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DESIGNING K-12 STUDENT-CENTERED BLENDED LEARNING ENVIRONMENTS

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Student-centered learning environments (SCLE) enable students to direct their own learning as they engage in authentic problem-solving. SCLEs may be designed using blended learning infrastructure present in many schools today. Using a qualitative single case study design, the researcher examined an alleged student-centered learning environment, with a focus on the environment's core design values as well as design components and methods. The context was a grade seven science classroom situated in a high-performing, resource-rich suburban school district in the southeastern United States. Sources of data included classroom observations; semi-structured interviews with eight teachers, staff, and administrators; classroom, school, and district documents; and classroom online learning spaces and resources. Data were analyzed using thematic analysis. The findings suggest that though designers value student-centered learning environments, and while the blended environment may technically fulfill the role of SCLE, designers are using the blended learning environment to support predominantly teacher-centered instruction. Implications for research, policy, and practice are discussed in relation to designing K-12 blended learning environments as SCLEs.

INTRODUCTION

Teachers can use blended learning environments to make learning student-centered, authentic, and motivating for K-12 students (Ferdig, Cavanaugh, & Freidhoff, 2014; Patrick, Kennedy, & Powell, 2013). In blended learning, a student "learns at least in part through online learning with some element of control over time, place, path, and/or pace and at least in part at a supervised brick-and-mortar location away from home" (Christensen, Horn, & Staker, 2013, p. 7). In the United States, where 75% or more of schools have reported some form of blended learning (Watson, Murin, Vashaw, Gemin, & Rapp, 2013), numerous models of blended learning exist (Horn and Staker, 2015). However, research focused on the design of student-centered blended learning environments is limited.

Designers of blended learning environments have the opportunity to leverage the affordances of technology to achieve the goals of student-centered instruction (Patrick, Kennedy, & Powell, 2013), the value of which is supported both by research (Bransford, Brown, & Cocking, 2000; Kamarainen et al., 2013; Sawyer, 2014; Wilder, 2015) and high-level policy and curricular leaders, including the United States Department of Education (2010), the International Society of Technology in Education (2017), and the Partnership for 21st Century Learning (P21) (2007). Student-centered learning is a valued approach in science classrooms, where it is believed to make science learning more authentic and motivating to students (Bransford et al., 2000; Land, Hannafin, & Oliver, 2012; NSTA, 2012; Sawyer, 2006; Treagust, 2007).

Despite the ubiquity of blended learning and the support for student-centered learning, research has indicated implementing student-centered instruction is challenging (Oliver & Stallings, 2014; Pedersen & Liu, 2003). In addition, researchers have noted the lack of professional development opportunities for pre-service and in-service teachers (Archambault & Kennedy, 2014; Dawley, Rice, & Hinck, 2010) and school leaders (McLeod & Richardson, 2018) to develop the necessary design and facilitation skills in the blended learning environment. Against this backdrop of high expectations for authentic learning, rapid technological change, and insufficient opportunity for professional development, it is useful to examine current practice in designing student-centered blended learning environments.

This case study was undertaken to examine a blended learning environment situated within an award-winning, high-performing, resource-rich suburban school district in the state of Georgia in the United States. One year prior to conducting this study, in my role as a pre-service teacher educator, I toured an elementary school and a middle school in the district to observe the blended learning model in action. During the visit, I noticed repeated use of the term "student-centered" by teachers and administrators to describe the district's blended learning model. As I observed the environment in action, however, I also noticed teacher-centered practices at play. I suspected the term "student-centered" was being misapplied or exaggerated in some instances. In their examination of a similar blended learning environment, Selwyn, Nemorin, Bulfin, and Johnson (2017) concluded, "Far from being a source of substantially different practices, the one-to-one presence of personal digital devices seemed largely to support the reinforcement of established ways of 'doing' school" (p. 306). Land et al. (2012) warned that such mischaracterizations are common, as they increase the risk that students will not experience the purported benefits of student-centered learning. I realized that there was a need to explore the extent of this blended learning environment's design as a student-centered learning environment. The findings of such a study could provide important design insights to both the participating school district and to practitioners and researchers in K-12 blended learning.

To address this need, I used Land et al.'s (2012) student-centered learning environment (SCLE) framework to explore the design assumptions and components of the blended learning environment using a single case study design (Merriam, 2009). The case study's unit of analysis was the blended learning environment situated within a seventh grade life science classroom during a month-long unit of instruction introducing cells. Multiple forms of data were collected, including classroom observations, semi-structured interviews, and school and district documents. This case study contributes to understanding how the blended science classroom may be designed as a student-centered learning environment, with implications for practice, policy, and research.

REVIEW OF RELEVANT LITERATURE

Tensions between teacher-centered and student-centered pedagogies have been at play in schools in the United States for more than a century (Cuban, 1990). Cognitivist research has supported the efficacy of a more traditional, teacher-centered mode of fully guided direct instruction, particularly in well-structured domains of learning (Kirschner, Sweller, & Clark, 2006). Jonassen (2009) responded that (a) Kirschner et al.'s (2006) architecture of cognition has been limited in its explication of learning as change in memory and that (b) other respected research traditions have suggested learning is impacted by additional factors, including biochemistry, social conditions, the environment, the age of students, and the activities students engage in. The knowledge necessary for successful authentic learning draws on the ability of students to function in ill-structured domains, where "prespecifiability of the conditions for knowledge use is not possible" (Spiro & DeSchryver, 2009, p. 107). Student-centered pedagogy is characterized by learning embedded in complex, relevant environments; social negotiation; multiple perspectives and modes of representation; ceding ownership of learning to students; and student metacognition (Bransford et al., 2000; Driscoll, 2005; Land et al., 2012). Learning is an active process of making meaning in authentic contexts (Brown, Collins, & Duguid, 1989; Jonassen, 1999).

Student-centered Pedagogy for Science Education

In the United States, most K-12 students have failed to achieve satisfactory levels in the domain of science (Anderson, 2007; National Science Board, 2014). Researchers and science educators have supported the need for student-centered pedagogy to improve science learning outcomes (Bransford et al., 2000; Land et al., 2012; NSTA, 2012; Sawyer, 2006; Treagust, 2007). Effective science learning environments help students to foster the "deep knowledge that underlies intelligent performance" (Sawyer, 2006, p. 4). Such environments do this by helping students transition from novice to expert performance, draw on prior knowledge and misconceptions, scaffold their learning, express emergent understandings, think about their learning, and move from concrete to abstract understandings through use of visual representations (Bransford et al., 2000; Sawyer, 2006). Despite the support within the science community for student-centered learning, research has suggested that K-12 schools continue to implement a predominantly teacher-centered, instructivist pedagogy (An & Reigeluth, 2012; Ertmer & Ottenbreit-Leftwich, 2010; Palak & Walls, 2009; Wang, Hsu, Reeves, & Coster, 2014). Indeed, student-centered learning has often remained on the "periphery of practice" (Greener, 2015, p. 1).

Learning Environments

The *learning environment* includes both the visible and the invisible: the people, the technology, the physical classroom and layout, the objects within the classroom, the books, the notes, the websites, the software, the school building, and "the social and cultural environment" (Sawyer, 2006, p. 10). The design of the learning environment directly impacts the enactment of pedagogy (Fraser, 2007; Land et al., 2012; Sawyer, 2014). The beliefs and experiences of teachers and students influence the ways in which they interact with, and position themselves within, the learning environment (Ertmer & Ottenbreit-Leftwich, 2010; Pedersen & Liu, 2003).

The changes brought about by technology-enhanced learning in K-12 schools have resulted in evolved roles for teachers and designers of instruction. In the past, the teacher was viewed as the primary designer of instruction. Today, the expanded toolset afforded by blended learning adds new roles for designers and educators to influence the design of the learning environment. Keeler (2015) noted the various design-related roles in fully online schools may employ single "teacher[s]-as designers" (p. 23) who are responsible for design and instruction; or they may employ teams of professionals, including "curriculum specialist, instructional designer, visual designer, web programmer, and teacher" (p. 23). Software programs used in blended learning can guide, teach, and scaffold learners, thereby shifting the classroom teacher to a facilitator role. When learning environments are designed at the system (e.g., school district) level, as in the current study, more organizational actors are involved. In the current case study, teachers, instructional technology specialists, school librarians, and school and district leaders influenced the design of the classroom learning environment.

Blended learning environments

Blended learning has rapidly increased as a practice in the face-to-face instructional space (Watson & Murin, 2014), and we are still in an early phase of its evolution (Powell, Rabbitt, & Kennedy, 2014). Blended learning is seen as a way to make K-12 education more affordable, flexible, and accessible (Horn & Staker, 2015). Despite the popularity of blended learning, Watson and Murin (2014) noted that little is known about the nature of district-based blended learning programs. In their review of blended learning research from K-12 through postsecondary educational levels, Halverson, Graham, Spring, and Drysdale (2012) found the amount of research completed on K-12 blended learning's nature or effects from 2000 to 2011 represented less than two percent of research studies.

The question of what teachers and instructional leaders should know and be able to do in the blended learning environment is an important foundation to a case study about the design of student-centered blended learning environments. Archambault and Kennedy (2014) outlined the essential competencies of teachers in blended learning environments: they

> …must be able to (a) convey knowledge with limited face-to-face contact, (b) design and develop course content in a technology-based environment, (c) deliver content in a way that will engage students, and (d) use assessment measures to assure that students master content. (p. 226)

Teachers' pre-service and in-service professional development on how to design and teach in this space has not kept pace with the evolution of blended learning in schools (Archambault & Kennedy, 2014; Dawley, Rice, & Hinck, 2010). Parallel to this trend, school-based administrators—who as instructional leaders in schools are expected to model best practice (Horing & Loeb, 2010)—have not been systematically prepared to lead instruction in blended settings (McLeod & Richardson, 2018). Therefore, while it can be assumed that teachers and instructional leaders have been taught to create traditional lesson plans, it cannot be assumed teachers and instructional leaders know how to design for blended learning.

Technology-enhanced science environments

Student-centered technology-enhanced environments enable the learning of conceptually challenging topics and provide students with experiences using the tools integral to doing science (Kali & Linn, 2003; Linn, 2003; Treagust, 2007). "Pedagogical uses" (McCrory, 2008, p. 195) of technology in the science classroom include scaffolding learning (e.g., doing virtual dissections prior to live dissections); enabling orderly, efficient data collection; and aiding in the understanding of complex phenomena (e.g., the oxygen cycle in a pond) through visualizations or simulations (McCrory, 2008). "Scientific uses" (McCrory, 2008, p. 196) of technology center around instances when technology is considered integral to the science methods that are being taught, such as using pH meters, microscopes, or telescopes to observe and collect data, or using models to learn about advanced mathematical and scientific processes (McCrory, 2008).

Framework: Student-centered Learning Environments

In this case study, I examined a blended seventh grade life science learning environment that was described by its designers as a student-centered learning environment. I used Land et al.'s (2012) SCLE as a conceptual framework. The district had used the guidance of P21's (2007) 4Cs (i.e., critical thinking, communication, collaboration, and creativity) as a model for its conception of student-centeredness. Once the research relationship began, it was agreed that using the SCLE framework would provide in-depth feedback related to the student-centered aspects of the blended learning.

The SCLE framework offers an overarching theory to guide the design of SCLEs "[enabling] students to engage complex, open-ended problems that are aligned authentically with the practices, culture, or processes of a domain" (Land et al., 2012, p. 3). The SCLE framework can be used as a guide to the design of learning environments across a variety of knowledge domains, including science, language arts, history, mathematics, and business. The framework explicates the core philosophical assumptions as well as design components and methods underlying SCLEs (Land et al., 2012) (Figure 1).

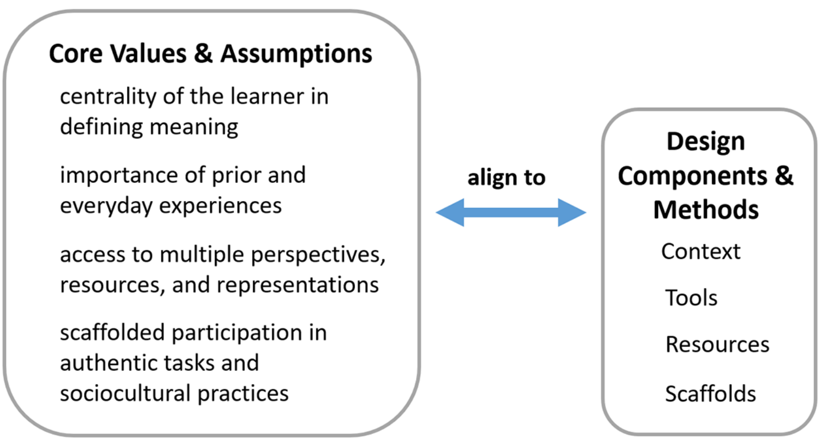


Figure 1. Assumptions and design components of SCLEs (Land et al., 2012, pp. 8-15).

Core assumptions of SCLEs

SCLEs share four common core values or assumptions about learning. *Centrality of the learner in defining their own meaning*: In SCLEs, students take an active role in making meaning as they pursue learning goals. S*caffolded participation in authentic tasks and sociocultural practices*: Student learning is enhanced when it occurs in an environment that allows students to access the people, tools, and thinking of the domain of knowledge (e.g., science, social studies). To help students move from novice towards expert practice, supports are built into the environment. *Importance of prior and everyday experiences*: Through the design of authentic contexts, students' existing beliefs, understandings, and misconceptions can be elicited to improve the likelihood of transfer of learning (Bransford et al., 2000; Land et al., 2012). *Access to multiple perspectives, resources, and representations:* SCLEs offer students various ways of understanding complex concepts, and they may support groups of students in the co-construction of knowledge. SCLEs also offer opportunities to visualize and manipulate phenomena, aiding in making abstract concepts or mental models explicit (Land et al., 2012).

Core design components of SCLEs

In addition to core assumptions, SCLEs share four design components: context, tools, resources, and scaffolds (Land et al., 2012). *Context* refers to the overall task or problem that guides learning and is characterized by activities that ask students to draw from personal or other perspectives to make meaning, pursue goals, or solve problems. Context may be generated by the students, the teacher, or the environment. Technology-based *tools* allow students to construct knowledge by means of the processing, manipulation, or communication of data and information relevant to the problem or task at hand. For example, among processing tools, there are cognitive, information-seeking, collection, organization, integration, and reflection tools. Manipulation tools allow students to make inputs, to see resultant changes, and to visualize complexity. Communication tools support dialogue among students. Mobile computing tools enable such applications as scientific measurement, use of geospatial capabilities, and recording audio and video. Resources comprise static or dynamic source content. Static resources include text and video, and dynamic resources may include socially-constructed content. Finally, *scaffolds* support students working through authentic, open-ended environments, and these may be conceptual, metacognitive (i.e., support for monitoring of learning), procedural (i.e., support for moving through an environment), or strategic (i.e., support for revising strategies for success). Scaffolds support novice students with low levels of expertise, motivation, and knowledge in a domain (Quintana, Shin, Norris, & Soloway, 2006).

Purpose of the Study

The purpose of this case study was to explore and describe the design of a blended learning environment in terms of the design values and assumptions and the design components and methods of the framework of the SCLE. Employing a single case study design (Merriam, 2009), I conducted classroom observations, semi-structured interviews, and document analyses to produce a context description and a thematic analysis. The aim of the case study was to identify ways the blended learning environment could be better designed to enable student-centered learning in the area of science. The findings contribute to broader understandings of how blended science classrooms may be designed to afford student-centered pedagogies.

Research Questions

The research questions guiding the case study were as follows:

1. To what extent are the core values and assumptions of student-centered learning environments supported or limited within the observed blended learning environment?
2. To what extent are the design components of student-centered learning environments (i.e., context, tools, resources, and scaffolds) supported or limited within the observed blended learning environment?

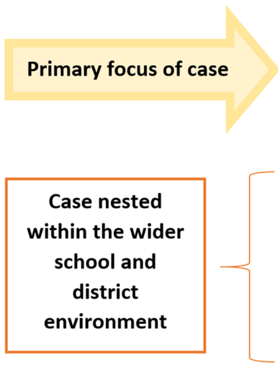
METHOD

The qualitative case study method is appropriate for the exploration and description of a complex social arena such as a learning environment (Fraser, 2007). The case study method calls for the collection and analysis of multiple forms of data in pursuit of understanding the nature of a specific case, or bounded system (Merriam, 2009). In line with the recommendations of Miles, Huberman, and Saldaña (2014), pseudonyms were applied to the district, school, and participants.

Boundaries of the Case

The purpose of this case study was to explore and describe the design of a blended learning environment in terms of the design values and assumptions and the design components and methods of the framework of the SCLE. The case under study was the blended learning environment of a seventh grade life science classroom in a middle school in the state of Georgia during the 2013-2014 school year. The 7th grade classroom was taught by a teacher who is referred to by the pseudonym of “Jane.” Jane had won awards in her school as an exemplary teacher, and she was the chair of the seventh grade science department.

In public K-12 schools in the United States, classrooms and teachers exist in complex ecosystems of rules and resources in their schools and district. Therefore, a detailed examination of a particular classroom or teacher benefits from the inclusion of further contextual layers. To understand the case of Jane's instructional environment, it was also useful to understand perspectives of her co-planning science teachers, school and district leadership, and support staff. Resources common to the team, school, and district were also important to understanding the case of Jane's learning environment (Figure 2).



Level	Features
Classroom	Jane's 7th grade science classroom, a blended learning environment, described by designers as student-centered
Grade-level Hallway	The hallway shared with all 7th grade teachers and the 7th grade counselor
School	The school, with computer labs, the media center, administrators, and support staff such as the instructional technology specialist
District	The school district, with common technological infrastructure, vision, leadership, and district administrators

Figure 2. The boundaries of the case.

Sampling Processes

I used purposeful sampling to gain entry into one of two school districts with the potential to offer an "information-rich [case]" (Patton, 2002, p. 230) of a blended, student-centered learning environment. My first choice, Newton School District (Newton SD), permitted the case study and was the most feasible choice in terms of time and expense. Newton SD was nationally renowned for its model of a student-centered blended learning environment, and it provided extensive information on its website for understanding what district instructional leaders had designed and why.

Using the definition of SCLEs provided in this case study to explain the type of environment I sought, I asked the district chief technology officer to recommend schools or teachers where the districts' vision of student-centered blended learning was evident. Through this snowball sampling approach (Patton, 2002), the chief technology officer connected me with three principals with whom I discussed Land et al.'s (2012) SCLE model. I selected Newton Middle School (Newton MS) based on one principal's selection of Jane as a teacher who used the blended learning environment in a way consistent with the Land et al. (2012) definition of SCLEs. After discussing the study aims with Jane, she agreed to participate.

Sources of Data and Instruments

Observations

Classroom observations revealed the enactment of the learning environment. I observed a total of 30 hours over a four-week period during a unit on the structure and functions of cells. I observed between two to three classes each day. Each class was 55 minutes long. There were between 25 and 32 students present in each observed class. I used observation guidelines (Merriam, 2009) to detail the physical setting, participants, activities, and interactions in relation to the SCLE framework. In addition, I used a classroom computer to observe the digital aspects of the blended learning environment, including the learning management system (LMS), the online textbook with its companion sites, and district-provided, subscription-based resources such as the learning objects repository Safari Montage. The LMS was custom-designed for the district, and teachers were expected to use it as a foundation for all lessons. While I explored the LMS, I wrote notes and sketched pictures to detail its features (i.e., email, discussion forums) and layouts. Forty-four other high-value online tools and resources (e.g., to deliver video content, to offer formative assessments, to create artifacts, to collaborate with peers, to explore scientific phenomena) were noted on district and school websites or in interviews, so I familiarized myself with their features and affordances, too, adding to the hand-written notes. I typed the notes for inclusion in qualitative data analysis. I assumed the stance of observer as participant, which allowed collection of data to address the research questions without interfering in classroom activities (Merriam, 2009).

Interviews

I conducted eight semi-structured interviews with personnel situated at the classroom, school, and district levels. Interviewees included a variety of personnel involved with the design or enactment of Newton SD’s blended learning environment, and their perspectives provided insights into rationales behind the learning environment as well as perspectives on its enactment. Interviewees’ perspectives were integral to understanding the learning environment.

Jane was the classroom teacher in whose classroom observations occurred. Marcos and Shana were two other teachers of seventh grade science with whom Jane co-planned daily. Ricky was the seventh grade guidance counselor, and his office was located on a common hallway. In addition, I interviewed Drew, the Newton MS instructional technology specialist (ITS), who was a certified social studies teacher whose role it was to assist teachers in effectively using the school district's blended learning environment. I also interviewed the school assistant principal, Candace; the school principal, David; and the district superintendent, Rex. I developed a semi-structured interview guide with questions related to (a) SCLE assumptions and design components, and (b) pedagogical and scientific uses of technology. I conducted and recorded phone interviews, each lasting between 30 and 60 minutes. I transcribed the audio recordings and invited participants to provide feedback for revisions through member checking (Merriam, 2009). Table 1 summarizes the participants.

Table 1
List of Interviewees

Name	Role	Years in Role
Jane	7th Grade Science Teacher & Chair	8
Marcos	7th Grade Science Teacher	2
Shana	7th Grade Science Teacher	4
Drew	School Instructional Technology Specialist	8
Ricky	7th Grade Counselor	15
Candace	School Assistant Principal	2
David	School Principal	6
Rex	District Superintendent	5

Documents

Documentary data were collected from Janes' seventh grade life science classroom, Newton Middle School, and Newton School District. Documents were included in the data corpus if they addressed values or beliefs about learning, pedagogy, or instructional technology; school and district visions and goals for students; nature of district infrastructure; or any contextual information about the county, district, or school.

I collected 108 documents from the school building and school and district websites. The scope of collected documents ranged widely and included information about school-based tutoring, scheduling, school library services for students and parents, district codes of conduct, minutes of district- and school-based committees, curricula, and teacher professional development. Documents also offered insights into district strategic planning and vision for student learning, Newton MS's school improvement plan, and grant narratives and rationales for funding the blended learning infrastructure. I collected 17 classroom documents, including the course syllabus, all lecture notes pertaining to the cell unit, lyrics of a song about cells, the science textbook chapters on cells, worksheets, project instructions and rubrics, a test preparation workbook, and enrichment magazines. These "official perspective" documents revealed the organization's driving values (Bogdan & Biklen, 1992, p. 137), and they spoke to the assumptions and design components related to SCLEs.

Data Analysis

The aim of data analysis in case study research is to present a description of the context of the case followed by findings born of an analysis of themes (Merriam, 2009). Thematic analysis is a theoretically flexible method for finding meaning in qualitative data (Braun & Clarke, 2008; Merriam, 2009). I used a theory-driven approach to thematic analysis: the SCLE framework drove the creation of research questions and related instruments as well as the initial codes created in the codebook (Braun & Clarke, 2008). I coded and organized data using NVivo 10, a qualitative software application.

I used a six-phased process of thematic analysis (Braun & Clarke, 2008). Within Phases 1, 2, and 3, I incorporated Saldaña's (2009) guidance for coding methods. Throughout the six-phased process, I maintained an evolving codebook (Braun & Clarke, 2008; Saldaña 2009). During Phase 1, I read through the entire dataset of observation notes, interviews, and documents. I used a combination of provisional and structural coding to make the first codebook entries (Saldaña, 2009). Provisional coding "[began] with a 'start list' of researcher-generated codes" (Saldaña, 2009, p. 118); and structural codes related to a conceptual aspect of a research question. I revisited the Land et al. (2012) framework to create codes tied to the core values, assumptions, and design components of SCLEs. During Phase 2, I worked through the dataset twice more to apply descriptive and values codes (Saldaña, 2009). Descriptive codes described coded extracts based on their contents. Values codes were applied to extracts to reflect the expression of attitudes or beliefs (Saldaña, 2009). Also during Phase 2, I placed some codes subordinate to other codes in parent-child relationships. During Phase 3, I searched for themes. Using pattern coding, I considered ways to arrange parent codes into broad themes (Saldaña, 2009). I wrote the name of each parent code on an index card and arranged codes in groups to create a draft map of themes (Braun & Clarke, 2008). During Phase 4, I returned to NVivo 10 and updated any parent and child relationships that were altered in Phase 3. I also reviewed the coded extracts tied to each theme, checking for coherence. During Phase 5, I defined the essence of each theme by a) exporting the coded data extracts under each theme, and b) writing a narrative account of the theme based on the extracts. During Phase 6, I took the thematic write-ups from Phase 5 and presented them as a combined story of the data (Braun & Clarke, 2008).

CONTEXT

Demographics

In this case study I explored and described the design of a blended learning environment in terms of the design values and assumptions and the design components and methods of the framework of the SCLE. I specifically focused on the blended learning environment observed in a seventh grade life science classroom at Newton MS during the 2013-2014 academic year. Newton MS was situated in an affluent county where median household incomes (in 2012 dollars) were more than one and one-half times the state level (U.S. Census Bureau, 2014). In 2012, 43% of the population over the age of 25 held a bachelor's degree or higher, as compared with the state average of 28% (U.S. Census Bureau, 2014). Seven percent of people in the county were below the poverty level, compared with 17% of people in the state (U.S. Census Bureau, 2014). Newton SD's 40 schools served approximately 40,000 students in grades pre-kindergarten through twelve.

Newton MS was a Title 1 school serving approximately 1,000 students, and 41% of students participated in the Free Lunch or Reduced Lunch programs in 2013 (School Website, 2014). During the 2013-2014 academic year at Newton MS, 63% of students were White, 26% were Hispanic, 5% were Black, 3% were Asian, and 2% were Multiracial (GOSA, 2016). Academically, the students performed well, with 90% of the school's seventh grade students achieving "meet or exceeds" status on the spring 2014 summative science exam (GOSA, 2016).

Blended Learning Environment

Newton MS used a rotation blended learning model. At the teacher's discretion, students in this traditional setting moved among various learning modalities, including small or whole-group instruction; projects; traditional, paper-based activities; and technology-enabled activities (Horn & Staker, 2015). District leadership endorsed a vision of personalized learning enhanced by the careful use of technology in line with P21's 4Cs of communication, collaboration, critical thinking, and creativity—skills deemed integral to students' future success in life and the workplace (P21, 2007).

The blended learning classroom environment included one teacher laptop, four computer workstations, 10 mobile laptops, Wi-Fi, an interactive white board (IWB), speakers, a printer, and a scanner. Students were encouraged to bring personal internet-connecting devices to complement classroom technology, which allowed for a 1:1 device ratio when all students complied. Students were encouraged to share devices with classmates when there was not a 1:1 ratio. A school computer lab with 30 workstations was available on a reservation basis. Newton MS maintained a class set of iPads, laptops, and mobile Wi-Fi units available for check-out for school or home use. Outside of school, more than 50 free Wi-Fi locations were available to district students. Students saved work to individual or shared online storage drives. The class science textbook was accessible online. The district's custom-developed LMS was available through desktop browsers and mobile apps. District subscription software resources were accessible online, including Safari Montage, BrainPOP, NetTrekker, Edublogs, Discovery Streaming, Socrative, VoiceThread, Wikispaces, Geometer's Sketchpad, Adobe Creative Cloud, and Wixie.

Summary of Observations of "Cell Unit" in Jane's Classroom

In observations of Jane's enacted cell unit, students used multiple media to learn about the structure and function of cells. The teacher used a mix of pedagogies, such as teacher-centered approaches that included lecture, note-taking, and closed-answer assessments, as well as more authentic experiences, such as working with microscopes to view cells, constructing a cell analogy using the medium of students' choice, and using technology-enhanced formative assessment to gauge students' knowledge and identify misconceptions.

FINDINGS

To address the research questions, I analyzed data from 30 hours of classroom observations, 108 documents, and eight interviews with Jane and her colleagues in the blended learning environment. I identified two themes related to design assumptions of the observed learning environment (Themes 1-2) and four themes related to the design components observed (Themes 3-6). A seventh contextualizing theme is presented at the end of the section (Theme 7).

RQ1. To what extent are the core values and assumptions of student-centered learning environments supported or limited within the observed blended learning environment?

Theme 1: District and school encourage student-centered learning designs

Numerous documents—from Newton SD webpages to accreditation reports to blog posts and vision statements—encouraged teachers to design instruction that would enable district graduates to define problems, present solutions, and apply understandings to real-world issues. The district science curriculum department called for "inquiry-oriented, student-centered approaches" to instruction. Superintendent Rex cited collaboration and problem-solving as top needs among community businesses. The district website featured examples of problem-oriented, technology-enhanced learning (e.g., students solving problems in virtual worlds).

District professional development (PD) supported student-centered instructional design in the district blended learning environment guided by P21's 4Cs. The district stopped requiring written lesson plans from teachers, which had resulted in teachers' allowing students to decide how they wished to learn a standard. Drew noted the value of this approach:

> We'd love to give [students] that overall standard and then have them go in their own direction so that could lead to different avenues and different findings for the kids when you give them that freedom or flexibility. So, they get to make decisions, they get to maybe go down a path that they wouldn't have ….

Jane, Marcos, and Shana held positive attitudes regarding the potential of the learning environment to facilitate problem-driven instruction: prior to my observations, Jane used the online Genetic Science Learning Center, where students explored life science problem scenarios. The teachers also valued having students use the blended learning toolset to collect data like real scientists. Though Shana noted challenges with assessment of multiple products, the three teachers embraced the process of providing students choices in assessments, which enabled them to take ownership of learning. Candace said this approach was more motivational for students. Jane expanded on the value of allowing students a variety of options for demonstrating learning:

> A kid learns a new way to present something because another child has knowledge that that child did not have…. I'll come up and say, "Here's some ideas that I have that you can present your learning," and then some kid will say, "Can we do this?" or "I've used this before," or "I have this app…." And I've learned some really cool ways that kids can present their knowledge.

Theme 2: Cultural elements support direct instruction

In addition to evidence of SCLE-supportive values and assumptions, there were signs of cultural elements that were more aligned to traditional methods of instruction. Windschitl (1999) noted, "Our personal histories furnish us with mental models of teaching, and these models of how we were taught shape our behavior in powerful ways" (p. 752). The examples that follow demonstrate professionals and parents showing a preference for teacher-centered models of instruction.

During a classroom observation, a support staff member opened the door—and interrupted the class session—to compliment Jane on her quiet and well-behaved class. In a hallway conversation, a seventh grade language arts teacher admonished Jane's lack of disciplinary structure, citing it as the cause for Jane's loud classroom environment. Jane's colleagues were reinforcing the traditional instructivist paradigm of learning, where authority rests with the teacher.

Another example of the culture of teacher-centered practice related to motivating students to perform. During observations, Jane used extrinsic rewards such as candy, cookies, hand-clapping, and shout-outs to recognize students for naming organelles, answering class warm-up questions correctly, or scoring high on a quiz. She provided free time for student and parent participation at a Newton MS open house event. While these practices appeared to motivate students to perform well, they are typical of teacher-centered classrooms where learners are rewarded for compliance to external authorities (Land et al., 2012). SCLEs, in contrast, are designed to encourage learners to "evolve greater responsibility for their own learning" (Land et al., 2012, p. 9).

In another instance of the preference for a traditional model of instruction, Principal David said parents balked at a problem-oriented approach to math in which students were asked to explain why one of two math solutions was correct. David said:

> So the students had to have enough of an understanding to be able to reflect on their own knowledge of the inequality and how to figure it out… And the parents were like, "That's so hard," and we're like, "You know what? That's error analysis. That's what we want our kids to be able to do." It made those kids reflect on their own learning, but that's because that teacher went out for that on that test. If we don't shoot for that, it's not going to happen.

While Candace wanted to see students taking ownership and solving problems using Newton MS's blended learning environment, similar to a postsecondary model with some learning time spent at home, she acknowledged the school's limitations: "We just can't have 1,100 students running around at their own pace right now with the manpower we have as far as teachers go."

With high-stakes exams taking place during the ninth month of a 10-month school year, and with 50-minute class periods, Jane, Marcos, and Shana noted the pressures of teaching a high volume of content expressed in the seventh grade science curriculum standards. Most of the standards took the form of declarative knowledge (i.e., what something is) or structural knowledge (i.e., how concepts fit together) (Howland, Jonassen, & Marra, 2012), which Jane said was more efficiently taught through traditional means without use of the blended learning infrastructure.

Though Newton MS was in its fifth year of using the blended learning environment, and teachers were encouraged to use it, it was not required that teachers use technology. David observed that teachers' inconsistent use of technology caused parental complaints. In addition, teachers faced parents who were not able to use the technology to access grades and teacher notifications. While David and Candace encouraged teachers' use of instructional technology, they did not require it. The administrators were satisfied with non-technology-using teachers so long as they were pedagogically-qualified.

School counselor Ricky expressed concern for the access to technologies afforded by the blended learning infrastructure and the responsible use policy that allowed students to bring their own devices to school for learning: "These kids, they really can't handle the responsibility to be able to access pretty much the whole world [using technology], so it's really dangerous." Ricky cited increased problems with students bullying one another online, sending sexually-charged texts to one another, and feeling inadequate if their personal devices were inferior to their peers' devices. He acknowledged some teachers were effective in their use of the blended learning environment but that other teachers were not monitoring students appropriately during blended instruction. Ricky supported a return to teaching in a more traditional way because he felt it was safer for students' emotional development.

Summary of themes related to SCLE values and assumptions

Of the four SCLE values and assumptions, *Centrality of the learner in defining their own meaning* was expressed by district leadership, by Newton teachers, and by Newton MS principals. The primary example of this value was in the practice of having students choose how they would be assessed on summative projects, a view supported by all levels of interviewee, by district documentation, and classroom observation. The SCLE value of *Scaffolded participation in authentic tasks and sociocultural practices* was implied in district documentation but not evident in other collected forms of data. The SCLE value of *Importance of prior and everyday experiences* was implied in high-level district documentation and evident in Jane's eliciting of student perspectives during class observations. Finally, *Access to multiple perspectives, resources, and representations* was expressed in the district's provision of a robust blended learning infrastructure with online textbooks, subscription-based content, open educational resources, Wi-Fi, and hardware. Figure 3 illustrates this summary.

SCLE Values and Assumptions	How Evident in Environment
Centrality of the learner in defining their own meaning	Evident in interviews with all participants and by some district documentation.
Scaffolded participation in authentic tasks and sociocultural practices	Evident in some documentation but not detected in observations or interviews.
Importance of prior and everyday experiences	Evident to a moderate extent in district documents and class observations.
Access to multiple perspectives, resources, and representations	Evident to a large extent in terms of the district's provision of digital content technologies to enable this value.

Figure 3. SCLE values and assumptions evident in the blended learning environment.

RQ2. To what extent are the design components of student-centered learning environments (i.e., context, tools, resources, and scaffolds) supported or limited within the observed blended learning environment?

Theme 3. Teacher-designers rarely design with the problem-oriented contexts characteristic of SCLEs

In the SCLE framework, context refers to the "overall problems or tasks that guide and orient students to learning," and they range "…from contexts that specify problems and outcomes, but allow for individual exploration to externally-generated problems to contexts that are uniquely defined" (Land et al., 2012, p. 14). For example, a lesson or unit that challenges students with the problem of designing a habitat where both humans and diverse animal species flourish would be an example of a context consistent with SCLEs. The context design component should include a problem-oriented design drawn from the domain of science and, if feasible, students' personal experiences (Land et al., 2012).

During observations in Jane's classroom, I saw no examples of the problem-oriented SCLE concept of context. Most class time was spent helping students to memorize information about animal and plant cells, organelles, cellular photosynthesis and respiration, cell membrane transport, cellular functions, mitosis, and meiosis through the methods of lecture, note-taking, quizzes, tests, daily warm ups, videos, songs, flashcards, and games. The blended learning technology was used every day, but not in a problem-oriented way consistent with the design of SCLEs. Jane's interview revealed that students struggled with open-ended, problem-oriented approaches.

Beyond the observations within Jane's classroom and her interview, examples of the support of problem-oriented contexts conducive to SCLEs were evident. Rex said businesses in the district explicitly requested more problem-based learning to prepare students for the workforce. He endorsed a learning culture that allowed students to fail and then succeed in pursuit of learning problems. Several district documents supported problem-oriented learning as integral to learning. Drew acknowledged the ongoing challenge of developing teachers to use problem-oriented approaches: "It's going to take time to get there. It's not easy. I know…it's…hard to give up that control. You like everything kind of in a line and linear."

In interviews, several participants indicated that the blended learning environment allowed all students to experience problem-based learning in two ways. The first way arose when students faced the problem of deciding how to show their knowledge. Candace illustrated this when she said, "[Teachers] give a very open assignment, and it's up to the student to display what they know in any capacity that they possibly can." The second way was when students were faced with the technical problems that arose daily with technology use (i.e., connectivity and hardware glitches). While technically correct that both of these examples allowed students to grapple with problems, these chance instances of "problems while learning" did not align with the SCLE conception of context because they did not advance students' knowledge and skills through problems authentically situated in the domain of life science.

Theme 4: The blended learning environment provides access to most SCLE tool types

SCLE tools "offer technology-based support for representing, organizing, manipulating, or constructing understanding" (Land et al., 2012, p. 14). All 10 tool categories outlined by Land et al. (2012) were evident in the blended learning environment. Six participants agreed there were plenty of devices for students at Newton MS. David said, "There's not a want for our teachers; they just have to sign up for it and plan accordingly."

Processing Tools

The blended learning environment provided a high level of access to tools used to support processing functions. There were tools to allow three-dimensional construction of models; to collect data such as photos, audio, visual and textual notes and geo-tag the locations of collected data; to input data, to graph, and to analyze; to allow groups of students to self-poll and see patterns of collective thinking; to conduct database searches; to store, upload and share files; to collaboratively author files; to synthesize and re-organize knowledge; to journal or blog; to make reflective podcasts; and to collaboratively make notes.

All interviewees noted information-seeking and collecting as primary activities afforded by the blended infrastructure, and students did this on several occasions during observations. Information-seeking was the act of looking up information through Google or NetTrekker, and collecting was the act of copying or downloading text-based or graphical information and saving in folders or documents. Tools for integrating and producing were also common, and I observed this when students created final artifacts for the cell unit.

Candace cautioned that students' information evaluation skills were not keeping pace with the technology changes in the classroom, and teachers were unable to effectively address this skill:

> Our students… think Google is the answer to everything. They're not checking and validating sources and verifying where information is coming from. I think we're so bogged down with the curriculum that we have to teach…that [information evaluation] is a separate piece altogether that I don't know that our teachers are equipped for.

Manipulation and visualization tools

Through the online textbook, its companion materials, and open educational resources (OER), manipulation and visualization tools were present though seldom used. Jane gave two examples of using such tools in her teaching, though no examples were apparent during the one-month cell unit. Prior to classroom observations, she had led students through a heredity activity using a manipulative simulation, and later in the school year, she intended to use another simulation so students could practice online frog dissections preceding real ones. Though the district subscribed to the tool Gizmos—and within it there were four interactive simulations related to cells—Jane said it required too much teacher assistance.

Communication tools

The district LMS supported communication among classroom learning communities, across schools, and between parents and teachers through email and discussion boards. District websites were used to communicate exemplary, technology-enhanced, summative student artifacts. Numerous Web 2.0 tools supported communication. During observations, communication was occasionally technology-mediated, such as when students would input feedback into a formative assessment tool that was released to the whole group or when students created their cell analogy project using a variety of media. Limited use was made of the LMS's email or discussion capabilities.

Mobile computing tools

Mobile apps allow teachers to take students outside of the classroom to observe natural phenomena. Land et al. (2012) noted that, "Mobile apps and handheld tools…enable GPS capability, scientific measurement, audio and video capture, as well as augmented reality of GPS-tagged locations" (p. 15). Access to mobile tools was available through school-owned iPads, mobile laptops, and BYOD devices. Additionally, Internet was provided inside Newton MS through Wi-Fi and outside the school through mobile Wi-Fi hotspot units available for check-out. Many mobile apps used at Newton MS had parallel software or browser-based desktop versions (i.e., Socrative, Quizlet, and the LMS). Through analysis, I found that aside from the occasional QR code-based scavenger hunt—where students used mobile devices to "hunt" for information on teacher-selected websites—the mobile aspects of the blended learning environment were rarely used to support scientific work, such as data collection, analysis, or reflection.

Theme 5: Static resources created by vetted sources are valued

According to the SCLE framework, static resources include such forms as text and video (Land et al., 2012). The district's provision of static resources was extensive, as the district subscribed to numerous content providers. In some instances, the creation of student-created static resources occurred. For example, Marcos allowed students to create vocabulary games for class use, and the cell vocabulary electronic flashcards created in Jane's class were a shareable static resource. Candace supported electronically-mediated static resources over print and noted, "Textbooks are outdated the second they come off the presses. Forget it. Let's do away with it." Jane saw the power of using static resources: "There are some amazing things out there that can teach things way better than I can."

Dynamically-evolving resources include socially-constructed sources such as wikis and blogs (Land et al., 2012). Philosophically, the district supports the idea of student-created dynamic resources, as evidenced by a district leader's blog post. However, no instances of student-created dynamic resources were detected through observation, interview, or other sources.

The SCLE ideal of the dynamic, student-created resource conflicted with the valued practice of vetting resources. David explained, "As the students get older, they're told to steer clear of that because you don't know that it's accurate… I don't know how much we would push sharing information resources between students because it may not be 100% reliable." Shana said, "In seventh grade, I don't see them doing the level of work where they are taking their work that they've made… and then posting it somewhere to share with others as a resource." She felt that with maturity of the current LMS, the potential for curating student work could increase.

Theme 6: The technology infrastructure can support use of SCLE-appropriate scaffolds

According to Land et al. (2012), "Scaffolds are support mechanisms designed to aid an individual's efforts to understand" and to "productively engage the complexity, authenticity, and open-endedness of the environment" (p. 15). There were many possibilities within the observed learning environment for using scaffolding, whether through digital technology or more traditional means, such as teacher-directed prompts delivered verbally or via handouts. The LMS could have been used to scaffold work, as could have the district wiki system. Science students maintained a notebook containing supportive lecture notes, worksheets, assessments, lab notes, and other activity-related artifacts.

Within the observed environment, scaffolding was teacher-directed in a one-to-one or a one-to-many modality, often with the aid of technology. Use of scaffolding appeared unplanned and dependent upon dynamically evolving learning needs. Major instances of scaffolding noted in observations and interviews included learning vocabulary using Google search (conceptual); monitoring one's learning using a polling tool (metacognitive); gauging and planning one's learning progress using LMS-posted resources (metacognitive); navigating the LMS (procedural); navigating the online textbook (procedural); dissecting a frog (strategic); and asking questions, finding answers, and making sense of answers (strategic). David and Candace acknowledged scaffolding as an area of opportunity in the blended learning environment.

Summary of themes related to SCLE design components and methods

There was little evidence of using the blended learning environment to design instruction using student-centered *context,* or instructional events situated in real-world or student-directed learning problems. Rather, the nature of instructional problems was more teacher- and content-centered with a focus on learning and memorizing information about cells, as guided by external curriculum guidelines. Looking at *tools* within the environment, all varieties of SCLE tools noted by Land et al. (2012) were available in the blended learning environment. The most frequently used tool type was information-seeking when students conducted just-in-time searches for information. Communication tools were also used regularly, such as when students emailed project submission files to Jane, or Jane posted announcements in the LMS. Little used for their potential in the scientific classroom were interactive manipulation tools, mobile tools, and other processing tools of critical thinking. The district provided access to resources, both static and dynamic, with static tools like video and text being used extensively. The use of dynamic, collaboratively-created resources was supported by the infrastructure but was resisted in practice due to educators' perception that student-created resources were not authoritative. The observed blended learning environment contained numerous ways for providing scaffolds that supported student-centered learning. See Figure 4 for a visual overview of this summary.

SCLE Design Components and Methods	How Evident in Environment
Context Problem-oriented, and drawn from students' interests or needs	SCLE contexts not observed.
Tools Processing, Manipulation, Communication, or Mobile	Strong provision of tools with highest use among information-seeking and communication tools. Manipulation and mobile tools little used.
Resources Static or Dynamic	Strong provision and use of static resources. Strong provision but limited use and support of dynamic resources.
Scaffolds Conceptual, Metacognitive, Procedural, Strategic	All types of scaffolds present in environment. Usually unplanned, teacher-directed and technology-enabled.

Figure 4. SCLE design components and methods evident in the blended learning environment.

Contextualizing Theme

I identified an additional theme relevant to the final discussion of designing blended student-centered learning environments.

Theme 7: Teachers lack time to understand and embrace the complex blended

learning environment

Through the district technology infrastructure, teachers and students could access many tools, but time constraints prevented thorough exploration. Jane said, "I've got to be better on having the time to sit down and rummage through all that Safari [Montage] has to offer." The teachers were not aware of the option of checking out mobile Wi-Fi hotspot units for porting the Internet outside the classroom. While mobile learning was compelling to Shana, short class periods and time-intensive setup made mobile scientific work unattractive. Further, interviewees noted a frequent loss of time to issues related to inappropriate use of technology, login problems, uncharged devices, unreliable Internet, cross-platform incompatibilities, and students' inability to type. Jane said, "Sometimes you put all this effort into it, and you have so many hiccups that come along with it, that it kind of defeats the purpose." Shana and Marcos said that blended teaching takes longer to implement. Marcos said, "It's just like what normally you could do in a day… sometimes with [blended learning]... it takes two days, three days."

DISCUSSION

In this case study, I used the SCLE framework to explore a blended learning environment described by its designers as student-centered. The findings showed that the blended learning environment described in the case study *could* be used to create a student-centered learning environment. The SCLE design components of tools, resources, and scaffolds were present in the observed blended environment, though the SCLE design component of context was not. The findings also showed that while the blended learning environment was technically capable of being designed as an SCLE, and while all participants demonstrated support of the tenets of student-centered learning, the enacted environment reflected Jane's prioritization of teaching her students the seventh grade life science curriculum at a declarative and procedural knowledge level utilizing a primarily teacher-centered approach. The findings suggested that participants recognized the benefits of designing student-centered learning, but other learning goals took priority in a work context low on time to plan instruction, explore learning designs, and schedule resources.

In this discussion, I identified some of the key issues related to designing SCLEs using blended learning environments similar to the one at Newton SD. This discussion is premised on the idea that technology is integral to scientific practice (McCrory, 2008) and student-centered instruction (Ertmer & Ottenbreit-Leftwich, 2010). Additionally, this discussion assumes that SCLEs can be designed in classes where teacher-centered learning environments are also used. Specifically, Jane could use the blended learning environment to deliver both teacher-centered practices as well as to immerse students in an SCLE-designed space (Cronje, 2006). Finally, this discussion has been written with the systems-view assumption that a shift to student-centered learning designs can be sustained if the larger educational system (e.g., school, district) embraces the goal (Levin & Schrum, 2013; Newmann, Smith, Allensworth, & Bryk, 2001). However, in the absence of school and district supports, lone teacher-designers could still benefit from the discussion that follows.

Newton SD valued student-centered learning. Visionary district technology administrators expounded at length through district documents, blog posts, open house presentations, and professional development plans about their support of student-centered learning. But observations and interviews revealed that the design of instruction was more teacher-centered: specifically, neither Jane, Shana, nor Marcos indicated a significant use of problem-oriented, student-centered contexts. Jane's predominantly teacher-centered instructional design processes achieved the outcomes the district desired: strong student performance on state exams at the end of the school year. Jane's design consisted of presenting a body of facts and processes related to cells and eliciting students' successful memorization and explanation of those facts. School administrators David and Candace would have been satisfied with no use of technology as long as students were performing well on benchmarks and standardized tests. While there were some student-centered qualities evident in Jane's design and approach, and while district educators valued student-centered learning (Theme 1), the district was not expressing a compelling enough argument to shift Jane's practice so fundamentally as to design student-centered experiences within the blended learning environment. When adding the design of student-centered learning environments, developing and sustaining a compelling rationale for the innovation is key.

Jane, Shana, and Marcos expressed the feeling of not having enough instructional time to teach the seventh grade science standards effectively. They noted their lack of time to sufficiently explore the robust blended learning environment provided by Newton SD. Jane perceived that technology-enhanced instructional activities took time away from the priority of teaching the content. In order to make designing SCLEs in the blended learning environment appealing to teachers, it is important to make effective use of time, capitalizing on moments when the teachers are already together (e.g., planning time) and providing clear examples of SCLE designs and accompanying facilitation plans so that teachers do not need to build from the ground up. In a large school district like Newton SD, instructional technology specialists at each school could facilitate content-area-specific teams of teachers to create such resources and lead their use among peer teachers.

Through the creation of design teams, a school district could leverage the talents of diverse designers to experiment and refine design ideas, as well as slowly build a repository of resources by grade level and content area. The LMS could house plans, designs, and implementations, allowing other teachers to browse and explore SCLE designs.

While static resources were a prominent feature of the blended learning environment, dynamic resources (i.e., those co-created by students) were less common. Interviewees disapproved of dynamic resources due to the perception they could expose learners to erroneous content. Few interviewees seemed to recognize the potential benefits of a co-constructed knowledge-building space. Indeed, the social construction of knowledge is integral practice in the use of SCLEs (Land et al., 2012). SCLE proponents and designers should consider ways to anticipate and overcome this distrust of non-authoritative, student-built resources. The school or district librarian may be a useful collaborator in this area.

Another way in which the school librarian could support an SCLE initiative is through the provision of guidance on information seeking and evaluation (Themes 4 & 7). On a daily basis during the observed cell unit, students conducted superficial Google searches with limited search strategies.

Newton SD's instructional leaders chose the P21 4Cs model to guide student-centered instruction, and teachers seemed to demonstrate a naïve understanding of the model. The common misconception that teachers were providing problem-based learning by virtue of students' inevitable struggles with technology issues was an example of how the theory behind the design of the student-centered blended learning environment was getting lost somewhere between the district level and the classroom. The study highlighted the challenge of conveying complex models or theories of learning. Designers of SCLEs should allow teachers to experience the chosen student-centered framework directly (Krajcik & Blumenfeld, 2006) within a community of teachers (Cochran-Smith & Lytle, 1999).

In this case study, the SCLE design component of context was absent from Jane's lessons and from interviews and documentary sources (Theme 3). Contexts authentically orient students' learning experience. In project-based learning, Krajcik and Blumenfeld (2006) advocated establishing context through an anchoring experience, which could be a story touching on key points in the unit of instruction. An anchoring experience can lead to driving questions that guide instruction. If teacher-designers can frame learning in ways connected to students' lives, or use a compelling problem-orientation, then the environment's robust tools, resources, and options for scaffolding will likely follow to support student-centered learning.

To design and enact student-centered learning, pre-service and in-service

PD should focus on teaching pedagogies for solving open-ended problems using the tools and processes of science. PD should address the framing or anchoring of instruction within interesting, relatable contexts or problems (Krajcik & Blumenfeld, 2006); the strengths and challenges of teacher-centered and student-centered pedagogical models (Ertmer & Ottenbreit-Leftwich, 2010); the design of scaffolding to support all students' explorations (Pedersen & Liu, 2003; Rose, 2014); and the design of meaningful assessments. PD should emphasize exploration of the effects of teacher beliefs on design and enactment of instruction. In addition, PD should align to the National Standards for Quality Online Teaching (iNACOL, 2011) or a similarly robust framework to ensure candidates are proficient in working in the online environment (Archambault, DeBruler, & Freidhoff, 2014).

This technology-rich district neither required teachers to use instructional technology nor to write lesson plans. Both of these policies pointed to an admirable level of respect for teachers as professional educators. However, making use of learning technologies optional runs counter to research that suggests technology is needed to aid in effective, student-centered instruction (Ertmer & Ottenbreit-Leftwich, 2010). While technology may not be necessary to implement constructivist approaches, technology is integral to scientific practice today (McCrory, 2008). Therefore, to make science learning authentic, it is necessary to design technology-enabled learning environments that scaffold learners as they progress through learning. The second policy of no longer requiring lesson plans pointed to a willingness by the district to grant students input into their own learning paths, which supported one of core values of SCLEs, "the centrality of the learner in defining their own meaning" (Land et al., 2012, p. 8). However, it may have also pointed to an overabundance of pedagogical options available to teachers in the district. The noise coming from too many options may have been detrimental to the kind of unified focus often beneficial to successful technology-enabled initiatives (Levin & Schrum, 2013).

Limitations

An important limitation of this study was the lack of surveying of participants about their beliefs and professional development experiences. Because beliefs and experiences are integral to teaching practice, adding these dimensions to the study could have improved clarity of findings. In addition, extending classroom observations to include all three science teachers on the team would have allowed for a more well-rounded view of the design of the blended learning environments used by the seventh grade science team. The qualitative case study method is limited in terms of the extent to which its findings may be generalized to a larger population, although Merriam (2009) would describe this limitation as a strength: through the detailed description of the case, readers can draw meaningful insights that they can then apply to their unique situations. To ensure trustworthiness of the data, I enacted several measures, including in-depth examination of my subjectivities, maintenance of an audit trail, member checking, and multiple methods of data collection to triangulate findings and analytic insights.

Future Research

Future research is needed to study K-12 middle school and secondary science blended learning environments designed as student-centered learning environments. Practitioners need more case study examples to delineate the variety of ways in which blended science environments may be implemented as SCLEs. Further, given that K-12 instruction is often found to be predominantly teacher-centered, research methods should account for the reality that learning within K-12 learning environments will likely be a mix of teacher-centered and student-centered approaches. Incorporating the four quadrant model proposed by Cronje (2006) and furthered by Elander and Cronje (2016) would allow for research approaches that acknowledge the possibility for both teacher-centered and student-centered approaches. In addition, better understanding how (i.e., design process) and by whom (i.e., design team) blended SCLEs are designed would help pre-service and in-service professional developers to determine appropriate learning interventions. Research focusing on both design and facilitation of blended SCLEs would provide a more holistic picture of their potential for enacting powerful science learning. Long-term, stakeholder-oriented, design-based research approaches could support such research aims (McKenney & Reeves, 2012). Research into the impact of blended SCLEs on outcomes of interest (i.e., knowledge, self-efficacy, motivation, interest in science occupations, undergraduate major, postsecondary employment role) would contribute to broader questions of their value. Researchers can offer their expertise in using methodologies of needs assessment and program evaluation to help schools explore needs and the success of instructional programs using SCLEs. Results of such investigations, in addition to the current case study, will inform the conversations on how to effect student-centered, authentic, self-directed science learning in blended learning environments.

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