Chapter 3
The Create Excellence Framework's Impact on Enhancing Creativity: Examining Elementary Teacher Candidate Mathematics Lesson Planning

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Abstract The focus of this research is to examine the impact of an instructional instrument to improve the quality of pre-service teachers' lesson plans to enhance creative learning opportunities for children. The Create Excellence Framework focuses on four components essential to high-quality lesson plans: Cognitive Complexity, Real-World Learning, Engagement, and Technology Integration. The research study examined data from two elementary education teacher candidate classes for five semesters to measure the impact of the instrument on instructional planning for mathematics or mathematics and science integration. Over the course of the five semesters, for each component, the mean scores increased, and there was a positive statistically significant difference between the scores from the baseline semester to the fifth semester. In the fifth semester, the component of Technology Integration had the largest increase and Real-World Learning has the highest mean score. As students learned to design instruction around authentic tasks, cognitive levels and engagement also increased. Students were exposed to and utilizing new digital tools to enhance their learning. Using these digital tools along with real-world applications of the content encouraged students to think creatively to solve authentic problems.

Keywords Lesson planning · Real-world learning · Creativity
Technology integration · Math instruction

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3.1 Introduction

Consider this scenario in a typical United States intermediate classroom:

> Allison walks into her 5th grade classroom at the beginning of the year, excited to be progressing to a grade level with more intensive mathematics. However, she finds that mathematics is excessive worksheets and old textbooks. Allison has not ever had an opportunity to do a creative project or use hands-on manipulative to solve real-world problems other than solving word problems from the textbook. She sees no connection between mathematics and technology which can lead to student inquiry and engagement. Allison sees mathematics as memorization, and she thinks that technology is used only for taking quizzes, locating information, and word processing papers. She sees the teacher use the ActivBoard to show a PowerPoint presentation or to have students come to the board one at a time to circle an answer. The teacher typically presents the lesson as a lecture everyday while the students sit in rows taking notes. Allison always works alone, never partnering with another student or working in a group on any type of assignments or discussions. When Allison or another student asks a question, the teacher is always the one to answer the question with no discussion. She had hoped to experience more real-world problem solving and interactive classroom discussions and explorations like her cousin at another school talks about.

Children are naturally curious and desire to learn through meaningful experiences (Division of Elementary, Secondary, and Informal Education, 2000). When given the opportunity to gather and use data from authentic scenarios, the students more readily experience passion for and higher degrees of learning in mathematics. However, mathematics classrooms are still experiencing a trend of sterile worksheet curricula environments which do not allow for creativity nor use of technology, both of which can allow for sense making as advocated by Wood, Merkel, and Uerkwitz (1996). With this worksheet curriculum in mind, there may be a long-awaited solution for teachers, consequently appealing to parents and students alike. Through this solution, students will experience challenging questions centered around authentic projects. In this chapter, an instructional framework is provided, supported with research, and discussed so that teachers can use it with children to help facilitate potential for more meaningful learning and mathematical understanding via a real-world, creative angle, while integrating technology (Tassell, Maxwell, & Stobaugh, 2013).

Technology integration is now more of an expectation rather than an option. Many United States teaching standards require effective technology integration (Tennessee Department of Education, 2007; Texas Education Agency, 2014). Schools are spending large portions of their budgets to purchase various technology capabilities, all in hopes that students engage in deeper learning that connects with the real world. Unfortunately, the primary use of technology is oftentimes for teacher presentations to garner student attention rather than for "student use" of technology to advance student learning to higher cognitive levels. For students to succeed in the formative up through pre-college years, teachers need to be considering how to embrace the new challenges they are facing in the mathematics classroom. Much of this can be tackled through a lens of a creative instructional disposition. Students filling classrooms are part of a "'creative, multimedia' generation" (Rosen, 2010, p. 218). The iGeneration is craving even more from education than ever before with technology and creativity (Oblinger, 2003; Prensky, 2010), yet many our mathematics teachers have not kept up with the awareness *and* learning curve (Shriki, 2010, 2013).

Teachers need to accept and embrace that students *love* to create (Rosen, 2010). Some students are wanting to channel this creativity in their coursework through technology in forms of movies, podcasts, webpages, and other digital products, and not the outdated technology formats of the past (Prensky, 2010). Students also want choice in their assignments and projects. When students have the responsibility of making choices, it increases engagement levels (Wood, 2010). Freedom to work at their own pace with support and partnership of the teacher is appealing to the students. Students enjoy space and time to creatively explore the content (Rosen, 2010).

To guide the integration of technology in the classroom, the International Society for Technology Education established standards for teachers (ISTE, 2008) and for students (ISTE, 2007). Both of these sets of standards promote students using technology to be creative, communicate, collaborate, and think critically. Another framework of skills, the Partnership for 21st Century Skills (2009), promotes students working collaboratively to create media products while engaging in critical thinking. For the teaching angle, the Partnership for 21st Century Skills (2009) stated that a learning experience should be one that "Enables innovative learning methods that integrate the use of supportive technologies, inquiry- and problem-based approaches and higher-order thinking skills" (p. 8). Therefore, when teachers are designing tasks, they need to consider these new expectations that indicate higher student competence when using technology to collaborate with students on cognitively demanding learning tasks about real-world topics. All of this leads to a broader and more inclusive view of technology—where technology integration is connected to higher-order thinking, real-world learning experiences, and engaged learning. However, the reality is that there is a gap between curriculum standards and instructional practices. The disconnect forms and urgency for the foundation of the Create Excellence Framework.

3.2 Review of Research on How Teachers Teach Creativity Through Real-World Lessons, Collaboration, and Intellectual Risks

Creativity as defined by Pink (2005) is a necessity in thinking through complexities of our interconnected world. Sternberg (2006) stated that educational researchers and psychologists profess the benefits of creative thinking on emotional, cognitive, and professional areas of life. However, even though there is an elevated focus on creativity, *teaching* in a way that supports creativity is still an anomaly (Henrickson & Mishra, 2013). With a focus on high-stakes stakes testing and published/scripted curricula, creativity is not the focus in most classrooms in the United States (Giroux & Schmidt, 2004).

At Michigan State University, a study was conducted for how to integrate creativity into classroom and the role of teachers in enhancing children's creativity (Mishra, Koehler, & Henriksen, 2011; Mishra, Henricksen, & The Deep-Play Research Group, 2012). Their focus is on embedding creativity into the context of the content area, and not just in a general sense of creativity instruction (Mishra et al., 2012). The goal is to help teachers learn how to teach their students to be the kind of creative people that can look beyond the boundaries of their content area of expertise and make connections back to that field to create new ideas (Henrickson & Mishra, 2013).

In a study conducted from 2000 to 2010 of eight United States award-recognized teachers by Henrickson (2011), research revealed that 90% of the teachers noted creativity as their main teaching mantra and gave examples of how creativity was taught through instruction in their classroom. Davidovitch and Milgram (2006) go on to emphasize that for instruction to be "effective", it must be "creative".

From the study of the eight teachers, ten key creative teaching approaches emerged (Henrickson & Mishra, 2013). One of these practices is: "link lessons to real-world learning." For this to happen, authentic experiences must be incorporated so that creativity is woven in relevant learning. The teachers in the study all stated that "real-world" learning is creative, offering novel opportunities for learning. Another approach to teaching that emerged is "valuing collaboration." The rationale was that successful design teams do their best work through collaborative efforts. These teachers also brought up concerns of working in isolation, emphasizing the importance of discussing and sharing ideas with others as a creative catalyst in learning. A third approach connected to our study is "taking intellectual risks." The teachers emphasized the idea of modeling new ideas and approaches in their classroom, showing that they were open to failure.

In this chapter, we will share the impact of the instructional planning support, Create Excellence Framework, on teacher candidates in designing their mathematics and integrated mathematics/science lessons. We begin with giving an overview of the Create Excellence Framework with details and research for the four components supported by research: Cognitive Complexity, Real-World Learning, Engagement, and Technology Integration. The next phase of the chapter shares the research of five semesters of working with teacher candidates in their lesson planning with this model. The overarching goal is to consider how these components connect to enhancing student creative thinking opportunities through real-world lesson plans.

3.3 The Create Excellence Framework

The Create Excellence Framework includes four components: Cognitive Complexity, Real-World Learning, Technology Integration, and Engagement. All the components important for adding depth to learning and planning comprehensive lessons are addressed in this framework. This instrument draws ideas from Moersch (2002) who originally developed the HEAT instrument (Maxwell, Constant, Stobaugh, & Tassell, 2011). The Create Excellence instrument measures five levels of integration of each component (see Fig. 3.1 for Create Excellence Framework). Each component covers the same five levels of increasing complexity to help the teacher target growth in his or her instructional development of tasks and projects: (1) Knowing, (2) Practicing, (3) Investigating, (4) Integrating, and (5) Specializing.

A target level of 3 or higher on the Create Excellence Framework was established because students are using higher-level thinking (Analyze or higher), engaging in learning where students experience choice and differentiation, simulating real-world experiences, and creating technology products even if they are an add-on to the lesson. At higher levels on the Create Excellence Framework students are more responsible for their own learning, beginning to think like experts, planning their own learning experiences while learning is embedded in the real world, and technology is seamlessly integrated and a necessary part of the learning experience. In the Technology Integration component *student* use of technology is emphasized, instead of teacher use of technology. The Cognitive-Complexity component also incorporates higher-level thinking skills (Maxwell, Stobaugh, & Tassell, 2015).

Tasks are small classroom activities while *projects* are more complex and use several instructional strategies, have open-ended solutions, involve more student choice and decision making, and take longer to complete. The lower levels of the framework are teacher directed (levels 1–3), whereas higher levels are more student directed (levels 4–5) with the teacher partnering with students to design projects and assignments (Tassell et al., 2013). The target levels for consistent student learning are levels 3 and 4, which are shaded in tables depicting the framework levels throughout the book. While level 3 is still teacher-directed, students are engaging in higher cognitively complex tasks and projects. Students are beginning to take more responsibility for their learning in level 4. Level 5 is attained after consistent learning at levels 3 and 4 and could be accomplished a few times a year (Maxwell et al., 2015).

3.3.1 Cognitive Complexity

The student's level of thinking with the content is vital to comprising a quality task. When objectives, activities, and assessments are properly aligned at higher levels of cognitive thinking, not only does instruction improve but student learning has a better chance of improving as well (Raths, 2002). The Cognitive Complexity component within the Create Excellence Framework is based on the revised Bloom's Cognitive Taxonomy (Anderson & Krathwohl, 2001). The revised Bloom's taxonomy includes six levels (Remember, Understand, Apply, Analyze, Evaluate, and Create along with nineteen cognitive processes classified within its six levels) (Anderson & Krathwohl, 2001).

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	CReaTE Levels	Cognitive Complexity (Bloom's Cognitive Processes in parentheses)	Real World	Engagement	Technology Integration	
Lower Cognitive Complexity	**Level 1 Knowing**	• Teacher directs student interaction with content/standard at REMEMBER level (Recognizing; Recalling)	• Non-relevant problems using textbook/ worksheets	• Teacher lecture or questioning and students take notes OR • One correct answer expected	• Code 0 for no technology • Teacher uses technology for demonstration or lecture OR • Student technology use at Remember level OR • Technology is a student option but not required or used for keyboarding	Teacher-Directed
Lower Cognitive Complexity	**Level 2 Practicing**	• Teacher directs student interaction with content/standard at UNDERSTAND level (Interpreting; Exemplifying; Classifying; Summarizing; Inferring; Comparing; Explaining) and APPLY (Executing; Implementing)	• Provide some application to real world using real objects or topics	• Students engaged in a task directed by the teacher AND • Multiple solutions for one task are accepted	• Students use technology for Understand or Apply thinking tasks OR • Students use technology for gathering information	Teacher-Directed
Higher Cognitive Complexity	**Level 3 Investigating**	• Teacher directs student interaction with content/standard at an ANALYZE level (Differentiation; Organizing; Attributing), EVALUATE level (Checking; Critiquing), or CREATE level (Generating; Planning; Producing)	• Learning simulates the real-world (such as a class store or assuming the role of a political commentator)	• Student choice for task AND • Task differentiated by content, process, and/or product (such as addressing learning preferences, interests, or ability levels).	• Technology use appears to be an add-on or alternative—not essential for task completion AND • Students use technology for Analyze, Evaluate, or Create thinking tasks.	Teacher-Directed
Higher Cognitive Complexity	**Level 4 Integrating**	• Student-generated questions/ projects with content/standard at ANALYZE level (Differentiation; Organizing; Attributing), EVALUATE (Checking; Critiquing), or CREATE level (Generating; Planning; Producing)	• Learning emphasizes and impacts the classroom, school, or community AND • Learning is integrated across subject areas	• Students partner with the teacher to define the content, process, and/or product AND • Student inquiry-based approach AND • Students collaborate with other students	• Student technology use: ○ is embedded in content and essential to project completion AND ○ promotes collaboration among students and partnership with teacher AND ○ helps them solve authentic problems at the Analyze, Evaluate, or Create levels.	Student-Directed
Higher Cognitive Complexity	**Level 5 Specializing**	• Student-generated questions/ projects with content/standard at CREATE level (Generating; Planning; Producing) AND • Complex thinking like a content expert OR open-ended, global learning emphasis	• Learning has a positive impact on a national or global issue or problem AND • Collaborates with experts in a field or discipline	• Students initiate their own inquiry- based learning projects; thorough immersion; full implementation from topic to solution AND • Students initiate appropriate collaborations pertaining to their project	• Student-directed technology use: ○ is seamlessly integrated in content at the ○ Create level AND ○ has several technologies AND ○ include ____________ expert ○ and/or global organizations to find solutions to an in-depth "real" problem	Student-Directed

Fig. 3.1 Create Excellence Framework

Create is the highest level on Bloom's revised taxonomy. It involves organizing information in a new way to design a product or novel solution, hence creative thinking. There are three Create-level cognitive processes within Bloom's taxonomy, and they occur sequentially: (1) generating, (2) planning, and (3) producing. When students engage in the generating cognitive process, they explore various ideas or solutions to solve an ill-defined problem through hypothesizing and exploring various relevant options. To begin this process, the topic must be researched and thoroughly understood so the ideas generated logically connect to the identified topic. The ideas should also be varied, unique, and detailed (Swartz & Parks, 1994). Planning is the second step in the creation process. Students will take the best idea they generated and decide on a plan to carry out the project. Often there is more than one way to solve the problem. Also, during the planning process, students often realize they must revise their idea or consider a new idea. The final step is to follow through with the plan and produce the product.

At levels 1 and 2 of the Create Excellence Framework in the *C*ognitive Complexity component, learners are engaged in teacher-directed learning experiences and Bloom's Taxonomy levels of Remember, Understand, and Apply level. While level 3 of the Create Excellence Framework is teacher-directed, students are engaging in the higher levels of Bloom's Taxonomy—Analyze, Evaluate, and Create. At the student-directed levels of the Create Framework (levels 4 and 5), students employ the top three cognitive levels (Analyze, Evaluate, and Create). At these two highest levels the *students*, instead of the teachers, are identifying the questions, tasks, or projects. On level 4 and 5, students generate projects on the Create level while thinking like an expert focused on an open-ended, global learning emphasis.

In the mathematics field specifically, Bloom's revised taxonomy helps teachers with instruction by providing steps and ideas for math questions worth asking, to know the difference between open and closed questions (Petti, 2017). As teachers work on their "good questions" that are worth asking, these questions lend themselves to exploration and more questions that students can reflect on and grow as inquirers. The outcome may then be the students are better mathematical thinkers and engaged, lifelong learners.

Table 3.1 provides an example for Cognitive Complexity in the Create Excellence Framework at the level 5. As students simulate and perform tasks and projects like professionals in the field, they often naturally engage higher-order thinking skills as they analyze, evaluate, and solve problems just like skilled workers.

3.3.2 Real-World Learning

Real-World Learning is where the student learns from, interacts with, and has an impact on the real world (Maxwell, Stobaugh, & Tassell, 2017). The goal of real world learning is for the student to interact with the real world to solve real

Table 3.1 Example of Cognitive Complexity with mathematics in Create Excellence Framework

Create level 5 description for Cognitive Complexity	Sample task/project
• Students generate questions or projects with content at Bloom's Create level (Generating, Planning, Producing) • Students engage in complex thinking like a content expert or with content that has an open-ended, global-learning emphasis	Have you ever wondered how polls are done? How did they calculate that 70% of Americans like a certain food or type of car? Do they ask every single person in America? NO, they use a polling percentage or a "sample" (or part of the population). Groups of students in your class will create their own poll, ask students around your school about their opinion on a specific school issue, and then predict the percentage of student opinions about that issue at your school (Maxwell et al., 2017)

problems and experience authentic learning. For example, students may learn letter-writing skills when they want to write a letter to their senator urging him/her to support water conservation near their town. This experience teaches the students that real-world solutions are complex—they may not always work, may not always please everyone, and may have consequences that impact other areas (Maxwell et al., 2017). Elements of real-world learning incorporate learning integrated across subject areas, learning as close to the real world as possible, and collaborating with experts in the field or discipline being studied.

3.3.2.1 Integrated Learning

Educators Barton and Smith (2000) state that interdisciplinary learning "provide[s] authentic experiences in more than one content area, offer[s] a range of learning experiences for students, and give[s] students choices in the projects they pursue and the ways they demonstrate their learning" (p. 54). Interdisciplinary units enable teachers to use classroom time more efficiently and address content in depth while giving students the opportunity to see the relationship between content areas and engage in authentic tasks and projects (Maxwell et al., 2017).

Students immersed in authentic-learning activities cultivate the kind of portable skills that are applicable in new and different situations, settings, or connections. These skills include judgment to distinguish reliable from unreliable information, patience to follow longer arguments and assignments, ability to recognize relevant patterns in unfamiliar contexts, and flexibility to work across disciplinary and cultural boundaries to generate innovative solutions (Jenkins, 2009).

In problem-based learning, students work for an extended period of time to investigate and respond to a complex questions, problem, or challenge. Problem-based learning is the center of medical students' training as they develop work skills—collaborating, chairing a group, listening, recording, cooperating, respecting colleagues' views, critically evaluating literature, self-directing learning and use of resources, and presenting on and engaging in real medical tasks and projects (Wood, 2003).

Students involved in authentic learning are motivated to persevere despite initial frustration, as long as the project embodies what really counts to them—a social structure they enjoy, topics and activities of personal interest, and a feeling that what they are doing is important and valued (Herrington, Oliver, & Reeves, 2003; Prensky, 2010). By confronting students with uncertainty, ambiguity, and conflicting perspectives, instructors help them develop more mature mental models that coincide with the problem-solving approaches experts use. Be aware that the balance of challenge and uncertainty must be just right so that students are sufficiently engaged but not overwhelmed. Authentic-learning exercises expose the messiness of real-life decision making, where there may not be a right or a wrong answer per se, although one solution may be better or worse than others depending on the particular context or consequences. Such a nuanced understanding involves considerable reflective judgment, a valuable lifelong skill that goes well beyond content memorization (Keyek-Franssen, 2010).

3.3.2.2 Learning in the Real World

When a student learns from, interacts with, and has an impact on the real world, higher retention of learning will occur. Real-world learning is organized around complex activities built on multiple themes and academic disciplines and requires multiple steps over an extended duration of time. Students have a real audience for their work. They use real data and learn content through working on projects and real problems that interest them (Schools We Need Project, n.d.). Take, for example, the fourth-grade class featured in the opening vignette of this chapter that decided to design landmarks for local heroes. This would be a level 4 real-world learning project in which learning impacts the school and community. Learning is integrated across subject areas—language arts, mathematics, science, economics, and social studies (Maxwell et al., 2017).

As another example, students may investigate and create projects to solve community issues such as developing a local walking trail, promoting girls' inclusion in community athletics, or endorsing stricter policies on littering in the community. This would also be a level 4 real-world learning project since it is student directed and the students are having an impact on their community (Maxwell et al., 2017).

Students prefer real, not just relevant, learning. Relevant means that students can relate, connect, or apply the content you are teaching to something they know about (for example, sports, music, social networking, movies, or games). The problem with relevance is it does not go far enough to make learning meaningful and engaging. As education innovator Prensky (2010) says, "Real means that there is a continuous perceived connection by the students between what they are learning and their ability to use that learning to do something useful or impact the real world" (p. 72). For students to actively attend to and retain information, it must be

Table 3.2 Example of flow in mathematics classroom from traditional to real learning

Traditional learning	Relevant learning	Real learning
Teacher assigns: Assigns problems about geometry from the textbook	Teacher scenario: We have been studying about how a city involves geometry in architecture. How could you help design blueprints for our city? Assume the role of an architect who is designing a new neighborhood for the city. Create a Voki to give your pitch to the decision panel	Teacher scenario: After studying how cities are planned and the geometry involved, students brainstorm building and neighborhood designs, and ways to be "green". One team decides to investigate how the city can be more efficient in using building materials. They work with a house planner to help troubleshoot issues in the city. They design posters with Glogster.com or Kerpoof.com to encourage citizens to conserve materials and go green. The mayor and "Go Green" director judge the posters and select one to duplicate and display around the city

relevant to their interests or foreseeable future needs (Sousa, 2006). In fact, traditional learning will usually fall under level 1 or 2, relevant learning under level 2 or 3, and real learning under level 4 or 5, depending on the level of impact. Table 3.2 provides a sample topic to illustrate the differences among traditional, relevant, and real learning.

3.3.2.3 Collaborating with Field or Discipline Experts

Real-world problems comprise complex tasks that students investigate over a sustained period of time. Students locate their own resources and are not given a finite list of resources. Collaboration is integral to authentic learning, where teamwork is critical to making decisions, solving problems, creating products, and maneuvering the social aspects of learning with a team. Collaboration between the teacher and students is essential to select the content, design the tasks or projects, and construct the assessment. Finally, authentic learning usually culminates in the creation of a whole product; however, the process is just as valuable to student learning as the product. For example, in a conservation unit, each student may document how much water his or her family uses each week, study personal water use habits, and make recommendations to his or her family about water conservation at home. The process of studying one conservation method at home could lead to other conservation efforts at home. It shows students that they can learn about topics that affect them and make informed decisions about many aspects of their lives (Maxwell et al., 2017).

Table 3.3 Example of Real World learning with mathematics in Create Excellence Framework

Create level 4 description for Real World learning	Sample task/project
• Learning emphasizes and impacts the classroom, school, or community AND • Learning is integrated across subject areas	Elementary students created an organic garden at their school in collaboration with a local organic farmer. Students implement their design (including geometric patterns and measurements), grow the vegetables, and sell their products at the local farmers' market. The organic farmer helped the students by reviewing their designs and giving feedback, advising about pricing and keeping accurate records of sales, and how to use the data to plan for next year's garden (Maxwell et al., 2017)

True collaboration with experts in the field is invaluable in student acquisition of the knowledge, skills, and dispositions necessary to develop discipline, work ethic, and collaboration proficiencies. Collaboration with these experts could occur in person at the school, through a field trip to the expert's work location, or via video conferencing with Skype. Teachers of a specific discipline may find themselves collaborating with other teachers and experts from other disciplines (Maxwell et al., 2017). Table 3.3 provides an example of collaboration with an expert.

3.3.3 Engagement

The Engagement component of the Create Excellence Framework is concerned with the degree to which learners take responsibility for their own learning; partner or collaborate with the teacher, other students, or outside experts; and use/manage resources such as teachers, experts in the discipline, and tools/technology. Teachers can help the student differentiate their interests and make choices in how they approach the task. They can also support the student by helping them identify resources and collaboration opportunities (Maxwell et al., 2017).

Student engagement has become an important quality in creating effective schools and advancing student achievement. Educators know now that students simply staring at the teacher or completing worksheets does not equal engaged learning, and just because students are quiet and busy, that does *not* mean they are engaged in their learning. Activities that focus on procedures and rudimentary tasks as opposed to cognitively demanding learning opportunities have been found to actually impede student engagement (Blumenfeld & Meece, 1988). Engaged learning involves students solving problems or creating solutions to ill-structured, multidisciplinary, real-world problems. There are several facets of engaged learning, including inquiry-based learning, student-directed learning, collaboration within and beyond the classroom–students collaborate or partner with other students, teachers, or outside experts, and differentiated learning (Maxwell et al., 2017).

3.3.3.1 Inquiry-Based Learning

Student engagement is connected to a movement in education toward inquiry-based learning. With inquiry-based learning, students are engaging with real-world issues while solving problems or creating solutions to develop deep understandings. According to biology instructor Schamel and research associate Ayres (1992), students learn in a more effective manner when they generate their own questions based on their observations rather than developing a solution to a situation or problem with a predetermined answer. The National Science Education Standards (1996) state, “Inquiry is something that students do, not something that is done to them” (p. 21). Since inquiry-based learning is student directed, it would be placed at the Integrating level (4) of the Create Excellence Framework if students are collaborating with the teacher and other students. It would be considered level 5 (Specializing) if students are collaborating beyond the classroom (Maxwell et al., 2017).

The basis of inquiry-based learning is that students are key planners and designers in the learning process. Table 3.4 shows the comparisons between traditional and inquiry-based learning with students directing the learning, the teacher facilitating the learning, and students having input in the assessment (Maxwell et al., 2017).

3.3.3.2 Student-Directed Learning

Student-directed learning is another key component of student engagement. Student-directed learning places the learning focus directly on the students and less heavily on the teacher’s actions. As incorporated in all elements of inquiry-based learning, students are active learners, take responsibility for their own learning, and constantly formulate new ideas and refine them through their collaboration with others (Hung, Tan, & Koh, 2006). In project-based learning, students have voice and choice. Students help teachers set clear expectations so that they know what success looks like. Students articulate the targets or goals and examine targets in their own work (Antonetti & Garver, 2015).

Table 3.4 Comparison of traditional and inquiry-based learning

Traditional	Inquiry based
Teacher directed	Student directed
Teacher as giver of knowledge	Teacher as facilitator of learning
Content mastery	Content mastery and beyond
Vertical and linear learning path	Learning is more web-like; concept development ranges from linear to spiral
Teacher-created assessment	Assessment requires student input

Finding the spark—a real-world subject, idea, or project that makes a student light up—is the key to customizing learning experiences and engaging individual students. In order to tailor learning to meet students' educational needs and aspirations, teachers seek and develop knowledge of each student's unique tendencies, circumstances, and interests through both formal processes (such as surveys or advisories) and informal processes (casual conversations and insight from partner or cooperating organizations, community members, or other teachers) (Martinez, 2014). For example, on a level 4 project, students might partner with the teacher to decide which tasks they need to complete or determine what type of products they might produce.

Student-directed learning in comparison to teacher-directed approaches increases students' depth of understanding, increase critical-thinking skills, improve long-term retention, and increase students' positive feelings toward the subject studied (Crie, 2005). At the highest levels of student-directed learning, students establish the learning goals based on their interests or questions they pose. At this level of self-directed learning, students may also co-construct knowledge, assume varied roles and tasks, and participate in self-monitoring and assessment (Maxwell et al., 2017).

The inquiry process identifies several levels based on the level of student input. Open inquiry involves the top level of student engagement in the learning process with *no predetermined questions since students propose and pursue their own questions*. This level could correlate with Create framework levels 4 or 5 in the student-engagement component, depending on the amount of student initiation of inquiry and collaboration. In the second level, guided inquiry, the teacher decides on the topic, but the students can decide how they will approach the topic and investigate the problem. This level could connect with Create framework level 3 or 4, depending on the amount of teacher input or student collaboration. At the third level, structured inquiry, the teacher determines the topic and method for investigation and students explore various solutions. This level could correlate with Create framework level 2 or 3, depending on task choices and differentiation. In the lowest level, limited inquiry, students follow the directions and make sure their results match those given in the text. This level would be Create framework level 2 since students are engaged in a teacher-directed task (Maxwell et al., 2017).

3.3.3.3 Collaborating Within and Beyond the Classroom

Collaboration is the third key component to student engagement. In engaging tasks, students should collaborate within the classroom with other students and teachers or beyond the classroom with outside experts. Teachers and experts provide real-world tools, techniques, and support that allow for open communicating and sharing (Hung et al., 2006).

Extending learning beyond the traditional classroom provides students with real-world learning experiences that allow them to communicate with experts, take ownership of their learning, and extend their support networks. Educators, including principals, act as consummate networkers throughout the process—searching for meaningful resources that meet school's learning goals and student interests in places like museums, colleges, and community organizations. For many educators, tapping these resources has been done to arrange internships or mentorships, but the Create Excellence Framework encourages teachers and principals to use their networking skills for deeper learning (Martinez, 2014).

3.3.3.4 Differentiated Learning

Opportunities for choice combined with a broad variety of instructional strategies result in the highest levels of engagement (Raphael, Pressley, & Mohan, 2008). When students are given choices, they have a sense of ownership of their personal learning. A diverse collection of instructional strategies should be paired with students' prior knowledge and readiness to learn in order to promote student engagement. However, the level and complexity of the varied instructional strategies and activities must also be challenging (Gregory & Chapman, 2007).

Differentiation begins at level 3 with the teacher differentiating content, process, or product. At level 4, students partner with the teacher to define their own content, process, or product. At level 5, students design and implement their own inquiry-based projects from topic to full implementation to solution. Students initiate their own outside collaborations with field experts. (See Table 3.5 for an example of Level 5.) With both of these top levels, instruction is differentiated as students choose what content to examine, what processes they will use to find the solution, and how they will demonstrate their learning (product) (Maxwell et al., 2017).

3.3.4 Technology Integration

With advances in technology doubling every eighteen months (McGinnis, 2006), there is a plethora of technologies available to schools. Internationally there is quite a variance of integration of technology based on factors including access to technology, government prioritizing and investing in technologies, and varying comfort levels and beliefs in the importance of utilizing digital tools for K-12 learning. According to a report by the European Commission (2013) in the European Union 63% of nine-year-olds do not study at a "highly digitally equipped school." Among the European countries, there is a large variance in the average ratio of computers available for educational purposes. The average for the European Union is 5:1, but in Greece it's 21:1.

Traditionally, technology in classrooms has been a gadget to obtain students' attention or inserted as an add-on to instruction to meet curriculum or teaching

Table 3.5 Example of Engagement with mathematics in Create Excellence Framework

Create level 5 description for Engagement	Sample task/project
Students initiate their own inquiry-based learning projects with thorough immersion and full implementation from topic to solution, and students initiate appropriate collaborations pertaining to their project	Students were disturbed after watching a documentary about students in a Kenyan school who did not have chairs for their classroom. The documentary deeply moved these fourth graders. The students wanted to raise funds for chairs for the African students. The teacher and students used Coggle (https://coggle.it), an online mind-mapping tool, to brainstorm ways to raise the funds. One student's idea was to sponsor a math day at school where students paid fifty cents for solving a math problem. Another student contacted his uncle, a member of a civic club, to help them. The students also participated in an event at the county fair to raise funds. The students kept careful records on a spreadsheet, set up formulas to calculate the total and amount still needed. The teacher contacted an international humanitarian group for the students to work with to purchase and ship the chairs. The humanitarian group delivered the chairs (with desktops) and made a video of the excited African students to share with the fourth graders

standards, but it fails to meaningfully impact instruction when teachers use it in that capacity. Technology used to deliver teacher-directed content (as a glorified blackboard) and digital worksheets has not delivered the rate of return expected for the millions of dollars spent on technology (Schwartzbeck & Wolf, 2012). Without sound application of technology integration, money spent on technology is wasted. Authors Greaves, Hayes, Wilson, Gielniak, and Peterson (2010) state, "Although educational technology best practices have a significant positive impact, they are not widely and consistently practiced" (p. 12). Technology is a *tool* to reach an educational goal; technology is not the goal itself. Author, educator, and technology administrator Richardson (2013) comments, "It's not about the tools. It's not about layering expensive technology on top of the traditional curriculum. Instead, it's about addressing the new needs of modern learners in entirely new ways" (p. 12).

Our research shows high correlation of technology integration with the other three components of the framework (Maxwell et al., 2011). Technology should be used not simply as an add-on but to meaningfully support the work to more efficiently and effectively accomplish the task, just as it is in the professional world. Authors Jukes, McCain, and Crockett (2010) state that the revised Bloom's taxonomy reflects the "new era of creativity that has been facilitated by the emergence of the online digital world" (p. 69). Technology paired with critical thinking, student engagement, and real-world learning provides opportunities for students to produce novel products to address authentic problems (Maxwell et al., 2017).

Schools must have a planned approach in order to maximize the impact of these technologies to enhance student learning (Pence & McIntosh, 2010). Educators, however, struggle to integrate technology in meaningful ways that involve higher-order thinking, collaborative tasks, and authentic problem solving (The United Nations Educational, Scientific and Cultural Organization [UNESCO], 2004). Optimally, technology integration is a seamless component of instruction to engage students in authentic, creative-thinking tasks (Maxwell et al., 2017).

The Create Excellence Framework's technology-integration component advocates for this new approach, incorporating real-world tasks that are naturally infused with critical thinking and student engagement. Effective technology integration seamlessly embeds technology tools as part of the instructional design in order to engage students with significant content at high levels of thinking, whereby students use varied technologies to collaborate with others, explore solutions to real-life problems, and share their results in an authentic manner. While some may view technology as helpful in building basic foundations of knowledge through online games that reinforce basic applications of content, students more effectively use technology to design solutions and create new products, which are high-level thinking activities. Technology tools have the potential to enhance student learning, but they must be implemented in a research-based framework to ensure sound implementation.

Jukes et al. (2010) developed a list of 21st century competencies that include students thinking creatively to address real-world issues, critically assessing the quality of digital content, and creating their own digital projects. The U.S. 21st Century Workforce Commission's (2000) National Alliance of Business maintains that "the current and future health of America's 21st century economy depends directly on how broadly and deeply Americans reach a new level of literacy—21st century literacy" (p. 5). Their alliance identifies 21st century literacy as including digital literacy, inventive thinking, and results-based thinking.

At the highest level on the Create Excellence Framework, students design projects where (a) technology is seamlessly integrated into content at the Create level of Bloom's taxonomy, (b) several technologies are used, and (c) students collaborate with field experts and/or global organizations to find solutions to an in-depth "real" problem. Teachers can partner with students to design open-ended assignments that have no single right answer, require students to design solutions to problems that require higher-level thinking, and naturally embed technology. Table 3.6 provides a description of the Create Level 4 along with a sample task/project.

Table 3.6 Example of Technology Integration with mathematics in Create Excellence Framework

Create level 4 description for Technology Integration	Sample task/project
• Student technology use… – Is embedded in content and essential to project completion AND – Promotes collaboration among students and partnerships with teacher AND – Helps them solve authentic problems at the Analyze, Evaluate or Create levels	You will find and investigate five different apps or websites that you think could help you, your classmates, and other third-graders practice and understand the concept of fractions. You will then review the apps or websites you researched and rank the top five programs. To share your thoughts, you will publish a review of the five best apps for learning fractions in our classroom newsletter and on our class website. After the newsletter is published, the class will choose the top five apps/websites out of all of those collected and critiqued to use for the next month to practice fractions (Maxwell et al., 2017)

3.4 Research Study

3.4.1 Purpose of the Research

As teacher candidates utilize the Create Excellence Framework, they can design higher quality lessons sparking student creativity. Use of the Framework can enhance the teacher's knowledge of intentional lesson plan design and can positively impact teacher candidate instructional planning performance, in turn providing opportunities for real-world learning opportunities that provide authentic learning opportunities for creative thinking. The authentic learning experiences can then inspire an environment for students to develop and tap into their creativity as applied to real-world learning and meaningful cognitive challenge. Creativity inspires discovery learning, an inquiry-based learning method where students discover facts and relationships for themselves (Bruner, 1961). For over ten years Robinson and Aronica (2015) has been saying that we are preparing students for careers that don't yet exist. Learning how to be more creative (and thus adaptable)—now that's what prepares students for life beyond the classroom. Business executives say that creativity is valued as the most important business skill in the modern world (Robinson & Aronica, 2015).

The researchers analyzed lesson plans developed by pre-service teacher education students at a southeastern university based on their level of the Create Excellence implementation over five semesters. Through utilizing the Create Excellence Framework in a pre-service Elementary Mathematics Methods course and an Elementary Education Senior Project course, the intention is that the participants should possess greater abilities to design higher-level thinking lessons around authentic topics that integrate student design with technology while employing creative thinking skills. The students, or pre-service teachers, were different students each semester. Therefore, the research is not following the students through the five semesters, but rather following the effect of instruction with the use of the Create Excellence Framework for impact on pre-service teachers' lesson plans.

3.4.2 Research Questions

The research questions for this study were as follows:

1. Is there a significant difference in pre-service teachers' mathematics/science lesson plan scores over the five semesters for the Cognitive Complexity component to enhance opportunities for creative thinking?
2. Is there a significant difference in pre-service teachers' mathematics/science lesson plan scores over the five semesters for the Real-World Learning component to enhance opportunities for creative learning in authentic situations?
3. Is there a significant difference in pre-service teachers' mathematics/science lesson plan scores over the five semesters for the Engagement component to enhance creativity in working with others?
4. Is there a significant difference in pre-service teachers' mathematics/science lesson plan scores over the five semesters for the Technology Integration component to enhance creative opportunities in learning?

3.4.3 Research Method

Over the course of five semesters in two different pre-service teacher preparation courses (Elementary Mathematics Methods and Elementary Education Senior Project), pre-service teachers were instructed on components of the Create Excellence Framework. These two undergraduate elementary program area courses required pre-service teacher education students to develop lesson plans as part of the typical course requirements. The pre-service teachers in the Elementary Education Senior Project course were required to design one mathematics or mathematics and science integrated lesson plan that embedded the Create Excellence Framework components at a level 3 or higher. In the Elementary Mathematics Methods course, the pre-service teachers were required to design a problem-solving lesson with the Create Excellence Framework components. The researchers then began using the Create Excellence Framework for instruction with the preservice teachers and continued four more semesters of data collection beyond the baseline semester: Spring 2010, Fall 2010, Spring 2011, and Fall 2011. The Fall 2009 semester data established a baseline before any instruction occurred on the Create Excellence Framework. In the study, a total of 253 pre-service teachers' lesson plans were collected from five semesters from the two courses. Researchers analyzed plans to identify the level for each component in the Create Excellence Framework.

Preservice teacher names were removed from the lesson plans, numbered, and randomly divided. Next, blind scoring was conducted by the researchers and scorers. The 253 samples were scored after the Fall 2011 semester. In total, eleven evaluators rated the lessons—three were the researchers, two were Assistant Superintendents, and the others were P-12 teachers. The researchers trained the other scorers on the use of the Create Excellence Framework for the scoring of the lesson plans. A main focus of the training was on calibration of the scoring of the evaluators. To establish the calibration, the researchers chose four anchor lessons with agreed upon ratings, and trained and discussed these in detail for scoring calibration of the application of the framework. The new members of the scoring team each scored the "training" lesson plans, shared and discussed their ratings for each of the four Create Excellence Framework components. At this point in the study, the calibration goal was to score two consecutive lessons with Create component ratings no more than one level apart on each component from the score set by the researchers. After each training lesson, the discussion provided opportunities to refine the understanding of the Create Excellence Framework. After three training lessons, the calibration goal was met.

After the calibration was established, three teams of scorers were paired together with one researcher in each of the pairs. The lesson plans were randomly distributed among the three scoring teams. A scoring team evaluated the same set of lessons—giving every lesson in the study two sets of scores. The ratings were recorded on spreadsheets. The scores were averaged when the scorers did not agree upon a score. (see results in Table 3.7.)

Table 3.7 Mean of each Create Excellence Framework component across five semesters

	Cognitive Complexity m	Real-world learning m	Technology integration m	Engagement m
Fall 2009 N = 43	2.00	1.674	.791	1.465
Spring 2010 N = 44	2.068	1.977	1.273	1.727
Fall 2010 N = 47	2.191	2.042	1.702	1.894
Spring 2011 N = 46	2.283	2.174	1.957	1.891
Fall 2011 N = 73	2.425	2.726	2.247	2.110
Increase in m from Fall 2009 to Fall 2011	.425	1.052	1.456	.645

m Mean—rounded to third decimal place

The scores were analyzed in SAS for statistical difference with an Analysis of Variance (ANOVA), followed by a Tukey Studentized Range (HSD) Test to determine where differences occurred. The researchers were primarily investigating if there was a difference between the first, or baseline, semester and the last semester in the five-semester sequence.

3.5 Results

The forthcoming results share the analysis of the four research questions, one question at a time. The data are analyzed in a progression of mean and standard deviation, ANOVA, and *Tukey's Studentized Range* (*HSD*). Following the Results section, the Discussion and Conclusions sections share more details and thoughts for interpretation.

3.5.1 Research Question One

Is there a significant difference in pre-service teachers' mathematics/science lesson plan scores over the five semesters for the Cognitive Complexity component to enhance opportunities for creative thinking?

The means of the scores of pre-service teachers' lesson plans of the Cognitive Complexity component of the framework increased from 2.00 in the Fall 2009 semester to 2.425 in the fifth semester in Fall 2011 (see Table 3.8). Although this component had the least growth over the five semesters, Table 3.9 reveals a significant difference among the means of the semesters. The significant difference did occur between the Fall 2009 and Fall 2011 semesters (see Table 3.10).

Table 3.8 Descriptive data for Cognitive Complexity component

Semester	N	Mean *m*	Standard deviation *SD*
Fall 2009	43	2.00000000	0.37796447
Spring 2010	44	2.06818182	0.66113811
Fall 2010	47	2.19148936	0.44907140
Spring 2011	46	2.28260870	0.58359208
Fall 2011	73	2.42465753	0.52487586

Table 3.9 ANOVA for the Cognitive Complexity component

Source	*df*	*SS*	*MS*	*F*	*p*
Model	4	6.37098940	1.59274735	5.71	<0.0002
Error	248	69.23375369	0.27916836		
Total	252	75.60474308			

Table 3.10 Tukey's studentized range (HSD) for Cognitive Complexity component

Group comparison	Difference between means	Simultaneous 95%	
		Confidence	Limits
Fall 2011–Fall 2009	0.14555	0.42466	0.70377

Only significant results reported for difference between Fall 2009 and Fall 2011

3.5.2 Research Question Two

Is there a significant difference in pre-service teachers' mathematics/science lesson plan scores over the five semesters for the Real-World Learning component to enhance opportunities for creative learning in authentic situations?

Compared to other components, Cognitive Complexity has the highest mean score at the beginning of the study while the Real-World Learning means were the highest at the end of the study. The Real-World Learning component also showed steady increase with a baseline score of 1.674 (Fall 2009) and moving to 2.726 (Fall 2011) four semesters later (Table 3.11). This was an increase of 1.052 over the five semesters. The ANOVA results (Table 3.12) indicated a significant difference. The Tukey results confirmed a significant difference between the Fall 2009 and the Fall 2011 semester means (Table 3.13). Therefore, the pre-service teacher lesson plan scores did significantly increase from the baseline to the fifth semester of the study.

Table 3.11 Descriptive data for Real-World Learning component

Semester	N	Mean	Standard deviation
Fall 2009	43	1.67441860	0.56572458
Spring 2010	44	1.97727273	0.45691770
Fall 2010	47	2.04255319	0.41480466
Spring 2011	46	2.17391304	0.60752130
Fall 2011	73	2.72602740	0.55927220

Table 3.12 NOVA for the Real-World Learning component

Source	*Df*	*SS*	*MS*	*F*	*P*
Model	4	35.43000102	8.8575026	31.62	<0.0001
Error	248	69.4632704	0.2800938		
Total	252	104.8932806			

Table 3.13 Tukey's studentized range (HSD) for Real-World Learning component

Group comparison	Difference between means	Simultaneous 95%	
		Confidence	Limits
Fall 2011–Fall 2009	1.05161	0.77204	1.33118

Only significant results reported for difference between Fall 2009 and Fall 2011

3.5.3 Research Question Three

Is there a significant difference in pre-service teachers' mathematics/science lesson plan scores over the five semesters for the Technology Integration component to enhance creative opportunities in learning?

Technology Integration had the lowest baseline score with a .79 average in Fall 2009 and the highest mean increase (1.456) of all four components (Table 3.14). Each semester the mean scores on the Technology Integration component progressively increased with the highest mean gain in the Spring 2010 semester when the Create Framework was first introduced. A significant difference was revealed by the ANOVA (Table 3.15) and confirmed by the Tukey test between the Fall 2009 and Fall 2011 semesters (Table 3.16).

3.5.4 Research Question Four

Is there a significant difference in pre-service teachers' mathematics/science lesson plan scores over the five semesters for the Engagement component to enhance creativity in working with others?

Table 3.14 Descriptive data for Technology Integration component

Semester	N	Mean	Standard deviation
Fall 2009	43	0.79069767	0.67464769
Spring 2010	44	1.27272727	0.81735923
Fall 2010	47	1.70212766	0.85757225
Spring 2011	46	1.95652174	0.75884479
Fall 2011	73	2.2467534	0.79548765

Table 3.15 ANOVA for the Technology Integration component

Source	*df*	*SS*	*MS*	*F*	*P*
Model	4	68.2748986	17.0687246	27.64	<0.0001
Error	248	153.1480263	0.6175324		
Total	252	221.4229249			

Table 3.16 Tukey's studentized range (HSD) for Technology Integration component

Group comparison	Difference between means	Simultaneous 95%	
		Confidence	Limits
Fall 2011–Fall 2009	1.4559	1.0408	1.8710

Only significant results reported for difference between Fall 2009 and Fall 2011

Table 3.17 Descriptive data for Engagement component

Semester	N	Mean	Standard deviation
Fall 2009	43	1.46511628	0.50468459
Spring 2010	44	1.72727273	0.54404328
Fall 2010	47	1.89361702	0.63362458
Spring 2011	46	1.89130435	0.60473174
Fall 2011	73	2.10958904	0.39305229

Table 3.18 ANOVA for the Engagement component

Source	*df*	*SS*	*MS*	*F*	*P*
Model	4	12.11609114	3.02902279	10.81	<0.0001
Error	248	69.47284166	0.28013243		
Total	252	81.58893281			

Table 3.19 Tukey's studentized range (HSD) for Engagement component

Group comparison	Difference between means	Simultaneous 95%	
		Confidence	Limits
Fall 2011–Fall 2009	0.64447	0.36488	0.92406

Only significant results reported for difference between Fall 2009 and Fall 2011

In Fall 2009, the Engagement component had a 1.465 average and increased to 2.110 in Fall 2011, a .645 increase (Table 3.17). Engagement scores continued to increase each semester, excluding a minimal decrease in Spring 2011. The ANOVA (Table 3.18) and Tukey (Table 3.19) again revealed a significant increase from the Fall 2009 to the Fall 2011 semesters.

3.6 Discussion and Conclusions

The means of pre-service teachers' lesson plans using the Create Excellence Framework demonstrated significant increase on all four components from the first to the last semester of the research period. This finding suggests that pre-service teachers can learn to increase these components in their lesson planning.

The Cognitive Complexity dimension had the least increase of all dimensions over the course of five semesters, but had steady increases each semester. To deepen students' understanding of Bloom's taxonomy (Bloom, 1956; Bloom, Englehart, Furst, Hill, & Krathwohl, 1956), the professors engaged teacher candidates in determining the Bloom's level of sample tasks. In addition, in other teacher candidate lessons for the classes, they were expected to demonstrate their ability to design instruction above the Remember and Understand level of Bloom's taxonomy; hence, they had multiple times to practice designing lesson with rigorous learning outcomes. It is not surprising that the teacher candidates had difficulty designing lesson plans beyond a Create Framework level 2 on average. A Create Framework level 3 lesson plan requires pre-service teachers to design instruction that challenges students to think within the top three levels of the Revised Bloom's Taxonomy (Anderson & Krathwohl, 2001): Analyze, Evaluate, and Create. Most of the pre-service teachers were able to design instruction on the Understand and Apply level of Bloom's taxonomy, but were not able to reach the top three levels on Bloom's taxonomy or develop student-generated tasks on the higher levels. As mentioned earlier by Henrickson and Mishra (2013) in the study of how teachers teach creativity, a related area to the Create Framework's Cognitive Complexity is a teacher's willingness to "Take Intellectual Risks" and model new ideas and approaches in their classroom, showing that they were open to failure. Perhaps for the teacher candidate, the risk-taking is too much of a leap.

The Engagement component also showed significant increase over the course of the five semesters, with just a slight dip one semester. The professors incorporated differentiation and grouping techniques for the teacher candidates to use within the lessons, along with encouraging different forms of collaboration. The teacher candidates were also encouraged to work toward a student-directed lesson versus a teacher-directed lesson. As mentioned earlier with the Henrickson and Mishra (2013) study of teacher awardees, a related area to Engagement that emerged as an indicator of excellent teaching of creativity was their area of "Collaboration." The master teachers emphasized that their students needed to learn about the benefits of working together to hear the ideas of others and solve problems with integrated strengths.

The Real-World Learning component had the highest mean scores in the final year of the study. Professors challenged students to determine a real-world situation as the context of their lesson and then design their plan. The Create Framework's Real-World Learning component is connected to the Henrickson and Mishra (2013) study, "Link Lessons to Real-World Learning," as it asserts that authentic experiences must be incorporated so that creativity is woven in relevant learning with creative and novel learning opportunities.

The Technology Integration component had the highest mean increase of the all the components. As professors modeled new technologies in class and adopted higher expectations for integration, teacher candidates quickly began utilizing digital tools to enhance instruction. As teacher candidates moved to higher levels of integration of each component, the instruction became more engaging via the use of technology and provided more opportunity for students to express their creativity and learning in a variety of ways.

With each subsequent semester the researchers gained expertise in various technologies, critical-thinking strategies, and new ways to engage students in authentic tasks, which were then incorporated into the class. Professors also started to have students select unique technologies for in-class presentations to challenge students to investigate the uses of various technologies. The researchers began asking students to create a sample student product of the Create Excellence lesson they designed, which then challenged the pre-service teachers to carefully analyze their task directions.

To increase the quality, professors displayed and discussed more examples of quality Create Excellence Framework lesson planning assignments. Students also critiqued each other's work suggesting ways to improve the assignments. This formative feedback increased the quality of the final product.

3.7 Implications for Future Research

With new technologies providing more efficient and effective methods for learning, students are able to utilize digital tools to creatively solve authentic problems. However, oftentimes, P-12 instruction is teacher-directed with little freedom to produce diverse solutions. In mathematics classrooms teachers are frequently pressured to meet the content standards by covering content instead of uncovering deep learning while also lacking instructional tools for developing students' creativity (Shriki, 2010, 2013). However, when instruction is designed focused on high levels of Cognitive Complexity, Real-Learning Learning, Engagement, and Technology Integration, students are empowered to direct their own learning, while solving real-world problem using relevant digital tools. These instructional experiences can invigorate even reluctant learners as learning becomes more than memorizing but bursting with opportunities for creative expressions (Mann, 2006).

Teacher candidates and practicing teachers in many states are now faced with changing evaluation systems for teacher quality (Danielson, 2007). Through this process, the hope is that the Create Excellence Framework will provide a tool to help both pre-service teachers and current teachers be prepared to perform in the upper echelon of these more rigorous teaching standards. This framework has been designed to be a tool to support raising P-12 student achievement. However, a lingering question is: By use of the framework, do teachers actually improve in their instruction? A possible next step for future research is to study the impact of the Create Excellence Framework implemented by teachers to thoughtfully and intentionally plan for the four components of instruction to ensure a well-rounded lesson and deeper student learning. As teachers and administrators look for another tool to plan and improve instruction, the Create Excellence Framework may be the answer!

3.8 Final Thoughts

So, let us check back in with Allison in her 5th grade classroom, as introduced in the opening scenario of this chapter. After learning of the Create Excellence Framework, her teacher was able to implement an authentic STEM project where students were able to have opportunities to expand in creative learning and choices through the four components of Cognitive Complexity, Real-World Learning, Engagement, and Technology Integration.

The teacher informs the class that the classroom student desks are going to be replaced due to being old/ineffective. Groups are assigned to develop the optimal student desk that would meet the needs of 5th grade students. Allison's group identifies what qualities a desk should have to meet the needs of students in their classroom. Students brainstorm various conceptual designs. Students evaluate which concept is most likely to meet their needs and is cost effective. Using their engineering skills, students make calculations of size of the desk, cost of materials, and build a prototype. Each group tests and evaluates their prototype; then they restructure and improve the original design. While Allison's group is formulating their conceptual design, they use a free online program, Google Sketch-Up, to develop their design. The class is told that the desk-constructing groups are in competition for a "school choice" award. Their persuasive presentation for the principal is created in Animoto (online presentation program). Allison's team collaborates with the teacher constantly to ensure the group is progressing on their solution and Skype with a furniture designer to pose questions about their prototype and get feedback from the designer.

In Allison's classroom instruction make-over, the Real-World Learning component is found in the real-world mathematics lesson of desk redesign scenario and the competition for student choice award along with the persuasive presentation. Cognitive Complexity is seen in the students generating their own questions and design; students evaluating which concept will meet needs; students at the creating level of thinking; students test and evaluate the prototype, then restructure and improve their plan. For Engagement, the students work as a team and collaborate with the teacher; they consult with a furniture designer. For Technology Integration, students use Google sketch-up, Skype, Animoto for presentation, and build a prototype of the desk.

The example of Allison's classroom experience provides a picture of how instruction can be enhanced in the mathematics classroom—infusing opportunities for children to creatively engage in authentic learning experiences.

References

Abrami, P. C., Lou, Y., Chambers, B., Poulsen, C., & Spence, J. C. (2000). Why should we group students within-class for learning? *Educational Research and Evaluation, 6*(2), 158–179.

Anderson, L. W., & Krathwohl, D. R. (2001). *A taxonomy for teaching, learning and assessing: A revision of Bloom's taxonomy of educational objectives*. New York, NY: Addison Wesley Longman.

Antonetti, J. V., & Garver, J. R. (2015). *17,000 classroom visits can't be wrong: Strategies that engage students, promote active learning, and boost achievement*. Alexandria, VA: Association for Supervision and Curriculum Development.

Barton, K. C., & Smith, L. A. (2000). Themes or motifs? Aiming for coherence through interdisciplinary outlines. *Reading Teacher, 54*(1), 54–63.

Bloom, B. S. (1956). *Taxonomy of educational objectives*. Philadelphia, PA: David McKay Publishing Company.

Bloom, B. S., Englehart, M. D., Furst, E. J., Hill, W. H., & Krathwohl, D. R. (1956). *Taxonomy of educational objectives: The classification of educational goals. Handbook 1: Cognitive domain*. New York, NY: David McKay.

Blumenfeld, P. C., & Meece, J. L. (1988). Task factors, teacher behavior, and students' involvement and use of learning strategies in science. *Elementary School Journal, 88*(3), 235–250.

Bruner, J. S. (1961). The act of discovery. *Harvard Educational Review, 31,* 21–32.

Crie, M. (2005). *Inquiry-based approaches to learning*. New York, NY: Glencoe. Retrieved from http://www.glencoe.com/sec/teachingtoday/subject/inquiry_based.phtml.

Danielson, C. (2007). *Enhancing professional practice: A framework for teaching*. Alexandria, VA: ASCD.

Davidovitch, N., & Milgram, R. M. (2006). Creative thinking as a predictor of teacher effectiveness in higher education. *Creativity Research Journal, 18*(3), 385–390.

Division of Elementary, Secondary, and Informal Education. (2000). *Foundations: A monograph for professionals in science, mathematics, and technology education*. Arlington, VA: Author. Retrieved from http://www.nsf.gov/pubs/2000/nsf99148/htmstart.htm.

European Commission. (2013). Survey of schools: ICT in education. *European Schoolnet*. Retrieved from https://ec.europa.eu/digital-single-market/news/survey-schools-ict-education.

Giroux, H. A., & Schmidt, M. (2004). Closing the achievement gap: A metaphor for children left behind. *Journal of Educational Change, 5,* 213–228.

Greaves, T. W., Hayes, J., Wilson, L., Gielniak, M., & Peterson, R. (2010). *The technology factor: Nine keys to student achievement and cost-effectiveness*. Chicago, IL: Market Data Retrieval.

Gregory, G. H., & Chapman, C. (2007). *Differentiated instructional strategies: One size doesn't fit all* (2nd ed.). Thousand Oaks, CA: Corwin Press.

Henrickson, D. (2011). *We teach who we are: Creativity trans disciplinary thinking in the practices of accomplished teachers* (Doctoral dissertation, Michigan State University). Retrieved from ProQuest Dissertations and Theses (3489807).

Henricksen, D., & Mishra, P. (2013). Learning from creative teachers. *Educational Leadership, 70* (5). Retrieved from http://www.ascd.org/publications/educational-leadership/feb13/vol70/num05/Learning-from-Creative-Teachers.aspx.

Herrington, J., Oliver, R., & Reeves, T. C. (2003). Patterns of engagement in authentic online learning environments. *Australian Journal of Educational Technology, 19*(1), 59–71.

Hung, D., Tan, S. C., & Koh, T. S. (2006). Engaged learning: Making learning an authentic experience. In D. Hung & M. S. Khine (Eds.), *Engaged learning with emerging technologies* (pp. 29–48). Dordrecht, The Netherlands: Springer.

International Society for Technology in Education. (2007). *The national educational technology standards for students*. Eugene, OR: International Society for Technology in Education. Retrieved from http://www.iste.org/standards/nets-for-students.aspx.

International Society for Technology in Education. (2008). *The national educational technology standards for teachers*. Eugene, OR: International Society for Technology in Education. Retrieved from http://www.iste.org/standards/nets-for-teachers.aspx.

Jenkins, H. (2009). *Confronting the challenges of participatory culture: Media education for the 21st century*. Cambridge, MA: MIT Press.

Jukes, I., McCain, T., & Crockett, L. (2010). *Understanding the digital generation: Teaching and learning in the new digital landscape*. Thousand Oaks, CA: Corwin Press.

Keyek-Franssen, D. (2010, December 15). Clickers and CATs: Using learner response systems for formative assessments in the classroom. *Educause Review*. Retrieved from http://www.educause.edu/ero/article/clickers-and-cats-using-learner-response-systems-formative-assessments-classroom.

Mann, E. L. (2006). Creativity: The essence of mathematics. *Journal for the Education of the Gifted, 30*(2), 236–260.

Martinez, M. (2014). *Deeper learning: The new normal*. Retrieved from http://www.advanc-ed.org/source/deeper-learning-new-normal.
Maxwell, M., Constant, M., Stobaugh, R., & Tassell, J. L. (2011). Developing a HEAT framework for assessing and improving instruction. In C. Maddux (Ed.), *Research highlights in technology and teacher education 2011* (pp. 13–20). Chesapeake, VA: SITE.
Maxwell, M., Stobaugh, R., & Tassell, J. L. (2017). *Real-world learning framework for elementary schools: Digital tools and practical strategies for successful implementation*. Bloomington, IN: Solution Tree.
Maxwell, M., Stobaugh, R., & Tassell, J. L. (2015). *Real-world learning framework for secondary schools: Digital tools and practical strategies for successful implementation*. Bloomington, IN: Solution Tree.
McGinnis, J. O. (2006). Age of the empirical. *Policy Review, 137,* 47–58.
Mishra, P., Henriksen, D., & Deep-Play Research Group. (2012). Rethinking technology and creativity in the 21st century: On being (in)disciplined. *Tech Trends, 56*(6), 18–21.
Moersch, C. (2002). Measures of success: Six instruments to assess teachers' use of technology. *Learning & Leading with Technology, 30*(3), 10–18.
Oblinger, D. (2003). Boomers, gen-xers, and millennials: Understanding the "new students". *Educause Review, 38*(4), 37–47.
Partnership for 21st Century Skills. (2009). *P-12 framework definitions*. Retrieved from http://www.p21.org/storage/documents/P21_Framework_Definitions.pdf.
Pence, H. E., & McIntosh, S. (2010). Refocusing the vision: The future of instructional technology. *Journal of Educational Technology Systems, 39*(2), 173–179.
Petti, W. (2017). Math questions worth asking. *Education World*. Retrieved from http://www.educationworld.com/a_curr/mathchat/mathchat026.shtml.
Raphael, L. M., Pressley, M., & Mohan, L. (2008). Engaging instruction in middle school classrooms: An observational study of nine teachers. *Elementary School Journal, 109*(1), 61–81.
Pink, D. H. (2005). *A whole new mind*. New York, NY: Riverhead Books.
Prensky, M. (2010). *Teaching digital natives: Partnering for real learning*. Thousand Oaks, CA: Corwin.
Raths, J. (2002). Improving instruction. *Theory into Practice, 41*(4), 233–237.
Richardson, W. (2013). Students first, not stuff. *Educational Leadership, 70*(6), 10–14.
Robinson, K., & Aronica, L. (2015). *Creative schools: The grassroots revolution that's transforming education*. New York, NY: Penguin.
Rosen, L. (2010). *Rewired: Understanding the iGeneration and the way they learn*. New York, NY: Palgrave Macmillan.
Schamel, D., & Ayres, M. P. (1992). The minds-on approach: Student creativity and personal involvement in the undergraduate science laboratory. *Journal of College Science Teaching, 21* (4), 226–229.
Schools We Need Project. (n.d.). *An engaging program of real world learning*. Retrieved from http://schoolsweneed.wikispaces.com/Real+World+Learning.
Shriki, A. (2010). Working like real mathematicians: Developing prospective teachers' awareness of mathematical creativity through generating new concepts. *Educational Studies in Mathematics, 73,* 159–179.
Shriki, A. (2013). A model for assessing the development of students' creativity in the context of problem posing. *Creative Education, 4*(7), 430–439.
Schwartzbeck, T. D., & Wolf, M. A. (2012). *The digital learning imperative: How technology and teaching meet today's education challenges*. Washington, DC: Alliance for Excellent Education.
Sousa, D. A. (2006). *How the brain learns* (3rd ed.). Thousand Oaks, CA: Corwin Press.
Sternberg, R. (2006). The nature of creativity. *Creativity Research Journal*, *18*(1), 87–98.
Swartz, R. J., & Parks, S. (1994). *Infusing critical and creative thinking into content instruction: A lesson design handbook for the elementary grades*. Pacific Grove, CA: Critical Thinking Press.

Tassell, J. L., Maxwell, M., & Stobaugh, R. (2013). CReaTE excellence: Using a teacher framework to maximize STEM learning with your child. *Parenting for High Potential, 3*(2), 10–13.

Tennessee Department of Education. (2007). *Educator licensure standards*. Retrieved from https://www.tn.gov/assets/entities/education/.../lic_educator_licensure_standards.pdf.

Texas Education Agency. (2014). *Texas teaching standards*. Retrieved from https://www.ritter.tea.state.tx.us/rules/tac/chapter149/ch149aa.html.

The United Nations Educational, Scientific and Cultural Organization. (2004). *Integrating ICTs into education: Lessons learned—A collective case study of six Asian countries*. Bangkok, Thailand: Author. Retrieved from http://www.unescobkk.org/fileadmin/user_upload/ict/e-books/ICTLessonsLearned/ICT_integrating_education.pdf.

U.S. 21st Century Workforce Commission. (2000). *A nation of opportunity: Building America's 21st century workforce*. Washington, DC: Author. Retrieved from http://digitalcommons.ilr.cornell.edu/cgi/viewcontent.cgi?article=1003&context=key_workplace.

Wood, D. F. (2003). ABC of learning and teaching in medicine: Problem based learning. *British Medical Journal, 326*(7384), 328–330.

Wood, J. (2010, April 11). *Rewiring education and connecting with the iGeneration*. Retrieved from JoeWoodOnline Blog: http://www.joewoodonline.com/rewiring-education-connecting-with-the-igeneration/.

Wood, T., Merkel, G., & Uerkwitz, J. (1996). Creating a context for talking about mathematical thinking. *Educacao e matematica, 4,* 39–43.