content does not determine good teaching and learning, but it requires a rich and deep understanding of many things (p 170). Pestalozzi (1951) affirms that learning slowly by one's own experience is better than to learn by rote memorization of facts that other people know, because this can lead to lose one's own free, observant and inquisitive ability to study (p. 35). Piaget (1973) explains that teachers should cease being a lecturer that is satisfied with transmitting ready-made solutions, but rather use a constructivist approach and become a mentor stimulating initiative and research (p. 16).

Constructivist Theory

According to Resnick (1989), constructivism is a theory of learning or *meaning making* where individuals create their own new understandings on the basis of an interaction between what they already know and believe and ideas and knowledge that they come into contact with. Piagetian Constructivism is a complex blend of biology, epistemology, philosophy, and psychology with the entire purpose of intellectual growth as one of coming to know reality more objectively through developing increasingly decentered-and hence more objective-perceptions of reality (O'Loughlin, 1992). Piaget (1973) explains two misconceptions of active methods of instruction to be 1) a fear that the teacher would have no role to play in these experiments and success would depend on leaving the students entirely free to work or play as they will, 2) the teacher is needed to provide counterexamples that will lead to reflection and reconsideration of hasty solutions (p. 16).

By allowing teachers the freedom and autonomy to teach necessary content, both students and teachers will be able to express their knowledge and skills in a variety of methods, not simply through a standardized, multiple-choice test. According to Devetak and Glazar (2014) good teaching involves activities that require students to identify and activate relevant prior knowledge, includes *active* learning, encourages students to reflect on their thinking and ongoing learning, and pushes students to discuss their work. Kumar and Gupta (2009) explain that a constructivist classroom provides opportunities to observe, work, explore, interact, raise question inquiry, and share their expectation to all. Constructivist teaching is a process of personal knowledge construction that occurs within the minds of individual learners and is contingent upon the way the learner constructs his/her thinking (Taber, 2019).

Scripted Curriculum

Schools face the pressure of passing standardized tests, causing many districts across the country to implement various forms of scripted curriculum. This scripted curriculum or lesson plan as defined by Demko (2010) is a series of scripts that determine instruction, which must be followed with perfect implementation. The role of the teacher is to "execute the commercial, scripted program without making adjustments" or the guarantee is lost (p. 62). Cilliers et al. (2019) further explain that this type of curriculum outlines what the teacher is to say, how the script should read, and what teaching strategies should be used. Scripted curriculum creates a precise process beginning with attention getting, linking prior knowledge or review, clearly stating the objectives of the lesson, followed by guided practice that involves MODEL, PROMPT, and CHECK steps (Gunter & Reed, 1997).

Several forms of scripted science curriculum have been introduced in Texas and other states over the years, such as CSCOPE, Pearson Interactive Science, and STEMscopes. The above-mentioned curriculum types are often recommended and sold to school districts by Regional Education Service Centers. Once adopted and introduced, it is the responsibility of the superintendents, principals, and teachers to implement the curriculum as intended. These curricula use an inquiry-based design to learn known as 5E lesson design. The Biological Science Curriculum Study's 5E instructional model refers to five steps of inquiry: engagement, exploration explanation, elaboration, and evaluation (Bybee et al., 2006).

The scripted curriculum used in this study is STEMscopes, an online, comprehensive, and inquiry-based approach to science that is "100% aligned to the Texas science standards and combines online content, activities, and teacher materials with hands-on experiments and explorations" (Rice University, 2017). This program is designed to guide students toward discovery of concepts and skills instead of using direct instruction. By using this program, the STEMscopes pedagogical models adds two key steps: intervention and acceleration. These two key steps provide teachers with tools for identifying students that may struggle with a particular concept, allowing for additional opportunities to learn, as well as provide teachers with activities for students that have demonstrated mastery of concepts. In a study conducted during the 2012-2013 school year, 5th grade state assessment data was collected and examined, indicating that teachers who used STEMscopes more often had students whose average scale scores were 46.6 points higher than teachers who used fewer steps per learning standard (Rice University, 2017).

Research Supporting Scripted Curriculum. Proponents of scripted curriculum believe that using a curriculum that is scientifically based will help students become more successful and increase their standardized scores. Gunter and Reed (1997) suggest that the foundation of scripted lessons is based on the model, prompt, and check steps to ensure learning of material.

Hiralall and Martens (1998) suggest that scripted curriculum may help reduce the inequality that exists in the classroom. According to an article written by Milner (2013), scripted and narrowed curriculum can be used to help teachers that are underprepared by way of what to teach, when to teach it, and how. The author explains that this form of curriculum ensures all students are exposed to the same curriculum no matter the teacher's skillset, where the students live, or even the particular needs of the individual student.

Supporters of scripted curriculum believe it makes teacher-led instruction "more efficient and predictable by scripting the teacher's spoken words and the child's likely responses" (Walsh, 1986). Watkins and Slocum (2004) argue that scripted curriculum accomplishes two goals: 1) it assures well designed instruction, and 2) it relieves the teacher of the responsibility to design, test, and refine instruction for every subject they teach. The authors explain that scripted programs provide systematic, structured, predictable, and consistent routines and learning environments while permitting training and supervision to ensure standardized instructional delivery (p. 306). They go on to explain that the detailed scripts are tools that are designed to allow teachers to relate to the students through the words in the scripts and the role of teacher is to focus on the critical job of delivering instruction and solving unexpected problems.

Vasquez Heilig and Jez (2014) explain that teacher education programs, such as Teach for America, make scripted curriculum necessary because many of the teachers are not prepared to make curricular decisions that are rational, appropriate, and responsive. Zhao et al. (2019) further explain that scripted curriculum narrows the lens to ensure that the teacher would focus on aspects that would most likely be tested in a given year. Twyman and Heward (2018) suggest that scripted curriculum offers continuity by using systematic methods for teaching specific content and ensure students have sufficient information to formulate the correct responses to the content. An analysis done by King and Zucker (2005), explains that the purpose of narrowing the curriculum was to allow teachers to focus on aspects of the curriculum that they would most likely be tested on in any given year.

Research Not Supporting Scripted Curriculum. While there is research in favor of scripted curriculum, several disadvantages have been brought to light after a critical review of research. Although scripted curriculum is not a recent phenomenon, it was created as a means of regulating, managing, and regimenting teachers' frameworks and instruction (Doyle, 1992).

Teachers are concerned that the reason for educational policies and scripted mandates is due to the belief that teachers can no longer do their job effectively (Eisenbach, 2012). They believe that it sends the message that teachers are not capable of providing their students with rigorous instruction and generate intelligent lessons and activities that promote student engagement and intellectual growth (Eisenbach, 2012).

In a longitudinal study conducted by Valli and Buese (2007), the authors examined the changes in teacher tasks over a 4-year period. Through detailed analysis, the authors explain that these changes greatly affected curriculum and instruction. One such change was the introduction of a scripted curriculum that required teachers to move through the curriculum on the district's schedule, with tests given at a prescribed time. This rapid paced content delivery or *drive-by teaching* hindered the teacher's ability to create lessons that involved inquiry. This form of curriculum limits teachers' flexibility, autonomy, creativity, and ability to ask critical questions within the content (Valli & Buese, 2007).

Srikantaiah (2009) and Milosovic (2007) explain that by narrowing the curriculum, teacher's efforts to align curriculum to standards and focus on tested material has diminished available class time for science, social studies and other activities in the elementary grades (p.2). Jerald (2006) affirms that taking time from other subjects, such as science and social studies, produces significant long-term costs on student reading comprehension and thinking skills, increases inequity among students, and makes the job of secondary teachers more difficult.

Smagorinsky et al. (2002) found that when implementing scripted curriculum, teachers were expected to use the same curriculum materials, in the same order, at the same time of day, across a diverse school district. During the study, students described the scripted materials provided as "unappealing" (p. 199) and that the flow and organization of the lesson did not meet the needs of the students.

Freire (2005) states, educators must constantly adapt their way of thinking, learning, and teaching, in order to become a better teacher, yet use "pre-packaged" materials to teach differentiated instruction to a classroom full of people from all walks of life (p. 32). These "pre- packaged" teaching materials are not only taking away the creativity of the students, but also that of the teacher. With the idea of a prepackaged curriculum, there is little room for teachers to adapt to the needs of students within the classroom setting, therefore hindering teacher creativity and limiting their input, as well as fostering an education rooted in lower-order skills (Firestone et al., 2000). Katz (2015) explained that scripted curriculum fails to acknowledge the creative potential of educators in the classroom and their ability to shape environments according to the lived experiences and actual educational needs of their students. Ede (2006) and Kang (2016) explain the diverse ethnic and cultural backgrounds of students within any given classroom makes it unlikely that one single curriculum will meet the needs and interests of all students. In a study conducted by Crocco and Costigan (2007), they found that in scripted lessons and mandated curriculum, teachers in New York City felt their personal and professional identity was thwarted, creativity and autonomy was undermined, and their ability to create relationships with their students was diminished. When the scripts and expectations are shaped by someone else, teachers and consequently students become robots (Milner, 2013). According to Eisenbach (2012) and Powell et al. (2017), the use of scripted curriculum provides teachers with three choices: accommodate, negotiate, or resist. In the study done by Eisenbach (2012), the author describes each of these choices: 1) Teachers that tend to accommodate believe they must set the example and follow the mandates set by the policy makers; 2) Teachers that negotiate or subtly oppose tend to incorporate their own ideas and beliefs into the scripts and create a hybrid classroom; 3) Teachers that resist do not use any of the curriculum provided and use what they believe works best for their student. A similar study done by Powell et al. (2017), describe these choices as acquiesce, subtly oppose, or actively resist. In this study, the authors describe the first two choices similar to Eisenbach (2012) but also explain that in the last choice, the teachers may not only resist use of curriculum, but some will even leave teaching altogether.

Kohl (2009) and Powell et al. (2017) suggest that the role of a teacher is changing as a consequence of scripted curriculum, teacher accountability, continuous monitoring of student performance, and high stakes testing. Kohl (2009) explains that scripted curriculum turns teachers into delivery systems that is leading to the erosion of self-respect and pride in one's work by treating teachers as objects with no independent educational knowledge or judgment of their own. Powell et al. (2017) suggest that the layers of control have become visible with the corporation making the decisions, school administrators requiring teachers to comply, and teachers fearing reprisal if they do not follow the rules. Herr and Arms (2004) describe standardized curriculum as mandates, where even administrators are held accountable for implementing them and bringing a sense of surveillance to the classroom (p. 536). Moustafa and Land (2002) describe scripted curriculum to be less effective than reading instruction where teachers are allowed to use their knowledge and experience to differentiate instruction based on the needs of the students. Mills (2008) and Carl (2014) explain that scripted curriculum may limit a teacher's ability to exercise professional judgement which may limit teacher efficacy and student potential. Elkind (1986), Flipo (1999) and Hargreaves (1994) are also concerned about academic achievement and the ability of the programs to develop deep lasting engagement that will increase student achievement as advertised by the program developers. In an audit done by Hos and Kaplan-Wolff (2020) they examined the New York State Education Department of the Sunnyside School District's curriculum and concluded that there was a disconnection between what was taught in the school district when compared with the state standards. The results of this study support the conclusion that teachers who choose to resist the scripted curriculum would rather engage their students in purposeful activities that represent their own professional identity and beliefs about learning (Hos & Kaplan-Wolff, 2020). With the growing concern about student achievement, other curriculum frameworks can be explored to allow for more autonomy, such as the understanding by design framework.

Understanding by Design

Understanding by Design (UbD) is a lesson plan framework designed to focus both curriculum and instruction on the development and deepening of student understanding and transfer of learning (Wiggins & McTighe, 2011). The purpose of the UbD framework is to 'teach' students that their job is not merely to learn facts and skills, but to question them for further meaning (Wiggins & McTighe, 2005, p. 104). The UbD model allows students to go beyond the information and make inferences, connections, and associations that will bind together seemingly disparate facts into coherent, comprehensive, and illuminating accounts and experiences (Wiggins & McTighe, 2005, p. 86). The UbD framework is rooted in the idea that teaching in and of itself never causes learning, but successful attempts by the learner to learn causes learning and achievement is the result of the learner successfully making sense of the teaching (Wiggins & McTighe, 2005, p. 228). Wiggins and McTighe suggest that by simply covering content required by state and national standards, learning becomes a more difficult task and levels everything to verbal stuff for recall (p.234). It is only when a concept becomes "real" instead of abstract that it makes sense and the learner can connect the learning with experience and knowledge (Wiggins & McTighe, 2005, p. 234). By using the method of teaching after revealing experience, students will have a more concrete understanding of the concept being taught, allowing for transferability. According to Wiggins and McTighe (2005) in order to ensure learning is fluid, a spiral approach should also be incorporated as a means to develop curriculum around recurring, ever-deepening inquiries into big ideas and important tasks (p. 297).

Reviews of Understanding By Design. A study done by Schiller (2015) was conducted using UbD to design unit lesson plans for the Next Generation Science Standards (NGSS) for the topic of evolution and correlated it to the NGSS performance expectations. The author explained that the findings showed the UbD unit lessons increased student achievement in the unit, using the NGSS assessment, as well as an increase in student interest in learning the science content.

According to a review done by Roth (2007), Understanding by Design overcomes the impasse of development of coherent and cohesive curriculum by providing concise and practical guidance for experienced and inexperienced teachers. Roth (2007) goes on to explain that UbD utilizes a practical and useful "backward" design process in which anticipated results are first identified, acceptable evidence for learning outcomes is established, and finally specific learning experiences and instruction are planned. The UbD framework was implemented at the University of Wyoming, in which graduate students were able to transform their original lesson plans into lessons that were more useful, functional, and valuable for both teachers and students (Roth, 2007).

When applying the backward design, Childre et al. (2009) and Whitehouse (2014) explain the key steps in differentiating instruction, more specifically when planning for classrooms with students with disabilities. These key steps include: 1) identifying individual learning needs as well as classrooms needs such as resources and educational background of students, 2) identifying curricular priorities using the standards to drive instruction using essential questions to pique interest, 3) design assessment that is ongoing and frequent that aims to move students beyond the recall of memorized facts to deeper understand of the meaning of content in applied contexts to other concepts, and 4) creating high-quality learning activities that guides students toward accomplishing the desired understanding and assessments while scaffolding information throughout the process. In a study done by Michael & Libarkin (2016) the authors implemented the UbD framework at the university level and found that using these steps, as described by Childre et al. (2009) and Whitehouse (2014), ensues instruction is moving away from lecturing and allowing students the opportunity to take an active role in their own learning. Research suggests there is no real benefit of scripted curriculum when considering student achievement. Studies researching the effectiveness of scripted programs exist in the form of dissertations and other publications, but much of the literature does not show a significant difference in student's achievement between scripted and non-scripted curriculum (Atkeison-Cherry, 2004; Dickson, 2006; Duncan-Owens, 2009; Lyons, 2009; Valencia et al., 2006; Bosen, 2014). Anderson (2011) suggested further research over time to identify patterns of support for scripted reading programs, while Halff (1988) and Hargreaves (1994) recommend a partial implementation of scripted mathematics curriculum. Research studies have been conducted that present the various aspects of the implementation of prescribed reading and mathematics curriculum, but there seems to be a gap in the literature regarding the use of scripted science curriculum. Table 1 shows a comparison between the two curriculum frameworks.

Table 1

Curriculum Framework Comparison

STEMscopes	Understanding by Design
K-12 digital curriculum that uses exploratory hands-on kits to promote inquiry and allows students to engage in real-world scientific connections (Accelerate Learning, 2021).	Lesson plan framework designed to focus both curriculum and instruction on the development and deepening of student understanding and transfer of learning (Wiggins & McTighe, 2011).

This study compared the effectiveness of scripted biology curriculum while comparing curriculum developed by the teacher that utilizes the Understanding by Design (UbD) framework. This study explored the following two research questions: (1) What is the difference in science content knowledge between those students receiving UbD curriculum/instruction and those students receiving the district-scripted curriculum/instruction? (2) What is the difference in student participation (constructivist practices) between those students receiving UbD curriculum/instruction and those students receiving the district scripted curriculum/instruction?

Methods

This study evaluated two curriculum designs among 9th grade Biology students at South Texas Charter School (STCS). STCS is an urban charter school located in south Texas that serves students from kindergarten through twelfth grade. According to the information from the 2017-2018 school year, there were a total of 906 students from grades K-12, with 58.8% (n=533) of those students on free/reduced lunch. Table 2 shows the ethnicity of students within the K-12 school are as follows: 2.6% (n = 24) Asian, 4.2% (n = 38) African-American, 73.8% (n =669) Hispanic, 18.8% (n =170) White, and less than 0.1 % (n =4) identified as Other. This study was conducted using 9th grade Biology curriculum over the course of the second quarter of the 2018-2019 school year.

Table 2

Descriptive Statistics: K-12 School Population

	N	%
Socio-Economic Status		
Free/Reduced Lunch	533	58.8
No Free/Reduced Lunch	373	41.2
Ethnicity		
Asian	24	2.6
African-American	38	4.2
Hispanic	669	73.8
White	170	18.8
Other	4	< 0.1

The participants consisted of the course instructor and students enrolled in the 9th grade Biology course at STCS during the 2018-2019 school year. Although there were three sections of Biology students, only two sections participated in this study. The third section was not used due to the population of the group consisting of honor students that required the use of a faster paced curriculum. Further assessment to determine which two of the three sections were most similar was unnecessary. The course instructor teaching the Biology course was a Hispanic, female with six years of science teaching experience, three of which were specific to teaching Biology. The two groups proceeded through the curriculum over the course of a nine-week period.

There were a total of thirty-five students, 22 of which experienced STEMscopes as the scripted curriculum framework. Thirteen (13) students experienced the UbD framework, a lesson plan framework designed to focus both curriculum and instruction on the development and deepening of student understanding and transfer of learning (Wiggins & McTighe, 2011).

The course instructor was asked to complete the teacher version of the Constructivist Learning Environment Survey (CLES), (Appendix A) and began teaching the two groups using the designated curriculum, maintaining a daily reflection log for each of the sections. At the end of the nine-week period, the instructor was asked to share a sample lesson plan used for both sections of Biology students, complete the teacher CLES, and submit the daily reflection logs.

The study used a mixed method, concurrent triangulation design. According to Hanson, Creswell, Plano Clark, Petska, and Creswell (2005), concurrent triangulation requires that quantitative and qualitative data are collected and analyzed simultaneously, where priority is equal and data analysis is separate and integrated using the triangulation of data to confirm, cross-validate, and corroborate study findings. The quantitative aspects of the design followed a quasi-experimental, nonequivalent group research design utilizing a content-based pretest/posttest design as well as a survey, while the qualitative aspects followed a case study design that utilized focus groups and teacher reflection logs. Once all data was collected it was triangulated to provide a confirmation measurement to increase the confidence and rigor of the research and build a coherent justification for themes. Member checking was also used to help determine if the participants felt that the themes were accurate.

In quasi-experimental designs, hypotheses are tested regarding the effectiveness of treatments that can be actively manipulated to achieve an outcome (Shadish & Luellen, 2006). The authors go on to explain some threats to internal validity of this design to include: a) ambiguous temporal precedence, b) selection of participants, c) history of events during the treatment, d) maturation over the course of the treatment, e) regression, f) attrition, g) exposure to the test, and h) instrumentation (Shadish & Luellen, 2006, p. 541). According to Creswell (2014) when utilizing a case study design, inquiry can be found through in-depth analysis of a program, event, activity, or individuals. During this process, data analysis must be conducted while still collecting more data in order to allow for various themes to emerge. Data is then coded or organized into chunks allowing the researcher to get a sense of main ideas present. The coding process should be used to generate a description of the topic, setting, and even complex themes for analysis in order to build additional layers (Creswell, 2014).

The first research question of the study focused on the difference in science content knowledge between those students receiving the district-scripted curriculum/instruction and those receiving the UbD curriculum/instruction. This was answered using a triangulation of data based on the pre- post unit tests, teacher reflection logs, and sample lesson plans. The second research question of the study focused on the difference in perception of the learning environment between the classroom receiving district scripted curriculum and UbD curriculum. Data triangulation consisted of student and teacher CLES surveys, student focus groups, and teacher reflection logs.

Assessment Measure Development

The study began with a content-based pretest administered to all students enrolled in the Biology course to determine which two of the three sections were most similar based on science content knowledge. The content-based pretest consisted of 20 multiple choice questions associated with the Texas Essential Knowledge and Skills (TEKS) that were taught over the nine-week period. The standard that was covered during this time was B.6F. This standard required students to predict possible outcomes of various genetic combinations such as monohybrid crosses, dihybrid crosses, and non-Mendelian inheritance. For purposes of this study, STEMscopes lessons were delivered as the scripted curriculum (control group), since this was the curriculum provided by the school. The treatment group was taught using lessons created by the teacher utilizing the UbD framework. The criteria for the curriculum provided to the groups was randomly selected by the teacher.

Before beginning treatment, the Constructivist Learning Environment Survey (CLES) (Appendix A and B) was administered to both the teacher and students to determine the level of constructivist practices occurring in the classroom. The CLES was originally developed by Peter Taylor, Barry Fraser, and Darrell Fisher at Curtain University of Technology in Perth, Australia (Taylor, Dawson, & Fraser, 1995). According to Johnson and McClure (2003), the Constructivist Learning Environment Survey can be used to determine both teacher and student perceptions of classroom learning environments (p.67). The CLES has been used in many qualitative studies of the nature of science knowledge and learning of science teachers and their students (Lucas & Roth, 1996; Roth & Bowen, 1995; Roth & Roychoudhury, 1993) as well as an investigation of the relationships between classroom environment and student academic efficacy (Dorman, 2001).

Focus Groups

During the first week, four students from each section were purposefully selected to participate in a focus group meeting. The criteria for purposeful selection included the ability to stay after school for 45 minutes, as described in the consent form, along with students of varying science content knowledge as shown by the pretest scores These students attended a total of two focus group meetings to discuss the level of constructivist practices that occurred. The first focus group meeting occurred during the first week of the nine-week period. An audio recording device was used during focus group meetings along with a list of guiding questions to ensure the students' conversation stayed on track (Appendix C). A final focus group meeting consisting of the same group of students was conducted during the last week of the nine-week period.

Teacher Reflection Logs

Over the course of the nine-week period, the teacher kept a daily log of each class using a structured reflection questionnaire, (Appendix D) where she analyzed the lesson using a set of questions for each of the lesson designs. One purpose of the reflection logs was to measure the difference in science content knowledge between those students receiving UbD curriculum/instruction and those students receiving the district- scripted curriculum instruction. The other purpose was to measure the difference in perception of the learning environment between the classroom receiving UbD curriculum and the district scripted curriculum.

Student Work Samples

Student work samples were used to provide an example of the types of materials and activities that were used in each of the classrooms. When comparing these samples, a rubric (Appendix E) was used to determine the depth of science content knowledge between the two frameworks. This rubric was adapted from Constructivist Lesson Rubric (2014) to measure four criteria: 1) evidence of the state standard being taught within the activity, 2) evidence of student expectations taught within the activity, 3) evidence of the essential knowledge assessed within the activity, and 4) evidence of student understanding.

Sample Lesson Plans

Sample lesson plans were used to provide an example of the types of daily lessons, materials, and activities that were used in each of the classrooms. When comparing these sample lesson plans, a rubric (Appendix F) was used to determine the depth of science content knowledge between the two frameworks. This rubric was adapted from Constructivist Lesson Rubric (2014) to measure five criteria: 1) evidence of instructional design, 2) evidence of standards alignment, 3) evidence that the assessments were used to guide instruction, 4) evidence that the learning activities were aligned to the curriculum and considered the perspective of the learner, and 5) evidence that the lesson was designed to optimize class time for the assignments.

Findings and Results

Using the mixed method, concurrent triangulation design, the quantitative data analysis consisted of an examination of scores of students based on the type of instruction given over a nine-week period as well as the perception of the learning environment described by the teacher and the students based on the type of instruction conducted in the classroom during the nine weeks. The qualitative data analysis consisted of examining the teacher reflection logs, sample lesson plans, student focus groups, and student work samples.

Science Content Knowledge

The first research question of the study focused on the difference in science content knowledge between those students receiving UbD curriculum/instruction and those students receiving the district-scripted curriculum/instruction. This was answered using a triangulation of data based on the pre- post unit tests, teacher reflection logs, sample lesson plans, and student work samples. The teacher reflection logs and student focus groups were triangulated and analyzed to identify two themes regarding science content knowledge. The two themes resulting from data analysis were Instructional and Learning Style and Using Discussion Within the Instructional Cycle.

Content-based Tests

A mixed-design ANOVA was used with time of content test (pretest, posttest) as a within-subjects factor and instructional type (UbD, scripted) as a between-subjects factor revealed a main effect of instructional type. Table 3 shows the results using content tests over time. There was no interaction effect between time and teaching method, $F(1, 33) = 41.81$, $p <$

$.05$, partial $\eta^2 = .56$. Mauchly's test indicated that the assumption of sphericity had been violated, therefore degrees of freedom were corrected using Huynh-Feldt correction model of sphericity (ε = 1.00). The Mauchly's test of sphericity was used to measure the assumption of sphericity when using repeated-measures ANOVA. The Huynh-Feldt correction model was then used because there was small p-value from the Mauchly's test. This revealed that there was a significant difference between the times the tests were taken showing that the students showed growth from the pretest to the posttest. There was no interaction effect between time and teaching method, $F(1, 33) = 41.81$, $p < .05$, partial $\eta^2 = .56$. Based on the type of instruction given to each class, there was no significant difference between the two types of instruction, $F(1, 33) = 2.65$, $p = 0.11$. This revealed that both types of instruction increased content knowledge among the students that participated in the study. There was a total of a 15.71point increase over the nine-week period, with a larger gain among the students receiving the district-scripted curriculum.

Table 3

Mixed-Model ANOVA results using Unit Tests over time

Predictor	Sum of Squares	*df*	Mean Square	F	*p*	partial η^2
(Intercept)	193062.38	1	193062.38	462.13	<.001	.933
time	3608.89	1	3608.86	41.81	<.001	.559
Instructional type	1108.10	1	1108.10	2.65	.113	.074
time x Instructional type	180.32	1	180.32	2.09	.158	.060
Error	13786.20	33	417.76			

Descriptive statistics was used to determine the mean overall score of the unit tests (pretest and posttest). As shown in Table 4, the mean total score of the participants on the unit pretest was 45.43 with a standard deviation of 16.60. The mean total score of the participants on the unit posttest was 61.14 with a standard deviation of 15.86.

Table 4

Descriptive Statistics: Unit Pretest and Posttest

	Instructional Type	N	M	SD
Pretest	STEMScopes	22	41.14	16.18
	UbD	13	52.69	15.22
	Mean Total Score	35	45.43	16.60
Posttest	STEMScopes	22	59.32	15.61
	UbD	13	64.23	16.44
	Mean Total Score	35	61.14	15.86

Teacher Reflection Logs and Student Focus Groups

The teacher reflection logs and student focus groups were triangulated and analyzed to identify two themes regarding science content knowledge. The two themes resulting from data analysis were instructional and learning style and using discussion within the instructional cycle for both curricula.

Instructional and Learning Style Using UbD. The purpose of the UbD framework is "to 'teach' students that their job is not merely to learn facts and skills, but also to question them for their meaning" (Wiggins & McTighe, 2005, p. 104). The teacher expressed that with this lesson framework, she has "the ability to chunk the information appropriately with [her] students in mind and make time for the detail that will set them up to understand concepts at a deeper level and allow them to build on that understanding with other concepts." During the focus groups, the students explained how the teacher would adapt her lessons to meet their needs but also encourage a productive struggle. One student explained:

> She lets us struggle, but productive struggle. Like if she sees that we really don't get it, she'll help us. When she notices we're really not getting it, she will be a little more elaborate and explain on it and go into more detail.

Another student explained when they would have multiple assignments due in various classes, students knew they could talk to the teacher; "Like I think if we go to her like specifically like one-on-one, she'll give you more time if you ask for it." The student went on to explain that the teacher would also provide different opportunities for them to finish their work or get extra help; "We had a working lunch if we didn't finish [an assignment] or come after school."

In the teacher reflection logs, the teacher explained that she was able to make connections to previous content and lay the foundation for upcoming concepts. As a precursor to labs and other activities, she would ensure the students understood the "how and why" of a concept as well make "direct connections to the TEKS" and allow them to relate it to real world examples.

The teacher further explained, in the reflection logs, that this framework "allowed for some flexibility and differentiation." One specific example of this can be seen when she stated, "I was able to cut out an elaborative assignment for the sake of time and [ensure] that students really focused on the practice assignment where they applied mitosis for the first time. The virtual lab I cut out, while interesting, goes deeper than needed for the curriculum and goals, and so was not necessary."

Instructional and Learning Style Using Scripted Curriculum. The district provided curriculum, STEMScopes, as the scripted curriculum for this study. According to a study done by Rice University (2017), this program is designed to have the teacher guide students toward discovery of concepts and skills instead of using direct instruction. The teacher expressed that STEMScopes did not go into the specificity required for each standard. She expressed numerous times that the STEMScopes curriculum did not allow for students to easily make connections between concepts or lay the foundation for new ones. The teacher explained that "STEMScopes focused more on the definitions...rather than effects. [It] seems to lead them through the process of [the various concepts] without going into the 'why' or 'what's happening'." She went on to explain how she would use "quick mini-lessons" to cover the information that STEMScopes did not cover.

Using Discussion Within the Instructional Cycle for Both Curricula. During the instructional cycle, the teacher frequently utilized student-led and class wide discussions. As explained in her lesson plans, she would use these discussions in various components in her lesson. During activities, the teacher had the students discuss the overarching concepts and encouraged them to work together to answer the higher order thinking questions asked within the assignment or activity. As explained by the students during the focus group, "Whenever she assigned us group projects, that's when I learned stuff." Another student went on to explain that "helping each other is better than asking the teacher for help...sometimes another student has an easier way."

Another method the teacher used to implement discussion was when students were given written assignments or worksheets. A student explained that the teacher would use them as a guideline of what they were supposed to talk about in their groups or partners. Along with student-led discussion, the teacher mentioned that she would bring the class together as a whole group to check for understanding. If a concept was not covered in the scripted curriculum, the teacher would provide the students with a basic overview of the concept before giving the assignment as written.

The last method the teacher used to implement discussion was as a form of formative assessment to guide instruction and monitor student learning. Group question and answer sessions were held during note taking sessions to make connections to previous content or lay a foundation for upcoming concepts. She would also use small group conferencing during independent work time to work with students that were struggling with a particular concept.

Student Work Samples

A rubric was created and used to analyze the student work for both scripted and UbD assignments. As shown in Table 5, when analyzing the assignments used in the scripted classroom, the state standards were somewhat evident. Neither assignment provided by STEMScopes (Math Connections: Genetic Outcomes and Progress Monitoring Assessment) covered a specific aspect of the standard regarding possible outcomes using non-Mendelian inheritance. A district created Essential Lab was implemented, Paternity by Blood Typing, to cover one type of non-Mendelian genetics called codominance. Student expectations were somewhat evident between the assignments. Only one third of the student expectations were covered within the two work samples. Neither of the assignments required students to show their understanding by inferring genotype of the F1 generation, inferring any phenotypic expression, or predicting genetic combinations using non-Mendelian genetics, specifically, incomplete dominance, using multiple alleles, or sex-linked traits. The essential questions were somewhat answered within the two work samples. The assignments exposed students to two ways to calculate the probability of inheritance in offspring but did offer opportunities for students to explain the limitations of this type of calculation. The student understandings were also somewhat evident within the two assignments.

Math Connections that were used included Genetic Outcomes requiring students to create five monohybrid Punnett squares and determine a specific percentage of the inherited gene, as well as one dihybrid cross to determine the phenotypic ratio of all offspring. Progress Monitoring Assessment consisted of 7 multiple choice questions that required students to use monohybrid and/or dihybrid crosses to answer the questions.

When analyzing the assignments used in the UbD classroom, the state standards were extremely evident. Genetic outcomes were determined *using* a variety of methods among the assignments. Students were required to predict genotypic and phenotypic expression using monohybrid and dihybrid crosses, and use various non-Mendelian combinations (incomplete dominance, using multiple alleles, and sex-linked traits). As shown in Table 6, student expectations were mostly evident between all of the assignments, with only one student expectation not met.

Table 5

Student Work Analysis: Scripted

Curriculum	Assignments	Category	Evidence
Scripted	Math Connections: Genetic Outcomes Progress Monitoring Assessment District Mandated: Paternity by Blood Typing	State Standards (TEKS)	State standards were somewhat evident in the scripted curriculum assignments. Genetic outcomes were determined using monohybrid and dihybrid crosses in each assignment. Neither assignment provided by STEMScopes (Math Connections: Genetic Outcomes and Progress. Monitoring Assessments) covered possible outcomes using non-Mendelian inheritance. A district created Essential Lab was implemented. Paternity by Blood Typing to cover one type of non-Mendelian genetics called codominance.
			Student expectations were somewhat evident between the assignments. Only one third of the student expectations were covered within the two work samples. The assignments from STEMScopes exposed students to monohybrid and dihybrid crosses using Punnett squares, calculating possible outcomes of F2 generation, and predicting combinations with genotypes. The Paternity by Blood Typing assignment required students to predict genetic combinations using codominance. None of the assignments required students to infer genotype of the F1 generation, infer any phenotypic expression, or predict genetic combinations sing non-Mendelian genetics, specifically, incomplete dominance, using multiple alleles, or sex-linked traits.
		Essential Questions	The essential questions were somewhat answered within the two work samples. The assignments exposed students to two ways to calculate the probability of inheritance to offspring but did offer opportunities for students to explain the limitations of this type of calculation.
		Student Understandings	The student understandings were somewhat evident within the two assignments. Math Connections: Genetic Outcomes required students to create five monohybrid Punnett squares and determine a specific percentage of the inherited gene, as well as one dihybrid cross to determine the phenotypic ration of all offspring. Progress Monitoring Assessment consisted of 7 multiple choice questions that required students to use monohybrid and/or dihybrid crosses to determine information necessary to answer the questions.

Table 6

Student Work Analysis: Understanding by Design

Curriculum	Assignments	Category	Evidence
Understanding by Design	Monster Genetics Zork Genetics DNA,RNA, Snorks X-linked Genes Bikini Bottom Incomplete Dominance District Mandated: Paternity by Blood Typing	State Standards (TEKS)	State standards were extremely evident in the UbD assignments. Genetic outcomes were determined using a variety of methods among the assignments. Students were required to predict genotypic and phenotypic expression using monohybrid and dihybrid crosses, and use various non-Mendelian combinations (incomplete dominance, using multiple alleles, and sex-linked traits). A district created Essential Lab was also implemented, Paternity by Blood Typing, to cover one type of non-Mendelian genetics called codominance.
			Student expectations were mostly evident between all of the assignments, with only one student expectation not met. The Monster Genetics and Zork Genetics assignments utilized by the teacher exposed students to monohybrid and dihybrid crosses using Punnett squares, calculating possible outcomes of F2 generation, and predicting combinations with genotypes. The Bikini Bottom assignment exposed students to incomplete dominance, while the DNA, RNA, Snorks assignment exposed students to gene expression by way of mitochondrial DNA. The X-linked Genes assignment gave students an opportunity to explore, predict genetic combinations with sex-linked traits. The Paternity by Blood Typing assignment required students to predict genetic combinations using codominance.
		Essential Questions	The essential questions were somewhat evident among the work samples. The assignments exposed student to various ways to calculate the 0robability o inheritance in offspring but did offer opportunities for students to explain the limitations of this type of calculation.
		Student Understandings	The student understandings were extremely evident among the assignments. Monster Genetics introduced students to the basics of Mendelian genetics, while Zork Genetics required students to utilize dihybrid crosses and infer phenotypic expression. DNA, RNA, Snorks required students to examine the DNA sequence of an organism and analyze the genes of a DNA sequence to determine what traits the organism has. X-linked Genes gave students an opportunity to predict the combination of eye color in flies as determined by the chromosome. The Bikini Bottom assignment had students explore incomplete dominance of the color of a specific flower, while the Paternity by Blood Typing assignment required students to predict traits using codominance.

Sample Lesson Plans

A rubric (Appendix F) was created and used to analyze the teacher's lesson plans for both the scripted and UbD classroom. This rubric looked at the instructional design, standards alignment, assessment, learning activities, and instructional pacing. When analyzing the lesson plans used in the scripted classroom, the instructional design used a 5E instructional model (Accelerate Learning, 2021) to cover two related standards. The standards were intertwined to create comprehensive instruction using the 5E model, while incorporating prior science connections, Reading/English Language Arts, and Math concepts. Progress Monitoring Assessments and Math Connections were used as formative assessments during class time. There were a total of three student-friendly essential questions derived from the standards that the teacher reviewed at the beginning of each lesson. Students were given opportunities to work together and have discussions during the engage, explore, and elaborate portions of the 5E instructional model (Accelerate Learning, 2021). According to the teacher's notes, certain aspects of the lesson were modified or shortened due to time constraints and repetition. The teacher also noted that the lessons lacked information required by the standards, Since the scripted curriculum did not contain needed concepts, the teacher incorporated notes and sample problems to ensure students were exposed to this information.

When analyzing the lesson plans used in the Understanding by Design classroom, the lesson also used a 5E instructional model to cover multiple standards. The progression through the standards supported the development and understanding of the concepts. The formative assessments used within this lesson plan included: a) group question and answer sessions held during note-taking; b) small group conferencing during independent work; c) peer dialogue; and d) observation of completion of various hands-on activities to ensure understanding. There were a total of nine student-friendly essential questions derived from the standards. Students were given opportunities to work together and have discussions throughout the learning process. The activities reflected vertical alignment and an appropriate level of rigor. Various instructional tools were used to address the needs of all learners. The sequencing of the lesson within the lesson plan allowed the teacher to think about the aspect of time prior to implementation. Teacher autonomy and the ability to adapt the lesson/time to fit the needs of the student was also a factor in optimizing in class time.

Triangulation: Science Content Knowledge

Although the data collected from the content-based tests revealed that both types of instruction increased content knowledge among the students that participated in the study, other factors should also be considered based on teacher reflection logs, student focus groups, sample lesson plans, and student work samples. Triangulation of data was used to capture different dimensions of each piece of evidence.

Based on the triangulation of the teacher reflection logs and sample lesson plans with the content-based tests, it was evident that the increase in content knowledge was primarily due to the teacher's understanding of the Texas Essential Knowledge and Skills (TEKS) as well as the ability to meet the needs of the students in each class. When looking at the student focus groups and student work samples with the content-based tests, it was evident that the increase in content knowledge was associated with the utilization of discussion during the learning cycle. The teacher utilized discussion at various points within the lessons to review the overarching concepts and encouraged students to work together to answer the higher order thinking questions asked within an assignment or activity.

Perception of the Learning Environment

The second research question of the study focused on the difference in perception of the learning environment between the classroom receiving UbD curriculum and the district scripted curriculum. This was answered using a triangulation of data that consisted of student and teacher CLES surveys, student focus groups, student work samples, and teacher reflection logs. The teacher reflection logs and student focus groups were triangulated and analyzed to identify two themes when looking at the perception of the learning environment. The two themes resulting from data analysis were the Effect of Teacher Relationship On Instruction and the Effect of Time On the Learning Environment.

Student CLES

Descriptive statistics was used to determine the mean overall score of student perception of the learning environment using the CLES (pre- and post-survey). The mean score of the perception of the learning environment at the beginning of the nine-weeks was 72.40 with a standard deviation of 7.60. The mean score of the perception of the learning environment at the end of the nine-weeks was 75.47 with a standard deviation of 10.37. As shown in Table 7, a mixed-design ANOVA was also used to analyze the difference in perception of the learning environments from a student and teacher perspective. When looking at student perception over the nine-week period, time of survey (CLES Pre, CLES Post) was used as the within-subjects factor and instructional type (UbD, scripted) as the between-subjects factor. The data revealed a main effect of time, $F(1, 33) = 4.20$, $p < .05$, $\eta p^2 = 0.113$.

Mauchly's test indicated that the assumption of sphericity had been violated, therefore degrees of freedom were corrected using Huynh-Feldt correction model of sphericity ($\varepsilon = 1.00$). This indicated an increase in student perception of the learning environment over the course of the nine-week period. Based on the type of instruction given to each class, there was no significant difference between the perception of the learning environment between the two instructional types, $F(1, 33) = 0.61$, $p = 0.44$. This revealed that both types of instruction increased student perception of the learning environment among the students that participated in the study. There was a total of a 1.17-point increase over the nine-week period, with a larger gain among the students receiving the UbD curriculum.

Table 7

Mixed-Model ANOVA Results for Student CLES with Instructional Type as Criterion

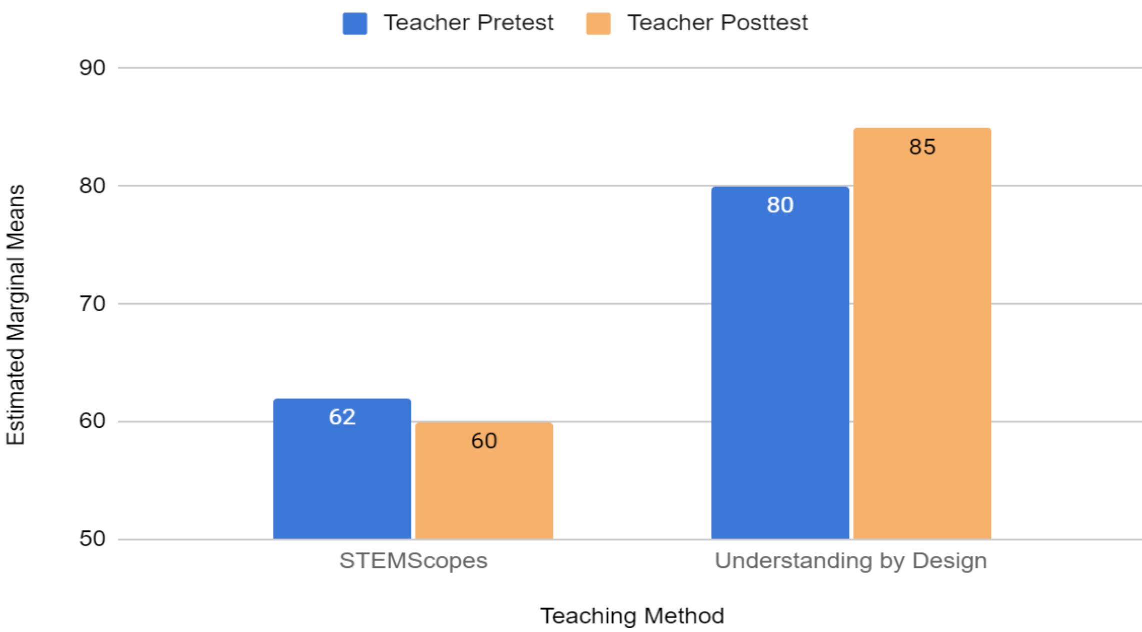
Predictor	Sum of Squares	df	Mean Square	F	p	partial η^2
(Intercept)	360456.17	1	360456.17	3040.50	.000	.989
time	203.61	1	203.61	4.20	.049	.113
instructional type	72.29	1	72.29	.610	.440	.018
time x instructional type	31.73	1	31.73	.654	.424	.019
Error	3912.20	33	118.55			

Teacher CLES

According to Figure 1 shown below, the teacher CLES score over the course of the nine-week period decreased from 62 to 60 in respect to the scripted STEMScopes curriculum.

Figure 1

CLES: Teacher Pretest and Posttest



This revealed that the teacher's perception of constructivist practices decreased in the scripted classroom. I n respect to UbD curriculum, the teacher's CLES score over the course of the nine-week period increased from 80 to 85. This revealed that the teacher's perception of constructivist practices increased in the UbD classroom.

This revealed that the teacher's perception of constructivist practices decreased in the scripted classroom. In respect to UbD curriculum, the teacher's CLES score over the course of the nine-week period increased from 80 to 85. This revealed that the teacher's perception of constructivist practices increased in the UbD classroom.

Teacher Reflection Logs and Student Focus Groups

The teacher reflection logs and student focus groups were triangulated and analyzed to identify two themes when looking at the perception of the learning environment. The two themes resulting from data analysis were, (1) Effect of Teacher Relationship On Instruction and the, (2) Effect of Time On the Learning Environment.

Effect of Teacher Relationships on Instruction. The teacher utilized various tools, such as differentiation, giving students extensions on assignments, and encouraging productive struggle, as ways to meet the needs of her students. To adapt to the needs of the students, she altered her original plans and "made the additional worksheets extra credit." In the UbD classroom, the teacher created stations to introduce the students to different concepts, as opposed to the packets utilized in the scripted curriculum. In respect to the scripted curriculum, the teacher explained how she would try to boost engagement when they had to do worksheet-type activities. She stated, "to avoid losing their attention and boring them (and myself) to tears, I offered them a choice. Students could read and work independently, or they could join me...We would read through part 1 (with me expanding on the information and clarifying where necessary) together and many students were making notes as we went on." She went on to explain that she would even "extend the deadline to the next class period" or give them about 30 minutes to work on it during class time. According to the student focus groups, students appreciated the opportunities for extra credit; "Well I did a worksheet where it was like about flies with red eyes and white eyes for extra credit" to help with understanding genetics and inheritance. The students went on to explain how the teacher would let them "struggle, but productive struggle." They went on to explain how she would not give them the answers right away but would give them time to answer questions and give them hints instead. When students had multiple assignments due in various classes, they knew they could talk to the teacher; "Like I think if we go to her like specifically like one-on-one, she'll give you more time if you ask for it."

Effect of Time on the Learning Environment. Each curriculum framework caused issues in respect to time. When using the scripted framework, the teacher explained that "STEMScopes focused more on the definitions...rather than effects. [It] seems to lead them through the process of [the various concepts] without going into the 'why' or 'what's happening'." Since the students were expected to understand these concepts in full, the teacher "[looked] for ways to cover [the topics] without straying from the material." She explained that "STEMScopes only has a couple of practice [problems]" and mentioned that the activities had numerous errors. The teacher went on to explain that there were "excessive short answer questions that ask[ed] similar [information] in different ways" so the "students [were] less likely to complete the assignment." According to the students, they felt they had enough time to complete assignments in class. They explained that the teacher would give plenty of in class time for the assignments, and she would also provide different opportunities for them to finish their work or get extra help; "We had a working lunch if we didn't finish [an assignment] or come after school."

The teacher stated that the UbD framework "allowed for some flexibility and differentiation" when planning and altering lessons to meet the needs of the students. She went on to explain that she would create stations to touch on each concept within a standard "for the sake of time, [allow students to] self-review," and encourage students to make connections between concepts. According to the students in the UbD classroom, they did not feel they were given enough time to complete assignments: "I think like every now and then she like gives us enough time and sometimes she doesn't. She does like a good job at teaching us things, but I feel like it's too much information all at once. I feel like she kind of like piles it on and then it gets to the point where I'm like I just kind of like panic a little bit because so much stuff all together." As a group, the students explained how the teacher would also provide different opportunities for them to finish their work or get extra help; "We had a working lunch if we didn't finish [an assignment] or come after school."

Triangulation: Perception of Learning Environment

Although the data collected from the teacher and student CLES revealed differences in the perception of the learning environment, other factors should also be considered based on teacher reflection logs, student focus groups, sample lesson plans, and student work samples. Triangulation of data was used to capture different dimensions of each piece of evidence. To answer the research question regarding perception of the learning environment between the two types of instruction used in the study, the teacher and student CLES were triangulated with student focus groups, teacher reflection logs, student work samples, and teacher reflection logs.

The student CLES revealed that both types of instruction increased student perception of the learning environment, while the teacher CLES revealed that the teacher's perception of constructivist practices decreased in the scripted classroom over the course of the nine-week period. Based on the triangulation of the teacher reflection logs and sample lesson plans with the teacher and student CLES, it was evident that the differences in the perception of the learning environment was primarily due to the relationship the teacher had with the students.

When looking at the teacher's description of the UbD classroom, she stated that the UbD framework gave the opportunity for flexibility and differentiation when planning and altering lessons to fully cover each TEKS standard. The teacher expressed with this lesson framework, she had "the ability to chunk the information appropriately with [her] students in mind and make time for the detail that will set them up to understand concepts at a deeper level and allow them to build on that understanding with other concepts." Using the triangulation of the student focus groups and student work samples with the teacher and student CLES, it was evident that the differences in the perception of the learning environment was influenced by the amount of time given for each concept within the learning cycle.

Discussion

The purpose of this study was to analyze the effectiveness of scripted curriculum as a means of providing students with the information required to be successful on standardized assessments, while comparing curriculum developed by the teacher utilizing the Understanding by Design (UbD) framework. Scholarly literature regarding the use of scripted curriculum in the science classroom was not apparent, indicating a need for this study. Several forms of scripted science curriculum have been introduced in Texas and other states over the years, such as CSCOPE, Pearson Interactive Science, and STEMscopes. The above-mentioned curriculum types are often recommended and sold to school districts by Regional Education Service Centers. Once adopted and introduced, it is the responsibility of the superintendents, principals, and teachers to implement the curriculum as intended and with fidelity. Research studies have been conducted that present the various aspects of the implementation of prescribed reading and mathematics curriculum, but there seems to be a gap in the literature regarding the use of scripted science curriculum. Thus, the findings of this study are unique and contribute to the body of literature for the effectiveness of scripted curriculum and add to the research on alternative curriculum and instruction methods for teaching science, such as the use of the Understanding by Design (UbD) framework. The following sections contain the existing literature and the implications of this study regarding science curriculum and content knowledge, the constructivist learning environment, and Understanding by Design in the science classroom.

Science Content Knowledge

Curriculum materials can be defined as resources to guide teacher instruction that can include textbooks and supplementary units or modules (Remillard et al., 2014). Many studies show that science curriculum materials can have positive effects on student learning, including an increase in students' attitudes and motivation toward science (e.g., Häussler & Hoffmann, 2002; Roblin, et al., 2017; White & Frederiksen, 1998), an increase in student understanding of science concepts (e.g., Harris et al., 2015; Sadler, et al., 2015), and an increase in their abilities to engage in science practices. In a study done by Sudduth (2020), strict implementation of scripted curriculum leaves educators feeling constrained by what to teach, the amount of time they have for lessons, and how students should be assessed. The author explains that scripted curriculum limits teachers and hinders their ability to tailor lessons to each of the different learning styles in the classroom. Curriculum materials have also shown to have an influence on teachers' beliefs about science teaching and learning, the nature of science, and about themselves as knowers of science (Dias et al., 2011; Wyner, 2013).

According to the data collected from the content-based tests, there was a significant difference between the times the content tests were taken. This showed student growth from the pretest to the posttest. Although the data collected from the content-based tests revealed that both types of instruction increased content knowledge among the students that participated in the study, other factors should also be considered based on teacher reflection logs, student focus groups, sample lesson plans, and student work samples.

Based on the triangulation of the teacher reflection logs and sample lesson plans with the content-based tests, it was evident that the increase in content knowledge was primarily due to the teacher's understanding of the Texas Essential Knowledge and Skills (TEKS) as well as the ability to meet the needs of the students in each class. The teacher expressed that the scripted curriculum did not go into the specificity required for each standard. She explained that "STEMScopes focused more on the definitions...rather than effects. [It] seems to lead them through the process of [the various concepts] without going into the 'why' or 'what's happening'." She went on to explain how she would use "quick mini-lessons" to cover the information that STEMScopes did not cover. She went on to explain that it did not allow for students to easily make connections between concepts or lay the foundation for new ones. As a precursor to labs and other activities, the teacher would ensure the students understood the "how and why" of a concept as well make "direct connections to the TEKS" and allow them to relate it to real world examples. One way to provide the students with the content specified in the TEKS, the teacher would use mini-lessons to cover the information that the scripted curriculum did not cover.

Based on the triangulation of the student focus groups and student work samples with the content-based tests, it was evident that the increase in content knowledge was associated with the utilization of discussion during the learning cycle. Discussion was implemented at various points within the lessons to discuss the overarching concepts and encouraged students to work together to answer the higher order thinking questions asked within an assignment or activity.

Constructivist Learning Environment and the Use of the Understanding By Design Framework the Science Classroom

According to Kumar and Gupta (2009), a constructivist classroom provides opportunities to observe, work, explore, interact, raise question enquiry, and share their expectation to all. One way to implement the constructivist model in the science classroom is through the use of Roger Bybee's 5E model, which was developed under the Biological Science Curriculum Study (BSCS) project (Singh & Yaduvanshi, 2015). Singh and Yaduvanashi (2015) further explain that the 5E constructivist-based model encourages learners to "reflect and question their own understanding via active meaning making process". According to Taber (2019), constructivist teaching is a process of personal knowledge construction that occurs within the minds of individual learners and is contingent upon the way the learner constructs his/her thinking. Devetak & Glazar (2014) explain that teaching involves activities that require students to identify and activate relevant prior knowledge, includes 'active' learning, encourages students to reflect on their thinking and ongoing learning, and pushes students to discuss their work.

Rubrica (2018) states that the Understanding by Design (UbD) framework has enhanced the delivery of instruction through curriculum mapping, construction of unit assessment matrices, revision of the learning module components, the integration of values in lesson, effective management of instructional time, and enriched student learning. Wiggins and McTighe (2005) explain that the teachers are coaches of understanding, that focus on ensuring learning, not just teaching. They further explain that the goal is to check for successful meaning-making and transfer of the information by the learner. Schiller (2015) conducted a study using UbD to design unit lesson plans for the Next

Generation Science Standards (NGSS) for the topic of evolution and correlated it to the NGSS performance expectations. The author went on to explain that the findings showed the UbD unit lessons increased student achievement in the unit, using the NGSS assessment, as well as an increase in student interest in learning the science content.

Student and teacher Constructivist Learning Environment Surveys (CLES), student focus groups, student work samples, and teacher reflection logs were used to explore the perception of the learning environment when utilizing each curriculum. The student CLES revealed that both types of instruction increased student perception of the learning environment, while the teacher CLES revealed that the teacher's perception of constructivist practices decreased in the scripted classroom over the course of the nine-week period. Although the data collected from the teacher and student CLES revealed differences in the perception of the learning environment, other factors should also be considered based on teacher reflection logs, student focus groups, sample lesson plans, and student work samples.

Based on the triangulation of the teacher reflection logs and sample lesson plans with the teacher and student CLES, it was evident that the differences in the perception of the learning environment was primarily due to the relationship the teacher had with the students. The teacher utilized various tools, such as differentiation, giving students extensions on assignments, and encouraging productive struggle, as ways to meet the needs of her students. When examining the student focus group data, the students felt comfortable to ask questions in the classroom, ask for more individualized help, and appreciated opportunities for extra credit as well as productive struggle. A student was quoted as saying:

> She lets us struggle, but productive struggle. Like if she sees that we really don't get it, she'll help us. When she notices we're really not getting it, she will be a little more elaborate and explain on it and go into more detail.

Based on the triangulation of the student focus groups and student work samples with the teacher and student CLES, it was evident that the differences in the perception of the learning environment was influenced by the amount of time given for each concept within the learning cycle. When looking at the teacher's description of the scripted classroom curriculum, the students in this classroom did not always engage in the same hands-on activities as the students in the UbD classroom. The teacher did not feel the assignments were being completed due to the excessive number of short answer questions that were asked in different ways. According to the students in the scripted classroom, there was a lot of paperwork.

When looking at the teacher's description of the UbD classroom, she stated that the UbD framework gave the opportunity for flexibility and differentiation when planning and altering lessons to fully cover each TEKS. The teacher expressed that with this lesson framework, she had "the ability to chunk the information appropriately with [her] students in mind and make time for the detail that will set them up to understand concepts at a deeper level and allow them to build on that understanding with other concepts." According to the students in the UbD classroom, they felt there was a lot of work and information presented during class time, but they appreciated that the teacher provided different opportunities for them to finish their work or get extra help. One student explained when students would have multiple assignments due in various classes, they knew they could talk to the teacher; "Like I think if we go to her like specifically like one-on-one, she'll give you more time if you ask for it."

Limitations

The present study has several limitations. Firstly, the sample size was small, which may not reflect the larger population. This sample size was also limited, as it was only utilizing one school within a district and would be more comprehensive if comparing across an entire district. Secondly, there was only one teacher, which may present a limited point of view when comparing the two classes taught. If multiple teachers were used in the study, it would also allow for a more comprehensive look at the curriculum from various perspectives, while utilizing the same curriculum.

The two curriculum frameworks in this study were used by a single teacher, and the increase in student content-based test scores over the course of the nine-week period could have been influenced by the teaching strategies used in each classroom, such as the *quick mini-lessons* within the scripted classroom. These mini-lessons were used to meet the needs of the students to cover the information that the scripted curriculum did not cover. When looking at the perception of the learning environment, the overall increase in student perception of the constructivist learning environment, other factors could have influenced these outcomes since the teacher differentiated instruction and adapted to the needs of the students, therefore not fully using a true scripted curriculum. These factors need to be considered when making generalizations from these results.

Recommendations for Future Research

According to Alwahaibi et al., (2019), science curriculum is often described as "unrelated, difficult, and boring to learn in comparison with other topics". Therefore, it is important for teachers to actively engage students in the learning process and have the ability to differentiate instruction to meet the needs of students in the classroom. Helldén (2005) explains that without students' interest in science, they may not make the effort to learn and understand the concepts that they are taught.

The results of this study have implications for designers of science curriculum, however other factors than the curriculum could have influenced the outcomes since only one teacher was used to teach both classes of students. It is important to look at teacher and student efficacy when scripted programs are implemented in the science classroom. Using scripted programs may cause teachers to feel that their professionalism has been devalued which may impact their teaching and consequently affect the students and their learning process. According to Costigan (2008), curricular mandates hinder four basic areas teachers need to thrive professionally: a) autobiographically based teaching, b) personal teacher theory is limited or extinguished, c) teaching is narrowed to assessment outcomes, and d) mandated curriculum does not promote understanding of student's lives or communities. Another factor to consider when implementing a scripted curriculum is the price per student. According to the Accelerate Learning (2021), the pricing per student for digital access to materials in Kindergarten – Grade 5 is $5.25, while Grades 6 – High School is $5.95. This does not include the hands-on and consumable kits that are required for Kindergarten through Grade 8. When looking at a district like STCS with a total of about 10,000 students in Kindergarten through Grade 12, the cost of STEMscopes reaches about $300,000 worth of school funds paid by the public.

It is important to look beyond the numbers and raw data when choosing curriculum. As shown using only the quantitative measures in this study, there was no significant difference between the two instructional methods, leaving room for curriculum decision makers to want to choose the pre-packaged curriculum to ensure success. Although the number showed little difference, the triangulation of data made it evident that the increase in content knowledge was primarily due to the teacher's understanding of the Texas Essential Knowledge and Skills (TEKS) as well as her ability to meet the needs of the students in each class. When looking at the Constructivist Learning Environment Surveys (CLES), there were differences in the perceptions of the learning environment. This was primarily due to the relationship the teacher had with the students. This study shows that it is important to look beyond the numbers to create a positive and engaging classroom environment. The use of a curriculum framework like Understanding by Design (Wiggins & McTighe, 2005), would be the better curriculum option.

The findings of this study have the potential to change current thinking about implementing scripted curriculum in the science classroom. Although the number of students in each of the classes was limited, the students involved in the study were the average students and show that the use of constructivist practices allows students to have a greater understanding of content and overall learning success. Additionally, as a result of the study, the teacher was able to reflect on the daily lessons and adapt the teaching style to meet the needs of the students in the classroom, as well as time constraints.

When utilizing the UbD framework, the teacher was able to choose activities and direct instruction to engage the students in the learning process. Additionally, the students retained more information from meaningfully planned activities created and/or utilized by the teacher in the UbD classroom. From the data gathered using the CLES, both types of instruction increased student perception of the learning environment, while the teacher CLES revealed that the teacher's perception of constructivist practices decreased in the scripted classroom over the course of the nine-week period. A topic that is relatively underexplored is the influence constructivist practices have on teacher efficacy when using the Understanding by Design framework in the classroom. It may be advantageous to explore how teachers with a strong sense of efficacy impact student efficacy and perception of the learning environment.

The length of time of this study was a nine-week period. Providing a study over the course of an entire school year and using several classrooms across a school district would provide a richer understanding of the importance of implementing a curriculum that allows for teacher autonomy. While these results should be taken into account when considering implementing a new science curriculum, further investigation into teacher training programs regarding the implementation of a constructivist learning environment while utilizing the UbD framework merits examination. It may be advantageous to do a follow-up measure during the students' senior year of high school to examine the level of Biology content knowledge that was retained. This data can provide evidence to determine which of the two curriculum frameworks, instructional styles, and activities helped the students retain the content learned during that school year.

When implementing a new curriculum, there are several factors to consider, such as the depth, rigor, and alignment of standards, differentiation tools provided, implementation requirements, professional development offered, resources necessary for hands-on instruction, budgetary constraints, and teacher buy-in. District curriculum decision makers can utilize curriculum adoption committees to provide teachers an opportunity to examine various curriculum resources before they are implemented in the classroom. This would include providing teachers and administrators an opportunity to use the state provided rubrics to review resources and discuss the benefits and disadvantages of each. Along with reviewing the resources, this would also give the committee time to create a budget for the hands-on equipment and supplies needed to implement these resources effectively in the classrooms. In my role as science curriculum coordinator, I plan to use the results of this study to promote a more inclusive method for adopting curriculum. With new science standards being adopted and implemented within the next year, I would like to utilize curriculum adoption committees to provide science teachers an opportunity to examine various curriculum resources before they are implemented in the classroom. This will allow teachers an opportunity to see how curriculum resources are aligned to the standards and choose one that will fit the needs of the students in our district.

Summary

In this study, participants were exposed to two curriculum frameworks over the course of a nine-week period. The use of content-based tests, Constructivist Learning Environment Surveys, student focus groups, teacher reflection logs, sample lesson plans, and student work samples were utilized to identify differences in science content knowledge and gain an understanding of the differences in the perception of the learning environment.

Each component of the study plays an integral role when implementing curriculum in the classroom. The teacher's awareness of student perception of the learning environment has influenced her teaching style and use of various strategies to keep students engaged during the lesson cycle. Additionally, the teacher was able to make note of gaps in the scripted curriculum and relay this information to the person at the district-level in charge of assessing curriculum.
Implementing constructivist practices along with a curriculum framework that allows for more teacher autonomy has a great potential for positively impacting teacher and student efficacy in the science classroom, thus creating a positive learning environment.

The authors received no financial support for the research, authorship, and/or publication of this manuscript.

Masomeh Mahzoon-Hagheghi (masomeh.mahzoon@gmail.com) is a graduate from Texas A&M Corpus Christi, receiving a PhD in Curriculum and Instruction. She received a bachelor's degree in biology with a minor in chemistry from The University of Texas at San Antonio, and a mater's degree in elementary education from Texas A&M- Corpus Christi. She is currently the district science curriculum coordinator for The Schools of Science and Technology. She has passion for science education and is dedicated to making science fun for students of all ages.

Faye Bruun (faye.bruun@tamucc.edu) is Professor of Education in the Department of Curriculum, Instruction, and Learning at Texas A&M Corpus Christi. She is Program Coordinator of the Ph.D. and Masters in C&I. Her research interests are in STEM teacher education.

References

Accelerate Learning. (2021). [The 5E + IA Instructional Model- Underlying principles of the 5E].

Alwahaibi, S.M.H., Lasharı, S.A., Saoula, O., Lasharı, T.A., Benlahcene, A. & Lubana, A. (2019). Determining Students' Intention: The Role of Students' Attitude and Science Curriculum. *Journal of Turkish Science Education*,16(3), 314-324.

Amrein, A. L., & Berliner, D. C. (2002). High-stakes testing, uncertainty, and student learning. *Education Policy Analysis Archives*, 10(18).

Anderson, C. G. (2011). A study of the impact of scripted reading on student fluency, comprehension, and vocabulary. (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI 3461716)

Apple, M.W. (2006). Markets, standards, god and inequality. In Blair, E. (2011). *Thinking about schools: a foundations of education reader* (p. 129-155). Boulder, CO: Westview Press.

Atkeison-Cherry, N. K. (2004). A comparative study of mathematics learning of third-grade children using a scripted curriculum and third-grade children using a non-scripted curriculum. (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI 3149291)

Bosen, P. K. (2014). Scripted or non-scripted: A comparative analysis of two reading programs. (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI 3623269)

Bybee, R. W., Taylor, J. A., Gardner, A., Van Scotter, P., Powell, J. C., Westbrook, A, & Landes, N. (2006). *The BSCS 5E instructional model: Origins, effectiveness, and applications.* Colorado Springs, CO: Biological Sciences Curriculum Study.

Carl, N. M. (2014). Reacting to the script: Teach for America teachers' experiences with scripted curricula. *Teacher Education Quarterly*, 41(2), 29-50.

Childre, A., Sands, J. R., & Pope, S. T. (2009). *Backward Design. Teaching Exceptional Children*, 41 (5), 6-14.

Cilliers, J., Fleisch, B., Prinsloo, C., & Taylor, S. (2019). How to improve teaching practice? An experimental comparison of centralized training and in-classroom coaching. *Journal of Human Resources*, 55(3), 926–962.

Costigan, A. T. (2008). Canaries in the coal mine: Urban rookies learning to teach language arts in " high priority" schools. *Teacher Education Quarterly*, Spring, 85-103.

Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches*. Thousand Oaks, CA: Sage.

Crocco, M. S., & Costigan, A. T. (2007). The narrowing of curriculum and pedagogy in the age of accountability: Urban educators speak out. *Urban Education*, 42, 512-535.

Cunningham, A.E., Zibulsky, J., Stanovich, K. E., & Stanovich, P. J. (2009). How teachers would spend their time teaching language arts: The mismatch between self-reported and best practices. *Journal of Learning Disabilities*, 42: 418-30.

Demko, M. (2010). Teachers become zombies: The ugly side of scripted reading curriculum. *Voices from the Middle*, 17(3), 62-64.

Devetak, I., & Glažar, S.A. (Eds.). (2014*). Learning with Understanding in the Chemistry Classroom.* Dordrecht: Springer.

Dias, M., Eick, C., & Brantley-Dias, L. (2011). Practicing what we teach: A self-study in implementing an inquiry-based curriculum in a middle grades classroom. *Journal of Science Teacher Education*, 22(1), 53-78.

Dickson, R. A. (2006). The effect on student achievement of research-based versus non-research based reading programs. (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI 3232104)

Dorman, J. (2001). Associations between classroom environment and academic efficacy. *Learning Environments Research*, 4, 243-257.

Doyle, W. (1992). Curriculum and pedagogy. In P.W. Jackson (Ed.), *The handbook of research on curriculum: A project of the American Educational Research Association* (pp. 486-516). New York: Macmillan.

Duncan-Owens, D. D. (2009). Commercial reading programmes as the solution for children living in poverty. *Literacy*, 44(3), 112-121.

Ede, A. (2006). Scripted curriculum: Is it a prescription for success? *Childhood Education*, 83(1), 29-32.

Eisenbach, B. B. (2012). Teacher belief and practice in a scripted curriculum. *The Clearing House*, 85, 153-156.

Elkind, D. (1986). Formal education and early childhood education: An essential difference. *Phi Delta Kappan*, May, 631-633.

Firestone,W. A., Winter, J., & Fitz, J. (2000). Different assessments, common practice? Mathematics testing and teaching in USA and England and Wales. *Assessment in Education*, 7(1), 13-37.

Flipo, R. (1999). *What do the experts say?* Portsmouth, NH: Heinemann.

Freire, P. (1970). *Pedagogy of the oppressed*. New York: Continuum.

Freire, P. (1993). *Pedagogy of the oppressed*. New rev. 20th-Anniversary ed. New York: Continuum.

Freire, P. (2005). *Teachers as cultural workers: Letters to those who dare teach*. Boulder, CO: Westview Press.

Giroux, H. A. (1988). *Teachers as intellectuals: Toward a critical pedagogy of learning*. Granby, MA: Bergin & Garvey.

Gunter, P. & Reed, T. (1997). Academic instruction of children with emotional and behavioral disorders using scripted lessons. *Preventing School Failure*, 42(1), 33.

Halff, H. M. (1988). Curriculum and instruction in automated tutors. In M. C. Polson and J. J. Richardson (Eds) *Foundation of intelligent tutoring systems*, (pp. 77-108). Hillside, NJ: Lawrence Erlbaum Associated.

Hanson, W. E., Creswell, J. W., Plano Clark, V. L., Petska, K. S., & Creswell, J. D. (2005). *Mixed methods research designs in counseling psychology*. Faculty Publications, Department of Psychology. 373.

Hargreaves, A. (1994). *Changing teacher, changing times*. New York: Teachers College Press.

Harris, C., Penuel, W., D'Angelo, C., DeBarger, A., Gallagher, L., Kennedy, C. .Krajcik, J. (2015). Impact of project-based curriculum materials on student learning in science: Results of a randomized controlled trial. *Journal of Research in Science Teaching*, 52(10), 1362-1385.

Helldén, G. (2005). Exploring understandings and responses to science: A program of longitudinal studies. *Research in Science Education*, 35(1), 99-122.

Herr, K. & Arms, E. (2004). Accountability and single sex-schooling: A collision of reform agendas. *American Educational Research Journal*, 41(3), 527-555.

Hiralall, A. & Martens, B. (1998). Teaching classroom management skills to preschool staff: The effects of scripted instructional sequences on teacher and student behavior. *School Psychology Quarterly*, 13(2), 94.

Häussler, P., & Hoffman, L. (2002). An intervention student to enhance girls' interest, self-concept, and achievement in physics classes. *Journal of Research in Science Teaching*, 39(9), 870-888.

Helldén, G. (2005). Exploring understandings and responses to science: A program of longitudinal studies. *Research in Science Education*,35(1), 99-122.

Hos, R. & Kaplan-Wolff, B. (2020). On and off script: A teacher's adaptation of mandated curriculum for refugee newcomers in an era of standardization. *Journal of Curriculum and Teaching*, 9(1), 40-54.

Jerald, C.D. (2006). School culture: The hidden curriculum. *Issue Brief*, December, 1-8.

Johnson, B. & McClure, R. (2004). Validity and reliability of a shortened, revised version of the constructivist learning environment survey (CLES). *Learning Environments Research*, 7(1), 65-80.

Kang, G. (2016). Advocacy for autonomy: Complicating the use of scripted curriculum in unscripted spaces. *Language Arts Journal of Michigan*, 32 (1), 43-50.

Kohl, H. (2009). The educational panopticon. *Teachers College Record*, Date Published: January 08, 2009, http://www.tcrecord.org, ID Number 15477, Date Accessed: 11/6/ 2016.

King, K. V., & Zucker, S. (2005). *Curriculum Narrowing*. San Antonio: Pearson Education.

Kumar, R. & Gupta, V.K. (2009). An introduction to cognitive Constructivism in Education. *Journal of Indian Education*. 35(3) 39-45.

Lucas, K. & Roth, W.M. (1996). The nature of scientific knowledge and student learning: Two longitudinal case studies. *Research in Science Education*, 26, 103-127.

Lyons, M. T. (2009). Comparing the effectiveness of scripted and non-scripted language arts programs in low-performing schools. (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI 3411179)

MacGillivray, L., Ardell, A.L., Curwen, M.S., & Palma, J. (2004). Colonized teachers: Examining the implementation of a scripted reading program. *Teaching Education*, 15(2),131-144.

Marchand-Martella, T. A. Slocum, & R. C. Martella (Eds.), *Introduction to Direct Instruction* (pp 28-65). Boston: Allyn & Bacon.

McLaren, P. (2007). *Life in schools: An introduction to critical pedagogy in the foundations of education*. Boston: Pearson/Allyn and Bacon.

Michael, N. A., & Libarkin, J. C. (2016). Understanding by design: Mentored implementation of backward design methodology at the university *level. New Waves Educational Research & Development,* 42 (2) 44-52.

Mills, C. (2008). Reproduction and transformation of inequalities in schooling. *British Journal of Sociology of Education,* 29(1), 79-89.

Milner, H. R. (2013). Scripted and narrowed curriculum reform in urban schools. *Urban Education*, 48 (2), 163-170.

Milosovic, S. (2007). Building a case against scripted reading programs: A look at the NCLB reading first initiative's impact on curriculum choice. *Education Digest*, 73 (1), 27-30.

Moustafa, M. & Land, R. E. (2002). The reading achievement of economically disadvantaged children in urban schools using Open Court vs comparably disadvantaged children using non-scripted reading programs. *In 2002 yearbook of the urban learning, teaching, and research special interest group of the American Educational Research Association* (pp. 44- 53). Washington, DC: AERA.

O'Loughlin, M. (1992). Rethinking science education: Beyond Piagetian constructivism toward a sociocultural model of teaching and learning. *Journal of Research in Science Teaching*, 29(8), 791-820.

Pestalozzi, H. (1951). *Education of man*. New York: Philosophical Library.

Piaget, J. (1973). *To understand is to invent: The future of education*. New York: Grossman.

Powell, R., Cantrell, S. C., & Correll, P. (2017). Power and agency in a high poverty elementary school: How teachers experienced a scripted reading program. *Journal of Language & Literacy Education*, 13 (1), 93-112.

Ravitch, D. (2010). *The death and life of the great American school system: How testing and choice are undermining education*. New York: Basic Books.

Remillard, J., Harris, B., & Agodini, R. (2014). The influence of curriculum materials design on opportunities for student learning. *ZDM Mathematics Education*, 46(5), 735-749.

Resnick, L. B. (1989). Introduction in L.B. Resnick (Ed.), *Knowing, learning, and instruction: Essays in honor of Robert Glaser* (pp. 1-24). Hillsdale, NJ: Erlbaum.

Rice University. Houston, Texas https:// www.acceleratelearning.com Date Accessed: 26 April 2017.

Roblin, N.P., Schunn, C., & McKenny, S. (2017). What are critical features of science curriculum materials that impact student and teacher outcomes? *Science Education*, 2017: 1-23.

Roth, D. (2007). Understanding by Design: A Framework for Effecting Curricular Development and Assessment. *CBE-Life Science Education*, 6(2), 95-97.

Roth, W.M., & Bowen, G. (1995). Knowing and interacting: A study of culture, practices, and resources in a grade 8 open-ended science classroom guided by a cognitive apprenticeship model. *Cognition and Instruction*, 13, 73-128.

Roth, W.M., & Roychoudhury, A. (1993). The nature of scientific knowledge, knowing, and learning: The perspectives of four physics students. *International Journal of Science Education*, 15, 27-44.

Rubrica, R.D. (2018). *An Action Research on Project-Based Learning and Understanding by Design and Their Effects on the Science Achievement and Attitude of Science Students.*

Sadler, T., Romine, W., Menson, D., Ferdig, R., & Annetta, L. (2015). Learning biology through innovative curricula: A comparison of game-and nongame-based approaches. *Science Education*, 99(4), 696-720.

Schiller A. (2015). Understanding by design unit lesson plans for the next generation science standards: Life science. *Graduate Research Papers*. 73.http://scholarwork.uni.edu/grp/73

Shadish, W. R., & Luellen, J. K. (2006). Quasi-experimental design. In J. L. Green, G. Camilli, & P. B. Elmore (Ed.), *Handbook of Complementary methods in education research* (pp. 539-550). New York, NY: Routledge.
Singh, S., & Yaduvanshi, S. (2015). Constructivism in science classroom: Why and how. *International Journal of Scientific and Research Publications*, 5(3), 1-5.
Smagmorinsky, P., Lakly, A., & Johnson, T.S. (2002). Acquiescence, accommodation, and resistance in learning to teach within a prescribed curriculum. *English Education*, 34, 187-211.
Smith, M.L., Edelsky, C., Draper, K., Rottenberg, C., & Cherland, M. (1989). *The role of testing in elementary schools* (Monograph). Tempe, AZ: Arizona State University, Center for Research on Evaluation, Standards, and Student Testing (Grant No. OERI-G-86-0003).
Spring, J. (2014). *American Education*. New York: Mc Graw Hill Companies, Inc.
Srikantaiah, D. (2009). *How state and federal accountability policies have influenced curriculum and instruction in three states: Common findings from Rhode Island, Illinois, and Washington*. Washington DC: Center on Education Policy.
Sudduth, K. (2020). Teachers' perceptions of enhancing student achievement through scripted and teacher-developed curriculums. (Publication No. 28155999) [Doctoral dissertation, Walden University]. ProQuest Dissertations and Theses Global.
Taber, K. S. (2019). Constructivism in education: Interpretations and criticisms from science education. In Information Resources Management Association (Ed.), *Early Childhood Development: Concepts, Methodologies, Tools, and Applications* (pp. 312-342). Hershey, Pennsylvania: IGI Global.
Taylor, P., Dawson, V., & Fraser, B. (1995). A constructivist perspective on monitoring classroom learning environments under transformation. Paper presented at the annual meeting of the American Educational Research Association, San Francisco.
Twyman, J. S., & Heward, W. L. (2018). How to improve student learning in every classroom now. I*nternational Journal of Educational Research*, 87, 78-90.
Valencia, S.W., Place, N. A., Martin, S. D., & Grossman, P. L. (2006). Curriculum materials for elementary reading: Shackles and scaffolds for four beginning teachers. *The Elementary School Journal,* 107(1), 93-120.
Valli, L., & Buese, D. (2007). The changing roles of teachers in a high-stakes era accountability. *American Educational Research Journal*, 44, 519-558.
Vasquez Helig, J., & Jez, S. J. (2014). *Teach for America: A return to the evidence*. Boulder, CO: National Education Policy Center. https://nepc.colorado.edu/publication/teach-for-america-return
Walsh, D. J. (1986). The trouble with program-directed curricula. *Principal*, 66(1), 68-70
Watkins, C. L., & Slocum, T. A. (2004). *The components of direct instruction*. In N.E.
White, B., & Frederiksen, J. (1998). Inquiry, modeling, and metacognition: Making science accessible to all students. *Cognition and Instruction*, 16(1), 3-118.
Whitehouse, M. (2014). Using a backward design approach to embed assessment in teaching. *School Science Review,* 95(352), 99-104.
Wiggins, G., & McTighe, I. (2005). *Understanding by Design* (2nd ed.). Alexandria, VA: ASCD.
Wiggins, G., & McTighe, J. (2011). *The Understanding by Design guide to creating high-quality units*. Alexandria, VA: ASCD.
Wineburg, S. S. (2001). *Historical thinking and other unnatural acts: Charting the future of teaching the past*. Philadelphia: Temple University Press.
Wyner, Y. (2013). The impact of a novel curriculum on secondary biology teachers' dispositions toward using authentic data and media in their human impact and ecology lessons. *Journal of Science Teacher Education*, 24(5), 833-857.

Zhao, Y., Wehmeyer, M., Basham, J., & Hansen, D. (2019). Tackling the wicked problem of measuring what matters: Framing the questions. *ECNU Review of Education*, 2(3), 262-278.

APPENDIX A: CONSTRUCTIVIST LEARNING ENVIRONMENT SURVEY: TEACHER

Constructivist Learning Environment Survey
Teacher Version

This questionnaire contains 20 statements about teaching and learning that could take place in a science classroom.
You will be asked how often each practice occurs: almost never, not very often, sometimes, often, or almost always. There are no "right" or "wrong" answers. Your opinion is what is wanted. Think about how well each statement determines your science classroom. Indicate the best response for each item.
Be sure to give an answer for each question. If you change your mind about an answer, just cross it out and circle another. Some statements in this questionnaire are fairly similar to other statements. Don't worry about it. Simple give your opinion about each statement. *Your identity will be kept strictly confidential.*

Today's date:___________________________
Your Name_____________________________Campus Name_________________________
Grade Taught___________________________Science Subject________________________

What Happens in My Science Classroom	Almost Always	Often	Some times	Not very often	Almost never
1. I teach about the world in and outside of school.					
2. Things I teach about connects to things about the world in and outside of school.					
3. I teach how science is part of in and outside of school life.					
4. I teach interesting things about the world inside and outside of school.					
5. I teach that science cannot always provide answers to problems.					
6. I teach that scientific explanations have changed over time.					
7. I teach that science is influenced by people's different cultural values and opinions.					
8. I teach that science is a way to raise questions and seek answers.					
9. It's okay for students to question the way that they are being taught.					
10. I feel I teach better when students are allowed to question what or how they're learning.					
11. It's okay for students to ask questions about activities that are confusing.					

12. It's okay for students to say they are concerned about anything that gets in the way of their learning.					
13. In this class, students help plan what they are going to learn.					
14. In this class, students help decide how well they are learning.					
15. In this class, students help decide which activities work best for them.					
16. In this class, students let the teacher know if they need more class time to complete an activity.					
17. In this class, students talk with other students about how to solve problems.					
18. In this class, students explain their ideas to other students.					
19. In this class, students ask other students to explain their ideas.					
20. In this class, students ask me to explain my ideas.					

Source: Johnson & McClure, 2004.

APPENDIX B: CONSTRUCTIVIST LEARNING ENVIRONMENT SURVEY: STUDENT

Constructivist Learning Environment Survey
Student Version

This questionnaire contains 20 statements about teaching and learning that could take place in a science classroom.
You will be asked how often each practice occurs: almost never, not very often, sometimes, often, or almost always. There are no “right” or “wrong” answers. Your opinion is what is wanted. Think about how well each statement determines your science classroom. Indicate the best response for each item.
Be sure to give an answer for each question. If you change your mind about an answer, just cross it out and circle another. Some statements in this questionnaire are fairly similar to other statements. Don’t worry about it. Simple give your opinion about each statement. *Your identity will be kept strictly confidential.*

Today’s date:____________________________
Your Name______________________________Campus Name__________________________
Grade _________________________________Science Subject_________________________

What Happens in My Science Classroom	Almos t always	Often	Some-times	Not very often	Almos t never
1. I learn about the world in and outside of school.					
2. Things I learn about connects to things about the world in and outside of school.					
3. I learn how science is part of in and outside of school life.					
4. I learn interesting things about the world inside and outside of school.					
5. I learn that science cannot always provide answers to problems.					
6. I learn that scientific explanations have changed over time.					
7. I learn that science is influenced by people’s different cultural values and opinions.					
8. I know that science is a way to raise questions and seek answers.					
9. It’s okay for students to question the way that they are being taught.					
10. I feel I learn better when students are allowed to question what or how they’re learning.					
11. It’s okay for students to ask questions about activities that are confusing.					

12. It's okay for students to say they are concerned about anything that gets in the way of their learning.					
13. In this class, students help plan what they are going to learn.					
14. In this class, students help decide how well they are learning.					
15. In this class, students help decide which activities work best for them.					
16. In this class, students let the teacher know if they need more class time to complete an activity.					
17. In this class, students talk with other students about how to solve problems.					
18. In this class, students explain their ideas to other students.					
19. In this class, students ask other students to explain their ideas.					
20. In this class, students ask me to explain my ideas.					

Source: Johnson & McClure, 2004.

APPENDIX C: FOCUS GROUP GUIDING QUESTIONS

1. Looking back at this week's lesson, what do you feel you have learned?

2. How do you think the activities you have done this week helped you truly understand what you were supposed to learn- the objectives written on the board?

3. Do you feel that you had enough time to complete the activities chosen for you to do in class? Give specific examples.

4. Were you given an opportunity to discuss what you learned from each activity? What are some things you discussed during these sessions? Did the teacher give you specific things to discuss, or were you able to choose?

5. How do you feel that your teacher gave you opportunities to ask questions and apply what you learned?

APPENDIX D: TEACHER REFLECTION LOG QUESTIONNAIRE

Teacher Reflection Questionnaire

Wiggins & McTighe, 2005.

Your name: ___________________________________ Today's date: _________________________

This questionnaire is a set of 4 questions about teaching and learning that take place in a science classroom. It is a two-part reflection process that will be used to gauge how effective the lesson design was in respect to achieving the goals of the lesson. There are no 'right' or 'wrong' answers. Your opinion is what is wanted.

Pre-Lesson Questions: Think about the enduring understandings you will be teaching today.

1. What goals (e.g., content standards, course or program objectives, learning outcomes) will this lesson address?

2. Why does this lesson matter? What big ideas would this lesson help students understand?

Post-Lesson Questions: Take a moment to reflect upon your lesson today. Think about what was taught and how the students reacted to your lesson.

3. What transferable knowledge and skills has the lesson yielded? What evidence has been collected to show what important learning occurred?

4. Through what evidence did the students demonstrate achievement of the desired goals? What opportunities (e.g., quizzes, tests, academic prompts, observations, homework, journals) were students given to demonstrate the desired understandings intended by the lesson?

APPENDIX E: STUDENT WORK ANALYSIS RUBRIC

Rubric		Student Work Analysis		
Score each item as follows: 1. Not evident 2. Somewhat evident 3. Mostly evident 4. Extremely evident				
Category	Indicators	Score	Assignment Name	Evidence
State Standards (TEKS)	Predict possible outcomes of various genetic combinations such as monohybrid crosses, dihybrid crosses, and non-Mendelian inheritance.			
Student Expectations	The student will be able to: ● Use Punnett squares or other methods to calculate possible outcomes of the F_2 generation based on genotype information about the F_1 generation ● Infer genotype information of the F_1 generation based on genotype or phenotype information about the F_2 generation ● Predict genetic combination with single gene trait on autosomal chromosomes with one dominant allele and one recessive allele using Mendelian genetics. ● Predict genetic combinations with genotypes including homozygous dominant (GG), homozygous recessive (gg), or heterozygous (Gg) using Mendelian genetics. ● Predict genetic combinations with two traits caused by two separate genes on the same or different autosomal chromosome using Mendelian genetics. ● Predict genetic combination with each gene following the dominant, recessive, homozygous, and heterozygous conventions independent of the other gene using Mendelian genetics. ● Predict genetic combinations with incomplete dominance (one allele does not completely mask the action of the other allele, so a completely dominant allele does not occur) using Non-Mendelian genetics. ● Predict genetic combinations with codominance (both alleles are expressed			

	equally in a heterozygous genotype) using Non-Mendelian genetics. ● Predict genetic combinations with multiple alleles (more than 2 alleles affect the trait) using Non-Mendelian genetics. ● Predict genetic combinations with sex-linked traits (genes that are located on the sex chromosome, usually the X chromosome) using Non-Mendelian genetics. ● Recognize that phenotypic expression is often the result of a complex interaction of many genes, gene products (proteins), and environmental factors using Non-Mendelian genetics. ● Recognize that some traits can be a result of mitochondrial DNA gene expression (e.g., Leber's hereditary optic neuropathy) using Non-Mendelian genetics.			
Essential Questions	Essential knowledge assessed by the assignment: ● In what ways can the probability of offspring inheritance be calculated? ● What are the limitations of calculating the probability of offspring inheritance?			
Student Understanding	● Does the student's work demonstrate his/her understanding of the task? ● Does the student's work demonstrate the depth of his/her understanding of the topic? ● Does the student's work demonstrate his/her proficiency with the requirements of the targeted standards?			
	Total	/16		

APPENDIX F : SAMPLE TEACHER LESSON PLAN RUBRIC

Lesson Plan Rubric			
Score each item as follows: 1. Not evident 2. Somewhat evident 3. Mostly evident 4. Extremely evident			
Category	Indicators	Score	Evidence
Instructional Design	● The lesson design is clear, coherent, and presented in a developmentally appropriate way. ● Concepts and skills build logically and purposefully with transitions to support development and understanding. ● The lesson teaches and uses active learning strategies to engage students and foster deep understanding. ● The lesson uses a variety of media to give students multiple and varied experiences with a single concept or skill, inviting students to explore a concept or skill from different angles. ● The lesson is differentiated and accommodates unique learning styles and various ability levels using scaffolding.		
Standards Alignment	● The lesson aligns with the current Texas Essential Knowledge and Skills for Biology.		
Assessment	● Assessments reflect types of questions students may see on future high stakes assessments. ● Formative assessments are used to guide instruction and monitor student learning.		
Learning Activities	● The lesson contains student-friendly essential questions derived from the academic standards. ● The activities reflect vertical alignment and appropriate level of rigor (Standard + Instructional Strategy + Verb + Product + Assessment = Rigorous Lesson). ● The activities actively engage and promote higher order thinking and problem solving.		

	● The activities address learner needs and considers the perspective of the learner (learning style, interest, developmental stages, and possible gaps). ● The activities provide students opportunities for student collaboration. ● The activities provide opportunities for students to have discussions (student-led, group, or class-wide). ● Exemplars are used within the lesson to demonstrate/model performance expectations		
Instructional Pacing	● Lesson is designed to optimize in class time for assignments.		
	Total	/20	

* Adapted from Constructivist lesson rubric (2014).