PERSONALIZED INTEGRATED EDUCATIONAL SYSTEMS (PIES) FOR THE LEARNER-CENTERED INFORMATION-AGE PARADIGM OF EDUCATION: A STUDY TO IMPROVE THE DESIGN OF THE FUNCTIONS AND FEATURES OF PIES

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I dedicate my dissertation to my parents, Pradeep and Anjana Dutta, for their ambition and vision; to my little brother, Siddhartha Dutta, whom I love to tease and promise to continue to do so; and finally, to my husband, Dr. Jacob Enfield, for his support, love, and companionship.

Tho' much is taken, much abides; and tho'
We are not now that strength which in old days
Moved earth and heaven, that which we are, we are,—
One equal temper of heroic hearts,
Made weak by time and fate, but strong in will
To strive, to seek, to find, and not to yield.

Lord Alfred Tennyson, Ulysses, (1842)

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Pratima Dutta

Personalized Integrated Educational Systems (PIES) for the Learner-Centered Information-Age Paradigm of Education: A study to improve the design of the functions and features of PIES

The Personalized Integrated Educational System (PIES) design theory is a design recommendation regarding the function and features of Learning Managements Systems (LMS) that can support the information-age learner-centered paradigm of education. The purpose of this study was to improve the proposed functions and features of the PIES design theory such that it is compatible with the technological needs of the information-age, learner-centered paradigm of education. Four schools or educational systems that embodied all or some of the characteristics of the learner-centered, information-age paradigm were selected through a purposeful, theoretical sampling process. They were selected based on how useful they would be in extending and improving the design recommendations for PIES and the extent to which the naturalistic cases had transitioned into the learner-centered, information-age paradigm of education. Research participants within these schools were chosen through a non-probability sampling method. Twenty teachers agreed to participate and were interviewed and observed. Data collected in the form of interview transcripts and observation notes were analyzed to reveal functions and features that could be added and removed from the PIES design theory. Data were analyzed to also reveal factors that encouraged/discouraged technology use, implementation, and policy.

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Chapter 1: Introduction

Toffler (1980) identified three paradigm shifts or systemic changes that our society experienced. Our society transformed from the agrarian age (the first wave) to the industrial age (the second wave) and from the industrial age to the information age, namely the *third wave*.

Paradigm Shift in Education

During the agrarian age — the first wave of paradigm shift — every aspect of life was guided by the paradigm of self-sufficiency. People lived in small communities, grew their own food, and travelled using horse-drawn carriages. The education of one's ward was the responsibility of the parent, the town priest, and/or the one-room schoolhouse.

With the advent of the industrial age, society underwent another systemic change (Kemp et al., 2006; Reich, 1991; Reigeluth, 1994; Toffler, 1980). "The dawn of the industrial age brought with it massive changes in all of society's systems, including family, business, and education" (Reigeluth, 1994, p. 4). Every aspect of an individual's life transformed due to the influence of this new paradigm. People moved to bigger cities, and food and basic necessities were produced at larger scales. With the invention of the steam engine and trains, goods and products produced in larger quantities were now shipped to areas far and wide. No longer did people depend on each other and their small, close-knit communities for their daily sustenance. With the emergence of large factories and industries, the need for people, who could work these machines, grew. It was then that an education system was created that catered to the needs of the industrial age. Students were introduced to a formalized and a standardized curriculum, where education

was based on what the society needed and not on the needs of individual students and their capabilities. Schools were used as sorting grounds for selecting students who functioned well under the prevailing constraints. Education was not imparted for the growth of knowledge in the individual; rather it was done to sort individuals who could function as effective and productive citizens of the industrial age. According to Senge and colleagues (2000)"[t]he result of this machine-age thinking was a model of school separate from daily life, governed in an authoritarian manner, oriented above all else to producing a standardized product, the labor input needed for the rapidly growing industrial workplace—and as dependent on maintaining control" (p. 31).

Our society is currently experiencing the third wave of paradigm shift, namely the information age (Toffler, 1980), also known as the digital age, the conceptual age, the space age, and the knowledge age. Much has been said about the change in our society due to the advent of the third wave characterized by the ubiquitous spread of digital technology (Kemp, et al., 2006; Reich, 1991; Reigeluth, 1994; Toffler, 1980). Due to this paradigm shift our needs as a society have systemically changed. The skills that our citizens need to successfully function in this new age have experienced a paradigm shift. Unfortunately, our education system, which was historically created to address the needs of our industrial-age society, remains grounded in the paradigm of the industrial age.

A New Paradigm of Education

Our education system continues to train our future citizens to function in the industrial-age paradigm. Many scholars (Kemp, et al., 2006; Reigeluth, 1994, 1997, 2003; Reigeluth & Beatty, 2003; Reigeluth & Garfinkle, 1994; Reigeluth et al., 2008; S.

L. Watson & Reigeluth, 2008; W.R. Watson, S. Lee, & C.M. Reigeluth, 2007; W. R. Watson & Watson, 2007) have stressed the need for our education systems to also undergo a paradigm shift or a systemic change in order to prepare our students to function more effectively in today's information-age society. Our schools need to change; however, that change needs to be systemic, which "entails replacing the *whole* thing" (p. 3) as opposed to *piecemeal* which, "entails modifying something (fixing a *part* of it)" (Reigeluth, 1994, p. 3)

The information age altered the very foundations on which the industrial-age school was built. Senge (2000) observed that due to the growth in communication and media technology, schools rapidly lost their monopoly on the provision of knowledge that they had enjoyed for many years. In addition, the world that we live in has changed so significantly that "the working world is no longer looking for 'industrial workers'" (p. 51). The needs of our society have changed, but the schools have not kept pace with that change. Our society, in order for it to keep pace with the new age, is in need of knowledge workers (Reich, 1991); unfortunately, our education system is not designed to prepare our students to be independent, creative, self-regulated, life-long learners—hallmark features of knowledge workers in the information age.

Technology in the Information-Age Paradigm of Education

Reigeluth and Garfinkle (1994) state that, in an education system that is designed to cater to the information age, technology (and by technology we are referring to computer systems) will play a significant role and will be used for teaching, assessment and keeping track of students' learning. Education in the information age needs to be

more learner-centered, as learner-centered instruction leads to better learning gains and is therefore more effective. It also needs to be attainment based instead of time-based, and customized instead of standardized. And it needs to use technology that is systemically integrated, where custom instruction can be created, where individual student progress can be tracked, and where students set goals based on their own abilities as opposed to abilities that state policies have decided that students should have (McCombs, 2000; Reigeluth, 1997; Reigeluth & Beatty, 2003).

> First, with learner-centered, custom-paced instruction, technology is needed to track what each learner has mastered. This will allow teachers to easily keep track of each student's progress and thereby provide appropriate guidance to each student. Second, decisions about what to learn next (i.e., the sequencing of instruction) for each student will also be important, and technology will need to play a central role in helping student and teacher decide what should be learned next. Third, as teachers move from being the sole source of instruction to being guides or coaches, technology will be needed to help instruct the students by providing content, often in more interactive ways than have traditionally been used. Simulations and instructional games can provide interactive content, give immediate feedback, diagnose student needs and provide effective remediation. Fourth, technology will also be needed to help in the assessment of student knowledge to certify student mastery and store examples of student work that represent their attainments (e.g., portfolios). Finally technology will need to provide a systemic integration of all these features. (Watson, et al., 2007, p. 69)

It has been further noted that Learning Management Systems (LMS), due to their systemic design, whereby they can manage the administrative and instructional aspects of education (Szabo & Flesher, 2002) in an integrated fashion, serve as a good tool for implementing the information-age, learner-centered paradigm of education. However, "… an information-age, learner-centered paradigm of education cannot be effectively implemented without technology, and by the same token, technology cannot approach its potential contribution to education and learning without a learner-centered paradigm of education" (Watson, et al., 2007, p. 70). Therefore, it is crucial that LMSs that are being

used in information-age schools — schools that aim to develop information-age skills in their students — embody the very same learner-centered paradigm of education. Such LMSs need to reflect the same philosophical paradigm that is embodied in the system of education and the broader society (Bush & Mott, 2009).

On that note, Reigeluth and Garfinkle (1994) present a vision of what education in the information age should look like. The education system that they envision is primarily learner-centered, and technology plays a significant role in making the learner-centered education a reality. In such a system, technology helps teachers create their own instructional materials that are dynamic and suited to all the different learning styles, enabling learning to happen even over distances. Reigeluth and Garfinkle (1994) envision that in such a system, technology will take away the drudgery of administrative tasks, such as maintaining grades, from the teachers such that they will be able to focus more on their students and their learning. W. R. Watson, S. L. Watson, and Reigeluth (2012) also note that the "[the] new paradigm of education will need to be customizable and student-centered if time to learn is allowed to vary, and the systemic application of technology to the learning process will therefore be needed to support all stakeholders" (p. 26). They continue to posit that the new technology is needed because current solutions are designed to cater more to the traditional paradigm of education; i.e. "they function primarily from the perspective of the institution rather than the learner" (p. 26).

Learning Management Systems for the Learner-Centered Information-Age Paradigm of Education

Reigeluth, Watson, Watson, Dutta, Chen, and Powell (2008) theorize that LMSs for the 21st century need to have certain features in order to be effective in educating students and preparing them for the 21st century workforce. Reigeluth et al. state that such an LMS needs to serve the following four major functions:

- Recordkeeping for student learning
- Planning for student learning
- Instruction for student learning
- Assessment for (and of) student learning

In the article the tasks associated with each of the mentioned features are further enumerated. The authors state that such information-age LMSs will have a **recordkeeping** utility which will replace the current report card for students. “The report card in general use serves to compare one student with another and tells you little to nothing about what the student has actually learned” (33). This utility will allow for teacher, students, and parents to keep track of an individual student’s progress compared to his/her own set goals. The **planning** utility in this information-age LMS will allow the student, teachers, and parents to identify long- and short-term goals as well as plan and chart the means through which they will be attained. The **instruction** tool in this system will allow the teachers to create and deliver customized instructional materials to the students, and the **assessment** tool will allow teachers to not only evaluate student

achievement, but also create customized assessment tools. Customized education, which will be offered by the proposed LMS, is also known as *Flexible Learning* (Collis & Moonen, 2001), which is described as the type of learning where instructional materials, types of learning activities, and media used to support the learning activities can all be made *flexible* in order to address the needs of individual learners.

Even though a robust LMS is defined as software that can manage tasks related to administration, documentation, tracking, and reporting (Ellis, 2009), LMSs that Reigeluth et al. propose for the learner-centered, information-age paradigm of education, do not fit the conventional and commonly accepted definition of an LMS (W. R. Watson, S. L. Watson, & Reigeluth, 2013). In addition, in the field of LMSs, there exists a degree of disagreement regarding what LMSs are and the functions that they serve (Watson, Lee, & Reigeluth, 2007). Therefore, to avoid confusion and miscommunication, LMSs that are specifically designed to support education in the learner-centered information-age paradigm are referred to as Personalized Integrated Educational System(s) (PIES) (W. R Watson, S. L. Watson, & Reigeluth, 2012, 2013).

A PIES system has not yet become the norm in schools across the nation; neither is it available yet for schools and teachers to use. The reason for this is quite simple — most schools are still functioning on the old industrial-age paradigm of education, and the proposed PIES system is incompatible with the old paradigm. A PIES system is specifically geared towards supporting and enabling the learner-centered, information-age paradigm of education. On the same note, without available tools that can support and enable the learner-centered, information-age paradigm of education, transition to the new paradigm will be difficult.

In order to make PIES a reality, it is important that an information-age LMS (PIES) that supports the tasks that teachers in learner-centered schools are accomplishing be created and made available. Therefore, the purpose of this study is to improve the proposed functions and features of PIES (Reigeluth, et al., 2008) such that it is more compatible with the technological needs of the information-age paradigm of education.

Chapter 2: Literature Review

I ended the previous chapter by stating the need for a paradigm change; illustrating the role that technology can play in facilitating the paradigm change, and establishing the need for technology to be compatible with the new paradigm of education. In this chapter, I will discuss in more detail the recommendations regarding the design of PIES for the information age, describe the theoretical underpinning of the recommendations, trace the development of these recommendations, discuss additional literature that has commented on the functions and features for PIES, and highlight the need for research to inform the design of the functions and features of PIES.

History of the LMS

According to Szabo and Flesher (2002), "Learning management systems are computer based database and presentation systems which manage the entire instructional program and learning progress of employees with respect to the competencies specified by the goals and objectives of an organization" (p. 1). Originally, LMSs were derived from Computer Managed Instruction (CMI) Systems, which managed the "learning program of individuals in terms of 1) diagnostic assessment of performance relative to some standards, and 2) prescriptive assignment of learning resources relevant to those standards" (Szabo & Flesher, 2002, p. 1). In other words, according to Szabo and Flesher, CMIs delivered customized assessments and instruction.

CMIs were defined by two major sources. The first major source was the functional specifications (see Table 1) laid out by Baker (1981) and the second was the creation of PLATO Learning Management (PLM) by Michael Allen, which was a

mainframe system devoted to the delivery of instruction and training (Szabo & Flesher, 2002).

Table 1

Baker's Functional Specifications for CMS's (Baker 1981)

Instructionally Related Functions	Computer Related Functions	Data Requirements
Scheduling	System generation	Assessment
Individualized diagnosis and prescription	Man-machine interface	Diagnostic
Performance monitoring	Data-base management	Prescription
Data Collection		Resources
Resource Allocation		Curriculum Evaluation
Reporting		

Baker presented these functional specifications, saying "modern instructional strategies [were] becoming more complex and thus harder to manage from an instructional and administrative point of view" (1981, p. 23); therefore, to manage complex instructional strategies, a CMI was much needed. However, a review of these functional specifications (probably the earliest conceptual design framework for an LMS) reveals the accentuated focus on the administrative tasks that were offered through this system. The issue of unmanageability of complex instructional strategies was addressed by offering instructors a tool that could help them manage their administrative duties. Baker's recommendations were primarily focused on the instructors and their

administrative tasks; the learners and their learning processes were not included in these specifications.

However, according to Szabo and Flesher (2002), because most CMIs originated in higher education, these CMI mainframe systems embodied several learning theories. They state that theories such as *Metacognition*, *Individual Responsibility*, *Error Correction in Human Judgment*, *Individualized Instruction*, and *Deep Cognition Processing* played a role in determining the features of the early CMIs. For example, using the theory of *Metacognition* in CMIs ensures that the learner is able to improve their individual learning approaches. The authors cited a study conducted by Szabo and Forsyth (1994) that found "that exposure to a CMI system while studying mathematics initially resulted in increased learning but the effect leveled off over time, leading to the hypothesis that CMI provides a metacognitive model which learners adapted to sharpen their study skills through a better understanding of their own learning approaches" (p. 2). The focus here was on ensuring that the learning process was effective and efficient.

Szabo and Flesher claimed that *Error Correction in Human Judgment* was also embodied in the design of CMI systems. Allowing a CMI system to "provide objective advice to learners to use to check their performance decisions" (Szabo & Flesher, 2002, p. 3) makes it possible for individuals to accurately estimate their own learning strengths and weaknesses. To corroborate their claim, the authors referenced a CMI system built by R.D. Tennyson in 1981 which he referred to as an advisement system. The system was used to provide feedback to learners about their learning process in order to ensure that the learners do not over estimate their strengths and underestimate their weaknesses. Tennyson found that using this system "resulted in both increased achievement and

increased ability to monitor one's own performance" (Szabo & Flesher, 2002, p. 3). Yet again, we observe that the purpose of designing the system was to make learning more effective and efficient by ensuring that learners were being realistic about their abilities.

The theory of *Deep Cognitive Processing* was also said to have informed the early design of CMIs (Szabo & Flesher, 2002). The theory of *Deep Cognitive Processing* states that for deep cognitive processing to occur, information dumping into short term memory should be periodically interrupted by cognitive processing activities. To support their claim that CMI systems did accomplish *Deep Cognitive Processing*, Szabo and Flesher referenced a computer-assisted instruction study management system (CAISMS) created by Anderson and colleagues in 1975. The CAISMS was based on the theory of *Deep Cognitive Processing* and was created for use in an economics course. The developers of the CAISMS conducted an experiment to measure successful learning, where successful learning "allowed a student to proceed through the syllabus, while unsuccessful learning required continued study of the material already covered with retest opportunities" (Szabo & Flesher, 2002, p. 5). The experiment found that students who used the CAISMS demonstrated successful learning and "significantly scored higher on all course exams" (p. 5). To support the claim that *Individualized Instruction* was also embodied in the early design of CMIs, Szabo and Flesher (2002) referenced a system based on PLM that was implemented in the Edmonton Police Department during the 1980s. A study to test the effectiveness of this system found that it was "instrumental in increasing paper and pencil achievement, on the job performance and reducing training time by 25 percent, resulting in a savings of approximately $350,000 over a 5 year period" (p. 5).

So far we have observed that, according to literature on the design and development of the earliest CMIs, the focus was greatly on maximizing learning output such that content delivered through these mainframe systems was learned most effectively and efficiently. We also observed, through the literature, that CMIs were viewed as systems that could assist in simplifying administrative tasks related to instruction. In other words, CMIs were viewed as tools that could help attain the same industrial-age instructional tasks and not as a tool that could be utilized to alter and support a new paradigm of instruction.

Following the CMIs, the education and training community saw the emergence of computer-based Integrated Learning Systems (ILSs). Computer-based ILSs were essentially "complex integrated hardware/software management systems using computer-based instruction" (Bailey, 1993, p. 5). According to Learning Point Associates (2004), even though both CMIs and ILSs allowed students to learn at their individual paces, what differentiated an ILS from a CMI was that an ILS had the ability of altering the level of complexity of an assessment based on the student's ability. The common subjects that were offered through these ILSs were Mathematics, reading, writing, English as a second language, and science. ILSs were also used to administer General Educational Development (GED) tests.

Shore and Johnson (1993) and Sherry (1993) illustrated the vision of ILSs in the future (see Table 2). Shore and Johnson stated that ILSs in the future would not be relegated to technology labs; rather, if the weaknesses identified by them were corrected, ILSs could be incorporated classrooms. Bracey (1993) even went on to state that "a

combination of information technology and various societal trends [could] render schools as we know them obsolete" (p. 146). Shore and Johnson (1993) stated:

> The classroom-based ILS must provide the user with easy-to-use tools for the complex task of delivering instruction to students with a wide range of instructional needs. Unlike the early ILSs, which were designed for lab use, systems under current development are being designed to work best within the classroom and are envisioned to provide the teacher with a complete instructional program. (Shore and Johnson, 1993, p. 90)

Table 2

Future Developments in ILS (Sherry, 1993)

Future Development in ILS
Development of truly-integrated systems
Newer technologies incorporated
Greater use of Local Area Networks (LANs)
Linked to district databases
Part of a larger network
Greater access for teachers and students
Artificial intelligence tutoring systems
Productivity programs and tools
Development of high quality courseware
Enhancement of reporting capabilities
Decreasing cost due to high consumer demand
Conduction teacher training programs
Systems will be donated

LMSs, CMIs, and ILSs

Learning Managements Systems (LMSs) owe their origination to CMIs and ILSs (W. R. Watson & Watson, 2007); however, what differentiated an LMS from the myriad of CMIs and ILSs is that "they [were] designed with the learner in mind and promote[d] a focus on the learning in addition to the content" (Roqueta, 2008). However, Content Management Systems (CMSs) were often mistaken for LMSs (Simonson, Smaldino, Albright, & Zvacek, 2006; W. R. Watson & Watson, 2007). CMSs were essentially focused on the delivery of courses, whereas LMSs, in addition to the delivery of course materials, were able to track individual learning needs and achievement (Simonson, et al., 2006). Smaldino and colleagues (2005) stated that the standards-driven education environment made it possible for LMSs to evolve from CMSs more rapidly, as their ability to track individual learning needs and achievements made them a compatible and a useful tool for education systems. It is the ability to be able to incorporate standards and simultaneously maintain a learner-centered mode of instruction that made LMSs far more effective and desirable. According to Ceraulo (2005), an LMS was superior to other learning systems because of "its emphasis on learning management rather than course management, its ability to store educational content so that it can be referenced by many courses, and its ability to streamline a distance or eLearning instructor's task" (p. 7).

LMSs in the Future

Rengarajan (2001) contested that "an LMS primarily focuses on competencies, learning activities, and the logistics of delivering learning activities" (p. 2) whereas a Learning Content Management System (LCMS) gave users far more freedom as it

allowed them to “create, reuse, locate, deliver, manage, and improve learning content” (p. 2). What differentiated an LCMS from a CMS, ILS, and LMS is the freedom that it afforded users by allowing them to create their own instructional materials, store instructional materials for future reuse, and manage customized instruction. Therefore, he suggested that a system that integrated features of an LMS with the abilities of an LCMS would be more effective and offer “unique benefits that surpass the value offered by each system separately” (p. 2). Essentially, by recommending that LMSs and LCMSs be integrated, he echoed one of the design recommendations made by Reigeluth et al. (2008); vis-à-vis, the function of *Instruction for Student Learning*, which allows teachers/instructors to create, reuse, locate, manage, and improve learning content.

Anderson (2006) suggested that Personal Learning Environments (PLEs), the new “distributed and syndicated set of tools” (p. 1), should replace the institutionally centered, owned, and controlled LMS. The hallmarks for a PLE that Anderson presented included the features of shared content with a focus on communication. Still at its conceptual stages, a PLE, essentially, was a management system that would enable and manage life-long learning goals. What differentiated the concept of a PLE from any LMS, CMS, CMI, ILS, and LCMS was its interoperability. The concept dictated that PLEs should not be institutionally confined as LMSs and should have the ability to communicate with all networks, whether Local Area Networks (LAN) or Wide Area Networks (WAN). Anderson (2006) stated that, in order to ensure the survival of LMSs and the emergence of PLEs, features from both needed to be integrated into an integrated product. He stated that, “LMS systems that survive will do so by opening themselves to the standards based enhancements, service requests and the strong evolutionary move

towards real learner centric educational applications" (p. 4). Anderson (2006) suggested that LMSs, in addition to being learner-centered, should also incorporate standards that would regulate the evolution of LMS design. Therefore, in addition to recommending that learning systems should be interoperable across networks, Anderson (2006) suggested a need for minimum design standards in the evolution of LMS design and development in order for them to be viewed as a viable solution for addressing learner needs.

Attwell (2007) echoed Anderson's (2006) vision of a PLE and took it a step forward by delineating the tasks that PLEs should be accomplishing given the emerging learning environment of our society. He maintained the basic description of a PLE as a system that "recognizes that learning is [continuous,] … seeks to provide tools to support learning, [and] … recognizes the role of the individual in organizing their own learning" (p. 2). Attwell then offered alternatives as to how a myriad of web-based tools that allow users to accomplish different tasks could be incorporated into PLEs for self-directed, learning-related activities. Anderson also noted that "we are some distance from being able to operationalize that vision" (2006, p. 3).

However, Reigeluth et al. (2008), by presenting the roles and functions of PIES for the learner-centered paradigm of education, do present an operationalized vision of an LMS that recognizes that learning is continuous and allows individuals to organize their own learning. Having operationalized this vision, what is now needed is a way to ensure that the vision is elaborated through concrete design recommendations grounded in tangible data.

In continuation of the discussion on including standards in the design of LMSs, let us consider the dilemma that was presented by Finke (2004). He stated that discussions on LMSs focused more on technical standardization issues instead of pedagogical issues of the effectiveness of learning objects. He claimed that, although it was beneficial to have standardization organizations such as the Aviation Industry CBT Committee (AICC) and the Advanced Distributive Learning (ADL) Initiative, which monitored technical aspects in the development of LMSs and other e-learning products, it was just as important to have a monitoring organization that standardized the effectiveness of learning objects within these LMSs and other e-learning products. Finke (2004) recommended that standardization guidelines could be crafted based on the co-constructivist learning model (see Fig. 1). The model was based on the assumption that instructional materials were processed by learners in a more effective manner when the materials were delivered to them through rich interactivity in real-world situations. He also stated that "collaboration with other learners, learning teams, learning communities, learning facilities, or … other complex environments [were] vital ingredients of the co-constructivist learning process" (p. 318).

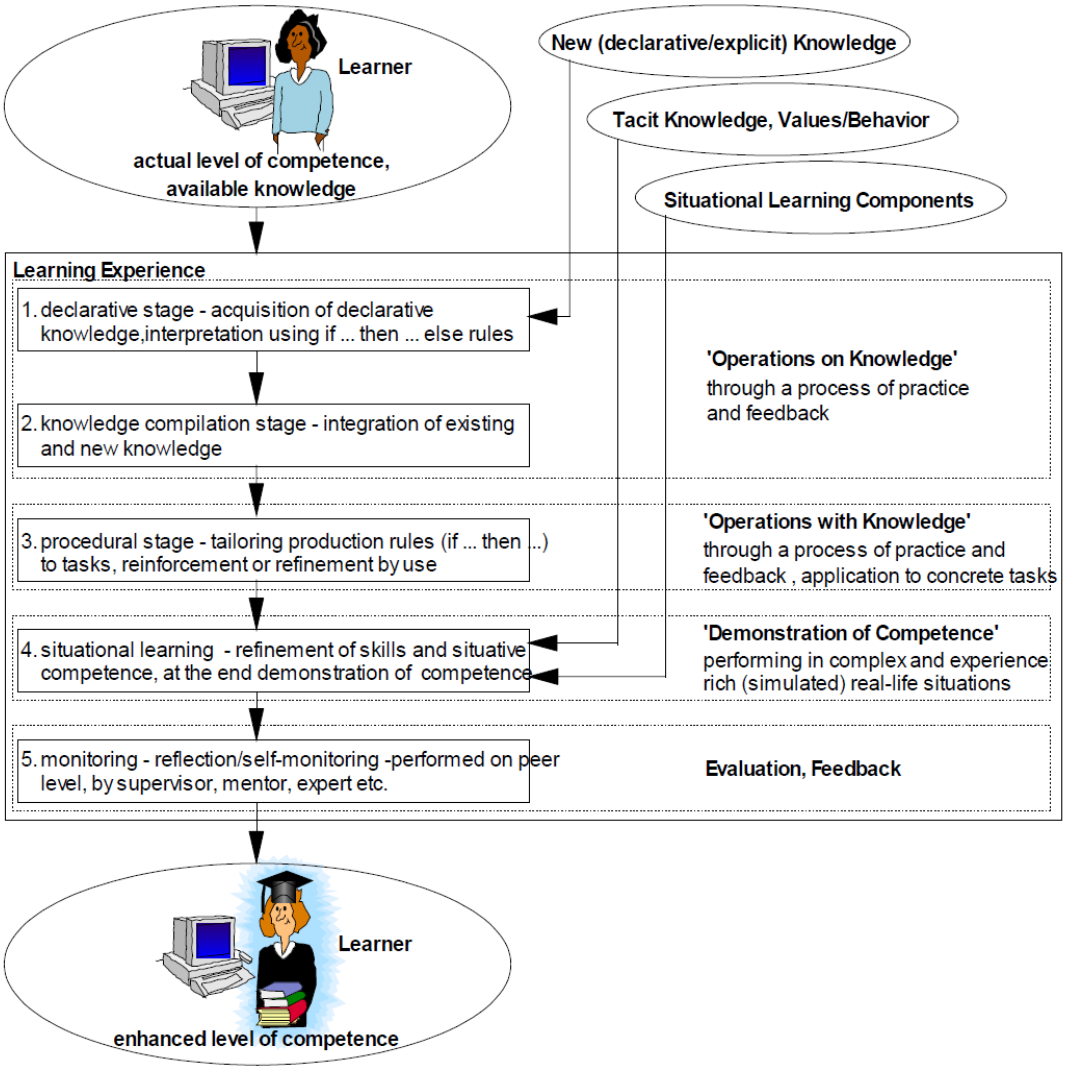

Figure 1: A model for co-constructivist learning (Finke, 2004, p. 315).

Recommendations for LMS functions made by Reigeluth et al. (2008) and recommendations for LMS standards made by Finke (2004) (see Table 3) are very similar. Both stress the need for designing LMSs that aid in effective learning in the information-age paradigm of education. Finke's LMS design recommendations were directed towards making learning more effective by incorporating a co-constructivist learning process and creating a standardization system for the design and development of

LMSs. The LMS design recommendations offered by Reigeluth et al. (2008) were made to create an LMS that could support learning within a learner-centered, information-age paradigm of education. The design recommendations made by Reigeluth and colleagues, if adopted, would also facilitate the process of standardizing the design and development of LMS.

Table 3

Finke's Outline for LMS Standards (Finke, 2004, p. 323)

Finke's Outline
Learning supervision system
Knowledge and competency assessment
Curriculum management system
Learn-flow management system
e-Collaboration system
Customizable user interface
Learning system administration client
Learning system development and maintenance
Master teacher portal
Learner-work environment
Learning facilitator work environment

Recently, Bush and Mott (2009) joined the chorus of voices that are calling for a redesigned LMS by bringing another crucial argument to the table. They adopted the viewpoint of educational reformers and stated that educational "transformation will come when we recognize and emphasize the importance of learner-centricity, content and tool

malleability [interoperability] and the network effect [collaboration and communication]" (p. 17). LMSs that can support the above-mentioned features need to be created. In addition, they also echoed Paulsen (2003), Finke (2004), and Anderson (2006) in stressing the importance of creating standardization systems for LMSs. However, Bush and Mott stated that "technological standards and content specifications stand side by side with the ideal of openness as a critically important catalyst for the long-awaited transformation of teaching and learning [mastery learning] that Bloom and others have predicted" (p. 17). They presented a vision of an LMS where users (learners and instructors) are able to plug and play with different applications — applications that are authentic, open, modular, and interoperable — to meet their learning and teaching goals. However, in order to make such fluidity possible, we must identify the roles and functions needed in such applications to achieve learner-centered goals. And these roles and functions have been theorized and recommended by Reigeluth et al. (2008). What we now need is research that can confirm, refine, and elaborate these recommendations such that the development community can use them to create the tool that our learning communities now need.

Functions for Technology in the Information-Age Paradigm of Education

The functions and features recommended by Reigeluth et al. (2008) were the result of an effort to develop a design theory for a tool that could enable and support learners, teachers, and school systems in the learner-centered, information-age paradigm of education. In this section we will chart the development of this design theory and present the ideas that were germane to the formation of these recommendations.

Reigeluth (1987) proposed a vision of how technology could be used to support the information-age paradigm of education. This vision was extended by Reigeluth and Garfinkle (1994), who suggested that computer-based tools should be used to create and access instruction and authentic learning activities, support different learning styles and attainment-based learning goals, enable staff professional growth and training, and manage student and staff information. In short, they envisioned a computer system that, in an integrated and holistic manner, is able to address every need of an education system modeled on the information-age paradigm. They introduced the idea that a computer system was needed as part of the holistic transformation process of school systems from the industrial-age to the information-age paradigm (Ellsworth, 2000; Kerr, 1996).

Watson, Lee, and Reigeluth (2007) continued to develop the above ideas and suggested 5 major functions for computer systems to serve in the information-age school: (i) offer custom-paced instruction and the ability to track the mastery level of the content; (ii) help students and teachers make decisions regarding individual student learning goals; (iii) assist teachers in providing instructional content; (iv) administer student assessments; and (v) integrate the above features in a seamless and systemic manner. With regard to making such a computer system a reality, they noted that LMSs could "promise an integrated tool for serving the five major functions that are needed for technology in the information-age schools" (p. 70). Some of these ideas eventually contributed to the most recent evolution of the PIES design theory presented by Reigeluth et al. (2008) that this study intends to inform. The recommendations made in the design theory, a seminal work in the field, are still at their early stages of evolution. Therefore, research, grounded in empirical data, is required to help improve it such that designers

and developers of LMSs can use the recommendations offered in the design theory to create an LMS that is ideal for the learner-centered, information-age paradigm of education.

In summation, Reigeluth and Garfinkle (1994) stressed the role that technology could play in transitioning schools from the industrial-age paradigm to the information-age paradigm; Kerr (1996) and Ellsworth (2000) corroborated the claim; and Watson, Lee, and Reigeluth (2007) offered the first outline of the tasks that the technology tools should accomplish.

Watson and Reigeluth (2008) suggested that an optimum way to create and support a learner-centered education system would be to develop technology tools that could facilitate and support such a system. Watson and Reigeluth (2008) framed their argument around past research that had been conducted by the American Psychological Association's (APA) Board of Educational Affairs that identified 12 learner-centered psychological principles based on educational research. These 12 principles were further categorized into 4 major areas (see Table 4).

Table 4

The Four Major Categories and the 12 Principles (S.L. Watson & Reigeluth, 2008)

Cognitive and Meta-Cognitive Factors	Motivational and Affective Factors	Developmental and Social Factors	Individual differences factors
Nature of the learning process	Motivational and emotional influences on learning	Developmental influences on learning	Individual differences in learning
Goals of the learning process	Intrinsic motivation to learn	Social influences on learning	Learning and diversity
Construction of knowledge	Effects of motivation on effort		Standards and assessments
Strategic thinking			
Thinking about thinking			
Context of learning			

A study conducted by the National Research council "…emphasize[d] the importance of customization and personalization in instruction for each individual learner … [and noted that] … self-regulated learners [took] more control of their own learning, and [customized and personalized instruction] facilitate[ed] deep understanding of the subject matter" (S. L. Watson & Reigeluth, 2008, p. 44). The authors continued to provide supporting evidence by citing studies in the fields of personalized learning (Clarke, 2003; Duval, Hodgins, Rehak, & Robson, 2004; J. Keefe, 2007; W. Keefe & Jenkins, 2002), differentiated learning (Csikszentmihalyi, 1990; Sternberg, Torff, & Grigorenko, 1998; Tomlinson, 2001, 2003), and brain research and brain-based

instruction (Caine, 2005, 2006; Caine & Caine, 1997) and established how leaner-centered systems were more effective in achieving individual learning goals.

Based on the positive impact of a learner-centered approach to learning, Watson and Reigeluth (2008) presented an illustration of an education system designed to support learner centricity. Such an education system, they stated, would not have any grade levels. Students in this system would strive towards mastery of content, which would be achieved through an attainment-based system as opposed to a time-based system. The role of the teacher in such a system would change to that of a facilitator. The article concluded by stating that for such an educational environment to succeed, powerful tools needed to be made available.

It was following this article that Reigeluth et al. (2008) published their seminal work that introduced the functions and features of a LMS ideal for supporting the learner-centered, information-age paradigm of education, later referred to as the Personalized Integrated Educational System or PIES (W. R. Watson, S. L. Watson, & Reigeluth, 2012).

The PIES Design Theory

Reigeluth et al. (2008) presented a design outline for LMSs that would be effective for the learner-centered, information-age paradigm of education. They envisioned four major roles and four secondary roles "seamlessly integrated into a single system" (p. 32). The primary functions included: (a) *Recordkeeping for Student Learning*, (b) *Planning for Student Learning*, (c) *Instruction for Student Learning*, and (d) *Assessment for (and of) Student Learning*. The four secondary roles recommended were:

(1) *Communication*, (2) *General Student Data*, (3) *School Personnel Information*, and (4) *LMS Administration*.

Recordkeeping for Student Learning

The *Recordkeeping for Student Learning* function in PIES replaced the industrial-age report card. This function, similar to a personalized learning plan (PLP) used in public school for students with special needs, helped maintain an inventory of each student's learning goals and helped identify his/her learning gaps. The recordkeeping function included the following three sub functions: (i) *Standards Inventory,* (ii) *Personal Attainments Inventory;* and (iii) *Personal Characteristics Inventory*. *Standards Inventory* informed all stakeholders of existing state and national standards and organized the standards into maps of each domain of learning based on Domain Theory[1] (Bunderson, Wiley, & McBride, 2009). It presented the competencies and learning objectives that the student should or could attain, "along with levels, standards, and/or criteria at which they should or could be learned" (Reigeluth et al., 2008, p. 33). The *Personal Attainments Inventory* tracked each student's progress in meeting the standards and served as a customized progress and mastery report. And the *Personal Characteristics Inventory* listed characteristics such as learning styles, multiple intelligences, and student interests, to inform the creation of customized instructional plans.

[1] A domain map illustrates how each attainment relates to other attainments, including its relative level of difficulty; it groups attainments into pathways to learning; and it organizes the attainments according to their level of difficulty and prerequisite relationships within these pathways.

Planning for Student Learning

This function allowed students, teachers, and parents to plan the student's educational road map. The *Planning for Student Learning* function included the following sub functions: (i) *Long-Term Goals*, (ii) *Current Options*, (iii) *Short-Term Goals*, (iv) *Projects*, (v) *Teams*, (vi) *Roles*, and (vii) *Contracts*. Planning one's *Long-Term Goals* allowed students to identify bigger life goals and chart instrumental goals to gradually attain them. Listing *Current Options* allowed users to "automatically identify the full range of attainments that [were] current options of the students" (Reigeluth et al., 2008, p. 34). Identifying *Short-Term Goals* allowed students to identity the goals that they needed to accomplish in the short-term. The sub function of *Projects* allowed students to identify projects they wanted to work on and allowed stakeholders to design and post new real-world projects. The sub function of *Teams* helped students identify other students with similar interested that they wanted to work with. The sub function of *Roles* allowed students to designate and identify their roles and responsibilities for each project. And creating *Contracts* allowed all stakeholders to finalize an agreement regarding their learning goals.

Instruction for Student Learning

The function of *Instruction for Student Learning* created, provided, and hosted instruction. It is comprised of four sub functions, namely: (i) *Project Initiation*, which helped teachers and students by introducing each project; (ii) *Instruction*, which provided all the instructional resources and activities required to complete each project; (iii) *Project Support*, which "[helped] students manage the project and [helped] the teachers

and parents monitor and support the students' work on the project" (p. 35); and (iv) *Instructional Development,* which supported teachers, students, and parents in developing new instruction.

Assessment for (and of) Student Learning

The *Assessment for (and of) Student Learning* function served the purpose of evaluating student learning by: (i) *Presenting Authentic Tasks*, (authentic tasks can be described as assessments that not only resemble real-world tasks, but also require the learners to apply a broad range of skills in order to complete each task (Roth, 1995). (ii) *Evaluating Student Performance,* (iii) *Providing Immediate Feedback*, (iv) *Certification*, (v) *Developing Student Assessment*, and (vi) *Improving Instruction And Assessment*. The sub function of *presenting authentic tasks* allowed the use of instruction activities as assessment tools to gauge the level of mastery of a particular competency. The sub functions of *Evaluating Student's Performance* and *Providing Immediate Feedback* evaluated the level of mastery of a competency and provided immediate feedback during the performance of the authentic task, respectively. The sub function of *Certification* assessed whether or not an attainment had been reached, the sub function of *Developing Student Assessments* allowed teachers to develop formative and summative assessment modules, and the sub function of *Improving Instruction and Assessments* allowed teachers to formatively evaluate and improve instruction and assessment materials.

Secondary Functions

Along with the four major roles, Reigeluth et al. envisioned that the PIES design theory would also include roles to accomplish auxiliary and administrative functions,

namely: (i) *Communication*, (ii) *General Student Data*, (iii) *School Personnel Information*, and (iv) *LMS Administration*. The secondary function of *Communication* was crucial in supporting the learner-centered paradigm as it allowed all stakeholders to communicate and collaborate with each other in order to accomplish their stated goals. *General Student Data* enabled the filing and maintaining of general student information and the function of *School Personnel Information* served a crucial role in "managing the entire learning process of a learning organization" (p. 38). The function of *LMS Administration* enabled the management of the LMS such that the tool stayed abreast of the evolving needs of its users and their technological capabilities.

Thus, presented above was a description of the PIES design theory that could support a learner-centered, information-age paradigm of education. The design recommendations made by the PIES design theory could also be viewed as a functional requirement specifications (FRS) document, which is described as a document that lists functions that the product must perform (Gilb & Finzi, 1988). In the world of software development, an FRS document is first finalized before development of the software can commence. Similarly, the study can also be viewed as an empirical process through which functional recommendations being made by the PIES design theory are being improved. The goal of this empirical process is to develop a product that can perform all functions that can address the needs of an information-age, learner-centered, customized educational environment.

Having established the goal, we will now look at empirical studies that have been conducted to improve the design of LMSs for the learner-centered, information-age paradigm of education.

LMSs and Past Research

LMSs have become a constant feature in education and training (Avgeriou, Papasalouros, Retalis, & Skordalakis, 2003; Coates, James, & Baldwin, 2005; Vrasidas, 2004); however, a search for research in the field of LMSs only found evaluation studies. For example, Grob, Bensberg, and Dewanto (2005) conducted a study on an open source LMS for a university in Europe. The study described the LMS developmental cycle and commented on the effectiveness of the features of the open source LMS as well as its usability. In other words, the study was an evaluation and a usability report of an open source LMS that the authors created. Passerini (2008) presented an evaluation study in which she demonstrated how web-based LMSs should be evaluated. In another study, DeLoose, Unger, Zhang, and Mosely (2009) evaluated Moodle and concluded that Moodle "can be used in any learning environment" (p. 31).

Due to its ability to incorporate features that allow for interoperability, learner centricity, customizability of content and instructional delivery methods, as well as its forums and mediums for communication and collaboration — as mentioned by DeLoose et al. in the study — it can be inferred that Moodle could possibly be used to support a learner-centered, information-age paradigm of education. However, DeLoose et al. (2009) note that, in spite of having a system that supported learner-centered education, "teachers were not using it in a student-centric way" (p. 29). And this observation echoes the very concerns that Bush and Mott (2009) raised when they stated, based on a study conducted by Larry Cuban (2001), that even though tools were made available that could support the learner-centered paradigm, that paradigm would not be achieved if

educational practices and processes did not mirror these new changes. New technologies could not be used for supporting traditional forms of teaching and also be effective.

In addition, for LMSs to be able to truly support learner-centric education in the information age, they need to be designed such that their functions are in sync with the tasks that need to be accomplished in a learner-centered educational environment. Therefore, there is a severe need for empirical studies that can gather information from existing learner-centered environments to inform the design of LMSs for the leaner-centered, information-age paradigm. The PIES design theory recommends functions for an LMS that can support a learner-centered paradigm of education. What we need now are research studies, grounded in empirical data that support and expand these recommendations by documenting the tasks performed in learner-centered educational environments.

PIES Design Theory and Research

A study conducted by Aslan, Huh, Lee, and Reigeluth (2011) was the first empirical study that used the PIES design theory as a conceptual framework. The goal of the study was to determine the extent to which "existing technology tools, such as Moodle, can currently serve these functions [recommended in the PIES design theory] and the extent to which teachers are taking advantage of any such capabilities" (p. 8)

Aslan et al. (in review) claimed that the tasks identified in the PIES design theory, were not being accomplished using Moodle. With the exception of conducting formative assessment, delivering instruction and instruction related resources, and maintaining student data, Moodle was not used for any of the other functions

recommended in the PIES design theory that are necessary for supporting a learner-centered, information-age paradigm of education. The study found that, while teachers wanted to accomplish functions similar to the functions described in the PIES design theory, they could not. This was largely due to the absence of functions in Moodle that supported learner-centered education.

Through this study Aslan et al. (2011) tried to determine if the functions recommended by the PIES design theory were present in a popular LMS and if teachers were accomplishing the said tasks. However, we also need to determine whether the functional recommendations made by the theory are reflecting the tasks that are being accomplished in a learner-centered educational environment. Unfortunately, no such studies have been conducted so far.

Conclusion

To summarize the discussion thus far, LMSs, due to their systemic design whereby they could manage the administrative and instructional aspects of education in an integrated fashion (Szabo & Flesher, 2002), had the possibility of evolving into a tool that could support the information-age, learner-centered paradigm of education. It was also noted that the new paradigm could not be effectively implemented without technology (W.R. Watson, et al., 2007, p. 70). The PIES design theory offered the functional recommendations that could help create a tool to support the new paradigm. The PIES design theory was new, and no research had been conducted to improve its functional recommendations to ensure the design theory reflected the tasks accomplished in a learner-centered educational environment. Therefore, the purpose of the proposed study was to improve the recommendations made by the PIES design theory by observing

how teachers accomplished instructional tasks in schools that had successfully adopted the learner-centered, information-age paradigm of education.

Research Questions

The research questions guiding the study were:

1. **Descriptive question:** What information-age tasks as identified by the PIES design theory (Reigeluth et al., 2008) are being accomplished by teachers in schools that have transitioned into the learner-centered, information-age paradigm of education?
    a. **Related formative question:** What improvements can be made to the functions offered by the PIES design theory to better perform those tasks?
2. **Descriptive question:** What information-age tasks identified by the PIES design theory are not being accomplished by teachers in such schools?
    a. **Related formative question:** What PIES functions, if any, should be changed or removed as a consequence?
3. **Descriptive question:** What tasks are being accomplished in such schools that are lacking from the PIES design theory, if any?
    a. **Related formative question:** What improvements can be made to the PIES functions to perform those tasks?
4. **Descriptive question:** What factors play into encouraging or discouraging teachers from using technology to accomplish the tasks?

5. **Inferential question:** What are the implications of the findings for the *2012-2013 eLearning Priorities* proposed by the Indiana Department of Education (IDOE)?

In closing, the goal of the study was to improve the recommendations made by the PIES design theory by observing tasks performed by teachers in schools that embodied a learner-centered paradigm of education. In this study, the term *task* was used to refer to all education-related activities that the teachers performed. Activities ranged from direct instruction to managing administrative tasks related to instruction, such as record keeping and maintenance and management of student contact information.

Chapter 3: Methods

The purpose of the study was to improve the functions and features of the PIES design theory recommended by Reigeluth et al. (2008). Therefore, the formative research methodology (Reigeluth & Frick, 1999) is the most appropriate method for answering the research questions. In this chapter, I discuss why formative research is the appropriate methodology, followed by a detailed description of what formative research is and how it was implemented in this study.

Knowledge, Theories, and Research Methodology

According to Frick (2004), there are six types of knowledge that can be created through disciplined inquiry in education. Namely, situated and theoretical *scientific knowledge,* which explains "what is"; situated and theoretical *praxiological knowledge* that sheds light on "what is instrumental" or that which is of utility; and situated and theoretical *philosophical knowledge,* which describes that what ought to be (p. 6).

Theories

When choosing a research methodology for a particular study, it is important that the researcher is aware of the type of knowledge that his/her study is going to create. **"**Epistemic Artifacts," also referred to as *theories*, are types of knowledge that serve to further advance knowledge (Scardamalia & Bereiter, 2006). It explains and describes the way things are and why things are as they are (Hooker, 2003). The type of knowledge that this study aims to inform is theoretical, praxiological (Frick, 2004), which, by definition, is knowledge that "describes the instrumental value of a methodology for creating an effective educational state of affairs, an educational product, or program" (p.

10). As the purpose of this study is to suggest recommendations, based on empirical data, for improving the functions and features of PIES that can support the learner-centered, information-age paradigm of education, it is offering improved "prescriptions, processes, principles or heuristics which are means to an end" (10), i.e., principles for the design of an LMS suited for a learner-centered, information-age paradigm of education.

Design Theory vs. Descriptive Theory

As described earlier, theory is a type of knowledge that explains the way things are and the reasons for why they are the way they are. This type of theory, which is referred to as descriptive theory, "is the result of what Cronbach and Suppes (1969) call conclusion-oriented inquiry, and design theory is the result of what they call decision-oriented inquiry" (Reigeluth, 2003, p. 342). Design, on the other hand, "is a passage from a functional description to a physical description of an artifact" (Hooker, 2003, p. 4); it is a practice. Therefore, design theory could be posited as the description of the knowledge of design practice. Wall, Widemeyer & Sawy (1992) describe design theory as:

> a prescriptive theory based on theoretical underpinnings which says how a design process can be carried out in a way which is both effective and feasible. Since they are prescriptive, design theories differ from explanatory and predictive theories found in the natural or physical sciences (p. 37).

Design theory, in the field of instructional design, can be viewed as:

> a set of principles[2] that are systemically integrated and are means to explain and predict instructional phenomena. Just as conditions and outcomes are integral parts of a principle, so also are conditions and outcomes integral parts of a theory.

[2] A principle describes a relationship between two actions. This relationship may be correlational or causal. This relationship may also be deterministic or probabilistic. (Reigeluth, 1983)

> In fact, a theory is to a model what a principle is to a single method variable; and hence a theory is to a principle what a model is to a single method variable (Reigeluth, 1983, p. 21).

"Design theories are prescriptive in nature, in the sense that they offer guidelines as to what method(s) to use to best attain a given goal … whereas descriptive theory attempts to provide a deeper understanding of effects that result from phenomena" (Reigeluth, 1999, p. 7). For example, Merrill's (2002) *First Principles of Instruction* is an instructional design theory that offers prescriptions for the design of instructional materials in order to increase the chances of learning under given conditions. The *First Principles of Instruction*, which is a design theory, is also what Reigeluth (1999) calls basic methods. Basic methods are one of the two types of instructional methods (the other being variable methods) which have been proven through research to increase the probability of learning under given conditions (Reigeluth, 1999).

Research Methodology for Design Theory

The methodological challenges that are encountered by research that investigates design theory are greatly different from those of research that investigates descriptive theory (Reigeluth & Frick, 1999). This is because in research intended to create or inform design theory "the research question is not whether a method works, but how well it works and how it can be made to work better" (Reigeluth & An, 2009, p. 370). Therefore, for design theory there are two major kinds of research that can be done: research to prove and research to improve. This study intends to improve the PIES design theory.

One of the approaches to develop and/or improve design theory is data-based theory development or grounded theory development as proposed by Glaser and Straus

(2009). In this approach theory is built inductively from the data on a what-works-best approach (Reigeluth & An, 2009).

> However, when the focus of the research is to improve rather than prove, this data-based theory development process should go beyond the grounded theory development guidance to observe, and also try out different methods (or different variations of a method), revise those methods based on formative data, and try them out again. Cycles of trial and revision are key to research that is focused on improving a design theory of any kind. Design-Based Research and formative research […] are valuable research methods for doing this. (p. 371)

Design Based Research. Wang and Hannafin (2005) included Design-Based Research and Formative Research under the umbrella of the Design-Based Research paradigm and state that the Design-Based Research paradigm "posits synergistic relationships among researching, designing, and engineering (p. 5). In this paradigm, Wang and Hannifin include several other research methodologies, such as: design experiments, design research, development research, and formative research. The characteristics that are common to all the above research methodologies and which qualify them to be included under the umbrella of the Design-Based Research paradigm are: (1) pragmatic; (2) grounded; (3) interactive, iterative, and flexible; (d) integrative; and (e) contextual.

Formative Research. Formative research is a kind of developmental research or design-based research (Reigeluth & An, 2009; Akker, Gravemeijer, McKenney, & Nieveen, 2006) which is useful in developing and improving design theories. One of the characteristics of all Design-based Research methodologies is that it is driven by theory. Which is to say that researchers practicing Design-Based Research "seek to revise and refine the theory they selected at the outset, and they draw on prior research" (p. 379).

Formative research "… is intended to improve three things": a particular case (product, event, or combination), an instructional theory related to that case, and descriptive theory related to the instructional theory" (Reigeluth & An, p. 381). It is a type of case-study-based research which lends itself well to answering how and why questions. The case study approach appropriately fits the formative research design because the goal of formative research is to answer the "how's and why's" of improving a theory. It is also important to note that case study research, especially in the social sciences, is a desirable methodology as it is able to reveal the nuances of a case in much more detail than experimental research methods, which confine themselves to describing data using statistical measurements (nominal, ordinal, interval, and ratio) and/or models (e.g., regression models) (Dooley, 2002; Rowley, 2002; Tellis, 1997).

There are two major types of formative research studies. The first type is the *designed case*, "in which the theory is intentionally instantiated for research" (Reigeluth & An, 2009, p. 382) and the instantiation is formatively evaluated. The second type is the *naturalistic case*, where:

> the researcher (a) picks an instance (or case) that was not specifically designed according to the theory but serves the same goals and contexts as the theory, (b) analyzes the instance to see in what ways it is consistent with the theory, what guidelines it fails to implement and what valuable elements it has that are not present in the theory, and (c) formatively evaluates that instance to identify how each consistent element might be improved, whether each absent element might represent an improvement in the instance, and whether removing the elements unique to the instance might be detrimental (Reigeluth & Frick, 1999, p. 637).

This study looked at cases that were not designed using the PIES design theory and can therefore be categorized as naturalistic cases in formative research.

Naturalistic cases can be further separated into two categories depending on whether the observation (or formative evaluation) is conducted during or after the event that is related to the said theory. The two types of naturalistic cases are *in vivo* and *post facto*. *In vivo* naturalistic cases are studied during the event, whereas *post facto* naturalistic cases are studied after the event (Reigeluth & An, 2009, p. 382). The current study looked at *in vivo* naturalistic cases, as they were studied during the event. Schools were in session while the teachers were observed and interviewed. In addition, in this study, the cases were also categorized as *post facto* naturalistic cases as some experiences that occurred prior to the interviews and observations were studied. For example, teachers were asked about tasks that they had completed in the past. In conclusion, because the purpose of the study was to improve an existing theory, it was classified as a multiple *in vivo* and *post facto* naturalistic case study.

Conducting Naturalistic Formative Research

Steps, prescribed by Reigeluth and Frick (1999) to conduct an *in vivo*, *post facto*, naturalistic, formative research study, were used to conduct the proposed study.

Step 1: Select a Design Theory

Step one requires that the researcher select a design theory that he/she intends to improve. The goal of this study, as stated earlier, was to improve the PIES design theory created by Reigeluth et al. (2008). Therefore, the design theory selected for this study was the PIES design theory.

Step 2: Select the Naturalistic Cases (sampling)

The next step in conducting an *in vivo*, *post facto*, naturalistic study is selecting the naturalistic cases. Schools or educational systems that embody some of the characteristics of the learner-centered, information-age paradigm served as naturalistic cases for improving the functions and features of PIES. This was justifiable as it was only schools that had transitioned and/or were transitioning into the new paradigm that would be able to accurately illustrate the needs of students and teachers in the said paradigm.

In the proposed study, a purposeful and theoretical sampling process was used to select the cases. According to Patton (1990), "the logic and power of purposeful sampling lies in selecting information-rich cases for study in depth. Information-rich cases are those from which one can learn a great deal about issues of central importance to the purpose of the research, thus the term purposeful sampling" (p. 169). Four naturalistic cases (schools) were selected based on how useful they would be in extending and improving the design recommendations for PIES. Selection was based on the extent to which the naturalistic cases had transitioned into the learner-centered, information-age paradigm of education. The selection criteria were determined based on the key markers of the information-age paradigm (see Table 5).

- ***Criterion #1:*** *Learner-centered and customized education.* Education systems that allowed students to create their own learning plans in collaboration with their teachers and parents fulfilled criterion #1. These learning plans were then used to create customized instruction and learning activities catered to the needs of an individual student.

- ***Criterion #2:*** *Learning was attainment-based as opposed to time-based*. Education systems that allowed students to master a particular topic before moving to the next topic and allowed them to move on to the next topic as soon as they mastered the current one fulfilled criterion #2. Students were not expected to demonstrate mastery within a fixed timeframe. Such education systems were not based on grade levels.

- ***Criterion #3:*** *Learning occurred in project-based, real-world environments*. Education systems that fostered project-based learning where students worked in small collaborative groups to meet their learning goals would fulfill criterion #3. Working in project-based, real-world environments has been shown to afford the students a sense of autonomy in making learning decisions as well as a sense of responsibility and accountability (Ayas & Zeniuk, 2001; Scarbrough et al., 2004) — key markers of the information-age paradigm of education.

Table 5

Key Markers of the Industrial-Age vs. Information-Age Paradigms of Education (Reigeluth, 1999, p. 17)

Industrial Age	Information Age
Standardization	Customization
Bureaucratic organization	Team-based organization
Centralized control	Autonomy and accountability
Adversarial relationships	Cooperative relationships
Autocratic decision making	Shared decision making
Compliance	Initiative
Conformity	Diversity

One-way communications	Networking
Compartmentalization	Holism
Parts oriented	Process oriented
Planned obsolescence	Total quality
CEO or boss as “king”	Customer [learner] is king

It is important to keep in mind that at the time of the study, the information-age paradigm of education was at its early stages of development. To use the analogy of the development of the airplane, the information-age paradigm in schools was developed to a level of sophistication comparable to that of the first aircraft developed by the Wright Brothers. Several schools across the nation were making significant strides towards such a transformation; however, the transformation was far from complete and also heading in different directions due different kinds of reform efforts. It is important to note that:

> [despite] the growing public pressure for change, and programs and policies focusing on further standardizing curriculum, increasing availability of computer technology, and holding schools and teachers more accountable, little has changed in either the approach to or the effectiveness of current K-12 education. Systemic-change advocates argue that a systemic view needs to be taken in understanding this complex problem--for a complex problem requires a complex solution that addresses change on many interrelated fronts. Furthermore, they argue that rather than trying to change our existing system of education, a new system of education needs to be designed specifically for today's needs and challenges. … This new paradigm of education will need to be customizable and student-centered. (W. R. Watson, S. L. Watson, & Reigeluth, 2012, p. 26)

Therefore, in this study, when making decisions regarding the choice of cases, the intention was to include several cases (schools) that had successfully incorporated at least one of the three criteria listed above.

The process of selecting the cases. Several schools in the Southern Indiana region were reviewed for plausible inclusion in the study. While making decisions regarding inclusion, schools were reviewed to ensure if they addressed one or more of the three criteria listed above. In addition, for the sake of feasibility, only schools within one hour driving time were reviewed for inclusion in the study. Traditional public schools were not included in the initial review as such schools still embodied the features of the industrial model as illustrated in Table 5.

Schools that were initially reviewed for selection in the study were Bloomington Montessori School, Bloomington New Tech High, homeschooling families, Decatur Discovery Academy, Harmony School, and Pinnacle School. The selected schools were reviewed to determine if they embodied at least one of the three criteria listed on page 40. In the initial step, the content on the schools' websites was reviewed to assess whether they met the criteria. If the schools did meet one or more of the criteria, a site visit was conducted to corroborate the conclusions made during the initial review. During the site visits, teachers and administrators were informally interviewed to confirm adherence to the stated criteria. Homeschooling families were reviewed through teachers who gave private science and music lessons for students in homeschool environments.

At the end of the review process, three schools and homeschooling families were chosen as possible cases for the study. However, homeschooling families were taken off the list of cases because findings from the data collected from homeschooling families could not be easily generalized to schools; constraints of a homeschool environment are different than those of a school. Therefore, three sites were initially selected. These included Bloomington Montessori School, Decatur Discovery Academy, and Harmony

School. Pinnacle School, a school for students with learning disabilities, was set aside as a possible site to consider later in the study if the selected cases did not yield sufficient and meaningful data.

However, during the course of the study, Harmony school was removed due to administrative difficulties in conducting research at the site. Pinnacle school, which was set aside as a possible site, was included back into the study. The Bloomington Project School (TBPS) was added as the fourth and final site for the study to add more detail to the data that had been collected thus far. Therefore, the schools included in this study were:

- Bloomington Montessori School (BMS)
- Decatur Discovery Academy (DDA)
- Pinnacle School (PS)
- The Bloomington Project School (TBPS)

Case 1- Bloomington Montessori School (BMS). Bloomington Montessori School was a private school in Bloomington, Indiana, established in 1968 and had been a member of the American Montessori Society since 1971. There were two programs offered at BMS. (1) The Preschool program that catered to students of ages 3-6. The preschool program focused on activities that helped develop practical life, cultural, and sensory manipulation skills, along with lessons in language and mathematics. (2) The second program that BMS offered was the Elementary program which was divided into

the Lower Elementary classroom (LEC) and the Upper Elementary classroom (UEC). The LEC catered to students ages 6-9 and the UEC catered to students ages 9-12.

The basic tenet of the Montessori model was customized, self-directed learning, which fulfilled criterion # 1 — *learner-centered and customized education.* In addition, learning at BMS was attainment-based as opposed to time-based, thus fulfilling criterion # 2, i.e., *learning was attainment-based as opposed to time-based*. During the preliminary selection rounds, students in the UEC participated in group projects during *intersession* — a week-long project, during which students participated in real-world projects of their choosing. Instruction took place during that week, directly or indirectly related to the projects that they were working on. This activity, therefore, resembled the third criterion, i.e., *learning occurred in a project-based, real-world environment*, and consequently supported the selection of BMS as a naturalistic case for this study.

Case 2 - Decatur Discovery Academy (DDA). Decatur Discovery Academy (DDA), a 7^{th}-12^{th} grade secondary school, was a part of the Metropolitan School District (MSD) of Decatur Township and was selected as the second naturalistic case in this study. Education at DDA was based on the Expeditionary Learning (EL) model. The EL model of instruction included an interdisciplinary, project-based approach to learning (Warschauer, Grant, Real, & Rousseau, 2004). Learning in this project-based environment was collaborative in nature, and the role of the teachers was that of a facilitator and a coach. It was an environment that fostered accountability, autonomy, responsibility, and collaboration and met the 3^{rd} criterion, i.e., *learning occurred in a project-based, real-world environment*. Because the EL model fit criterion # 3, Decatur Discovery Academy was chosen as a naturalistic case for this study. DDA, however, did

not meet criteria 1 or 2. At DDA education was not learner centered and customized (criterion # 1). Learning goals were created based on state standards, and all students had the same learning goals. In addition, at DDA, education was not attainment-based (criterion # 2); rather, all learning objectives (goals) had to be addressed by the end of each academic year..

Case 3 - The Bloomington Project School (TBPS). TBPS successfully met criteria # 1, #2, and # 3. Criterion # 1 stated that education in the schools should be learner-centered and customized. At TBPS, teachers and parents routinely met with the students to identify individual educational and developmental goals, thus fulfilling criterion # 1. Students in TBPS had the opportunity to master their learning goals that were customized to their needs, abilities, and interests. Education at TBPS was attainment-based as opposed to time-based and enabled multi-age classrooms with 4-5 teachers/assistants in each class. This observation helped determine that TBPS was able to successfully meet criterion # 2. In addition, TBPS provided, for its students, an educational environment that was project-based and grounded in real-world practices, thereby successfully meeting criterion # 3. All projects that were identified for students to work on were integrated through the entire curriculum — a curriculum that was guided by state standards. The projects were also designed such that they had a positive and constructive impact on the community surrounding the school.

Case 4 - Pinnacle School (PS). Pinnacle School was a not-for-profit, private school geared towards serving students with learning and developmental disabilities. Students who had been diagnosed as being dyslexic as well as found to display characteristics within the autism spectrum made up a majority of the student population.

The purpose of the school was to help students who, due to their learning or developmental disabilities, had fallen behind statewide, standards-based curricula. Therefore, at the beginning of every academic year, current and in-coming students where tested to determine their level of proficiency in reading, writing, and mathematics. Subsequently, teachers were made aware of these levels, whereon they would begin customizing instructional materials, assessments, and activities to meet the students' needs. Although learning goals were not customized for each student, instruction in the school was customized based on individual student learning styles, thereby meeting the first selection criterion — *learner-centered and customized education*.

Because the focus of the school was to address specific learning gaps, such as lower proficiency level in reading, writing, and mathematics, the school had computer-based resources in place that allowed students to work on these skills at their own pace. The computer-based resources where able to successfully customize assignments and activities based on the students' individual learning pace and ability, consequently allowing students to master certain topics at their own pace. (It is important to note, however, that only part of the instructional content was accessed using computer-based resources.) Therefore, TBPS was able to also address criterion # 2, which states that learning needed to be attainment-based and not time-based.

Step 3: Collect and Analyze Data

Select study participants. Given the research questions, research participants were chosen with a nonprobability sampling method. All teachers were approached with the basic information regarding the study. The goal was to get at least one teacher from

each subject to participate in the study in order to yield findings that would be truly representative of all learning tasks. It was also important that teachers from all grade levels were represented, to get a more representative sample and, therefore, a more complete data-set. However, not all cases had grade levels, so age levels were used to ensure that data collected were representative of all levels of learning.

A total of 20 teachers were interviewed and observed during the course of the entire study. Towards the end of the data collection and analysis, during the process of member checking, one of the teachers withdrew from participating in the study. Therefore, the results are based on interview and observation data collected from 19 teachers. The teachers were identified based on several criteria: grade level, subject area, and attitudes towards the information-age, learner-centered paradigm. Those attitudes were determined through conversations with administrators who were familiar with the teacher's work.

It should be noted that the number of teachers recruited in each school varied greatly. The reason for doing so depended largely on the kind of school that was being observed, how closely the school embodied the learner-centered paradigm, the extent to which the school's educational practices matched those suggested by the PIES design theory, and how quickly data saturation was reached. For example, only three teachers were recruited from TBPS as its design and mission successfully fulfilled only the third criterion. Data saturation was quickly reached at TBPS after the third interview. On the other hand, eight teachers and one principal were recruited from Bloomington Montessori School as it truly embodied the learner-centered paradigm and met all three selection criteria used in this study. In addition, the number of recruits also depended on gaps

identified in the data during the data collection process. For example, the study began with observations and interviews conducted at Decatur Discovery Academy (DDA). DDA is primarily for grades 7-12, and most classes that were observed consisted of high school students. Observations and interviews conducted at Bloomington Montessori School provided data that covered grades 1-6. Missing in this data pool were observations and interviews from classes catering to grades 7-9. This gap was addressed by targeting the recruitment of teachers from TBPS and Pinnacle School who taught classes that included the missing grade levels.

In addition to ensuring that all grade levels were included in the study, efforts were also made to ensure that all subject areas were represented. In Decatur Discovery Academy, the criterion used in the selection of the four teachers was that of subject areas. The four teachers selected represented Mathematics, Science, Social Studies, and Language Arts. In contrast, teachers at Bloomington Montessori School were not selected based on subject areas or grades that they taught; rather, they were selected based on the multiage classrooms that they were assigned to. At Bloomington Montessori School, it was easy to ensure that all subject areas were represented by the participants as the teachers taught as a group. Even though each teacher within a group was a specialist in one subject area, they often co-taught in several subject areas and collectively covered all subjects.

Collect data. According to Reigeluth and Frick (1999) “three techniques are useful for collecting formative data: observations, documents, and interviews” (p. 640). In this study, data were collected in the form of interview and observation results. In addition, Reigeluth and Frick (1999) also specify that, for studies intended to improve an

existing theory, there are three major types of data that should be collected "based on the presence and absence of elements in the theory and in the case" (p. 645). In other words, data should be collected on, (i) elements that are present in the theory as well as the case; (ii) elements present in the theory but absent in the case; and (iii) elements absent in the theory, but present in the case. Through interviews and observations, the study identified elements present in both the PIES design theory and the naturalistic case(s), elements present in the PIES design theory but absent in case(s), and elements absent in the PIES design theory but present in case(s).

The selected participants were interviewed and observed. During observations the goal was to collect rich and detailed data on how teachers accomplished the tasks associated with the students' learning. See Appendix A for the Observation Rubric.

Each teacher who was selected and agreed to participate was observed and interviewed over two to three days or until data saturation was reached. Observation notes were taken from the beginning of the observation sessions. Informal interviews, which were recorded, were conducted throughout the observations. The observations were concluded with a longer, more intensive interview. The semi-structured interview protocol (see Appendix B) that was created prior the start of the study was primarily used. However, several questions were added to the interview protocol based on observations and the informal interviews that were conducted during the observations.

If the cases were using an LMS or a course management system (CMS), the learning platform was evaluated to address the stated research questions. The researcher also observed how participants interacted with the LMS/CMS and looked for

functions/features that the LMS/CMS offered in an effort to determine the presence or absence of functions/features supporting the learner-centered, information-age paradigm of education.

During the observations, notes were taken on what tasks the teachers accomplished, what tools they used, and the features of the tools. When interviewing, the focus remained the same, only with an emphasis on formative evaluation of the tools and their features.

Because the goal of the study was to see what and how information-age tasks were being accomplished by teachers, teachers were the primary participants in this study. The PIES design theory does encompass roles for students and parents, as well. However, the proposed study dealt exclusively with improving the design theory by observing tasks performed by teachers in a learner-centered educational environment. The focus of this study was to observe how teachers were accomplishing their everyday tasks and what tools they were using to accomplish those tasks. No students were recruited, nor did they participate in the study. However, observations of teacher interactions with students and computers were recorded, as this information was crucial in informing the results of the study.

Instruments. The observation rubric (Appendix A) and the semi-structured interview protocol (Appendix B) were the two data collection instruments used in this study. The interview questions were emergent and were revised based on preliminary data. It is important to note regarding the instruments that even though in this report we refer to LMSs as PIES, when conducting the interviews, the researcher did not use that

terminology, as teachers were not familiar with either of the terms. The researcher, during the preliminary interview process, determined the terminologies with which teachers were familiar and proceeded to ask questions using the teachers' vocabulary.

Data analysis. The processes of data collection, triangulation, and analysis were overlapped so that the concepts, categories, and properties would start emerging as early as possible. The first set of concepts, categories and properties was formulated based on the research questions. These concepts, categories, and properties led to the creation of themes. The data, in the form of interview responses and observation notes, were then coded using the identified themes. The data were coded in order to identify (i) elements that were present in the theory as well as the case, (ii) elements present in the theory but absent in the case, and (iii) elements absent in the theory, but present in the case. Overlapping the stages of data collection, triangulation, and analysis during the data collection process allowed for improvements and changes that could be made to ensure that the data collected were relevant and useful.

It is important to note that, in the following chapter, data (interviews and observation notes) were described in a manner that could have seemed similar to *Activity Theory* — a theoretical framework for qualitative analysis of human activity.

> Activity Theory is a valuable tool for researchers to incorporate into their repertoire as it enables a means of discovering human activity without the express explication of tasks by participants, instead, through the mediated study of the participant's tools an understanding of activity is revealed which includes tacit and explicit actions. (Hashim & Jones, 2007, p. 8)

As noted in the quote above, the analysis that is driven by the framework of activity theory focuses on discovering human activity by analyzing study participants' tools. In this study, however, the focus is not on the tool; rather the focus is on

discovering human activity "with" the "express explication of tasks by the participants" as well as by observation of tasks being performed by the participants. Therefore, the unit of analysis, in this study, is the *activity* and not the *tool* (the tool is the unit of analysis in Activity Theory).

Coding the interview and observation results. Once the data had been transcribed, Ian Dey's (1993) method of qualitative data analysis was used to analyze the transcribed data. Dey's method is a synthesis of several accepted and tested qualitative data analysis techniques. Dey's recommendations regarding categorizing, reading, and annotating data draw heavily from the work of Strauss (1987) and Strauss and Corbin (1990). Analytical procedures are drawn from the work of Patton (1980) and Becker and Geer (1982); associating categories and mapping data are largely drawn from Bliss, Monk, Ogborn, and Black (1983) and Miles and Huberman (1984); and the stage of linking data is mainly informed by Day's previous work. The process that was followed is illustrated in Figure 2.

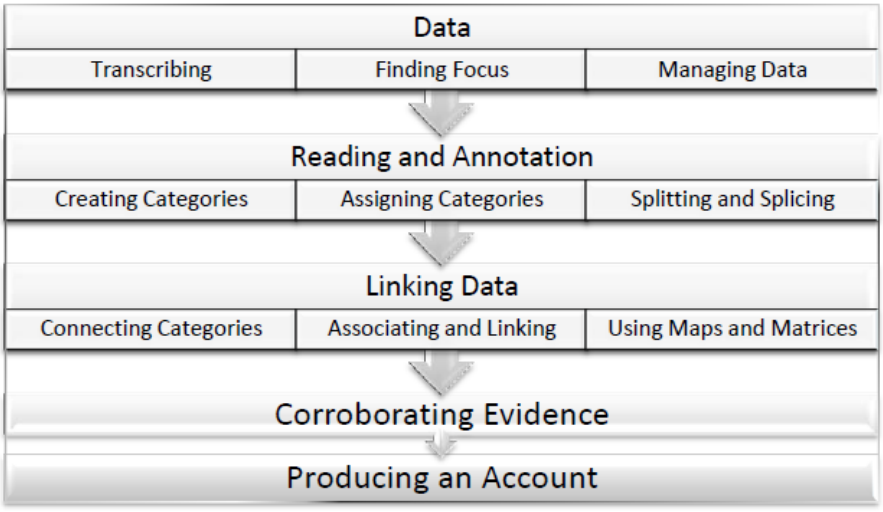

Figure 2: The process of data analysis used in this study (Dey, 1993).

Creating codes and analyzing data. Codes for data analysis were created based on the PIES design theory. All functions and sub functions in PIES were abbreviated to create tags. The tags created can be viewed in Figure 3 below. The interview and observation data were tagged with the abbreviations in order to identify the presence and absence of PIES functions and sub functions in the case that was being analyzed.

CODES: PIES Functions				
Recordkeeping for Student Learning (RSL)	Planning for student learning (PSL)	Instruction for Student Learning (ISL)	Assessment for (and of) Student Learning (ASL)	Secondary function (SF)
CODES Sub-Function				
Standards Inventory RSL-SI	Long-term Goals PSL-LG	Project Initiation ISL-PI	Presenting Authentic Tasks ASL-PAT	Communication SF-C
Personal Attainments Inventory RSL-PAI	Current Options PSL-CO	Instruction ISL-I	Evaluating Student Performance ASL-ESP	General Student Date SF-GSD
Personal Characteristics Inventory RSL-PCI	Short-term Goals PSL-SG	Project Support ISL-PS	Providing Immediate Feedback ASL-PIF	School Personnel Information SF-SPI
	Projects PSL-P	Instructional Development ISL-ID	Certification ASL-C	
	Teams PSL-T		Developing Student Assessments ASL-DSA	
	Roles PSL-R		Improving Instruction and Assessments ASL-IIA	
	Contracts PSL-C			

Figure 3. A table showing the codes that were created to analyze the data

The next set of codes was created to address the fourth research question — *What factors play into encouraging or discouraging teachers from using technology to accomplish the tasks?* First, all data related to encouraging and discouraging technology use was separated into two categories of *Encouraging Technology Use* and *Discouraging Technology Use*. Once they were separated into the two categories, each category was reviewed to identify themes that eventually helped identify the factors.

The third set of codes was created to address the 5th research question — *What are the implications of the findings for the 2012-2013 eLearning Priorities proposed by the Indiana Department of Education (IDOE)?* To answer this question, policy-related documents were located and technology-integration-related policy goals were identified. Themes such as *Leadership Development*, *Networking*, *Digital Resources*, *Digital Learners, and Innovation* were created based on the policy goals. The interview and observation data were again reviewed for findings that could inform the themes that were identified.

***Corroborating Evidence*.** The interviews were recorded, transcribed and analyzed. Interviews and observations were iterative in nature. In other words, observations were interspersed with interviews. Once the interviews were transcribed, interviews were sent back to the participants for member-check. Some of those transcribed interviews were also accompanied by follow-up questions to which the participants had the choice to respond. It was made clear to the participants that their responses to the follow-up questions, although not mandatory, would greatly help the research effort. In addition, once the interviews and observation data were analyzed and results for the cases written up, the write-up was sent back to at least one teacher for each school. This was done to ensure that all descriptions offered about the school were accurate. Some of the teachers responded with corrections to the write-up, which helped greatly in increasing the accuracy of what was being reported in the study.

Permissions and privacy. Prior to the start of the study, participants were asked to review a consent form to indicate their willingness to participate in the study by being

observed and interviewed. Participants were also informed that they could stop participating in the study at any time without the need to provide an explanation.

Step 4: Offer Tentative Revisions for Theory

The fourth and final step in conducting an *in vivo, post facto,* naturalistic case study is to offer, based on the findings, tentative revisions for the selected theory. In the following chapters, each of the four cases has been analyzed to reveal functions that are present or missing in the case as well as in the PIES design theory. Based on the presence and absence of functions, each chapter then concludes with recommendations regarding revisions to PIES. Each chapter also includes a section which answers the fifth inferential research question — *What are the implications of the findings for the 2012-2013 eLearning Priorities proposed by the Indiana Department of Education (IDOE)?* Finally, the Discussion chapter (Chapter 8) is based on the findings presented in the result chapters, and recommendations are made for the features and functions of PIES.

Chapter 4: Bloomington Montessori School (BMS)

Case 1, Bloomington Montessori School (BMS), was a privately funded, not-for-profit school that catered to students aged 3-12. The school was founded in 1968 and has been a member of the American Montessori Society since 1971. Education at BMS was highly learner-centered. It closely followed the Montessori model where the student was responsible for identifying and pursuing their own learning goals. The role of the teacher at BMS was that of a facilitator and a guide.

At the time the study was being conducted, the school employed a total of 19 teachers who served a total of 178 students. The school had a student to teacher ratio of 9:1. Nineteen teachers and one administrator were approached to participate in the study, and seven teachers and one administrator agreed to participate. Out of the seven teachers, three taught the Upper Elementary Curriculum and four the lower elementary curriculum. The teachers and administrator were observed and interviewed over the course of two semesters and one summer. The interviews and observation notes were recorded and later transcribed. The transcripts were then coded to answer the research questions.

Three teachers, EM, DM, and CM from the Upper Elementary Classroom (UEC) were interviewed and observed. The UEC, led by head teacher DM, consisted of 27 students of ages 9-12. All lessons were collaboratively taught by all three teachers. However, each of the three teachers specialized in one or two subject areas. For example, teacher EM was a science and mathematics teacher; teacher DM specialized in mathematics, literature, language, history, and culture; and teacher CM was a specialist in geography, history, and civics.

Teachers, AM, JM, SM, and JA from the Lower Elementary Classroom (LEC) participated in the study. The LEC, led by head teachers AM and JM, catered to 50 students of ages 6-9. The LEC functioned in a slightly different format than the UEC. Each teacher was assigned a group of students. The teachers rotated through the groups every week in order to ensure that all students had the opportunity to work with all the teachers. Similar to the UEC, teachers in the LEC collaboratively taught topics in language, mathematics, zoology, botany, history, geography, and peace education.

Descriptive Question 1: PIES Functions Reflected in Case 1

This section addresses the first descriptive question: *What information-age tasks as identified by the PIES design theory (Reigeluth et al., 2008) are being accomplished by teachers in schools that have transitioned into the learner-centered, information-age paradigm of education?*

The information-age tasks or functions identified by the PIES design theory are: (i) *Recordkeeping for Student Learning*; (ii) *Planning for Student Learning*; (iii) *Instruction for Student Learning*; (iv) *Assessment for (and of) Student Learning*; and (v) *Secondary Roles* of *Communication, General Student Data, School Personnel Information,* and *LMS Administration.* Based on the interviews and observations conducted at BMS, I describe below the PIES functions and sub functions that were incorporated in the school.

Recordkeeping for Student Learning

BMS was observed to have a robust recordkeeping system that was similar to the *Recordkeeping for Student Learning* function described by the PIES design theory.

Analysis of the data revealed the functions of the *Standards Inventory* and the *Personal Attainments Inventory*, with the exception of *Personal Characteristics Inventory*, to be in practice at BMS.

According to the PIES design theory, the purpose of the recordkeeping function goes beyond simple maintenance of a report card; rather, it is meant to "… provide systematic and comprehensive information about what each student has learned" (Reigeluth et al., 2008, p. 33). At the classroom level in BMS, teachers maintained a *Grade Sheet* – a list of activities that the student had decided to complete in a given academic year – for each student. Although referred to as *Grade Sheets*, these did not show grades earned by the students; rather, as one teacher described, "[w]e give … quantification for content, mechanics, number of drafts and number of edits [made]" (DM, Personal Interview, October 13, 2011). In other words, *Grade Sheets* simply reflected the level of mastery a student had achieved in a given topic and the different processes that the student went through to achieve the current level of mastery.

Standards Inventory. A sub-function of the PIES *Recordkeeping for Student Learning* function is the *Standards Inventory*. Based on the interviews and observation data, the BMS curriculum was designed on a set of standards; however, BMS standards were defined by the *Montessori Scope and Sequence* document (discussed in the planning section below). While the Lower Elementary classroom (LEC), which consisted of grades 1-3 (ages 6-9), was completely driven by *Montessori Scope and Sequence*, the Upper Elementary classroom (UEC), which consisted of grades 4-6, followed a blend of state standards and *Montessori Scope and Sequence*. Students in the UEC followed the state standards for History and Math. The science curriculum, on the other hand, was

completely driven by *Montessori Scope and Sequence*. One of the UEC teachers, EM, interviewed on October 3rd, 2011, also mentioned that their curriculum was transitioning away from the state standards to incorporating more traditional Montessori lessons.

Personal Attainments Inventory. The second sub function of the PIES *Recordkeeping for Student Learning* function is the *Personal Attainments Inventory.* This sub function allows students, teachers and parents to keep track of a student's progress and level of mastery in meeting their personalized learning objectives.

A system similar to the *Personal Attainments Inventory* was observed in BMS. As illustrated in Figure 4, the LEC tracked student progress via: (i) *the Weekly Work Plan*, (ii) the *Language Progress Report*, and (iii) the *Math Progress Report*. LEC teachers decided, based on *Montessori Scope and Sequence*, the list of lessons that they would be offering for the year. The teachers then worked with individual students to determine their ability levels. Students were grouped according to these ability levels, and language lessons were created for them based on the group's abilities. These ability groups were not static and were modified based on a student's rate of learning, interests, and individual learning styles. Based on constant assessment by teachers, students were moved between groups and at times given individual lessons.

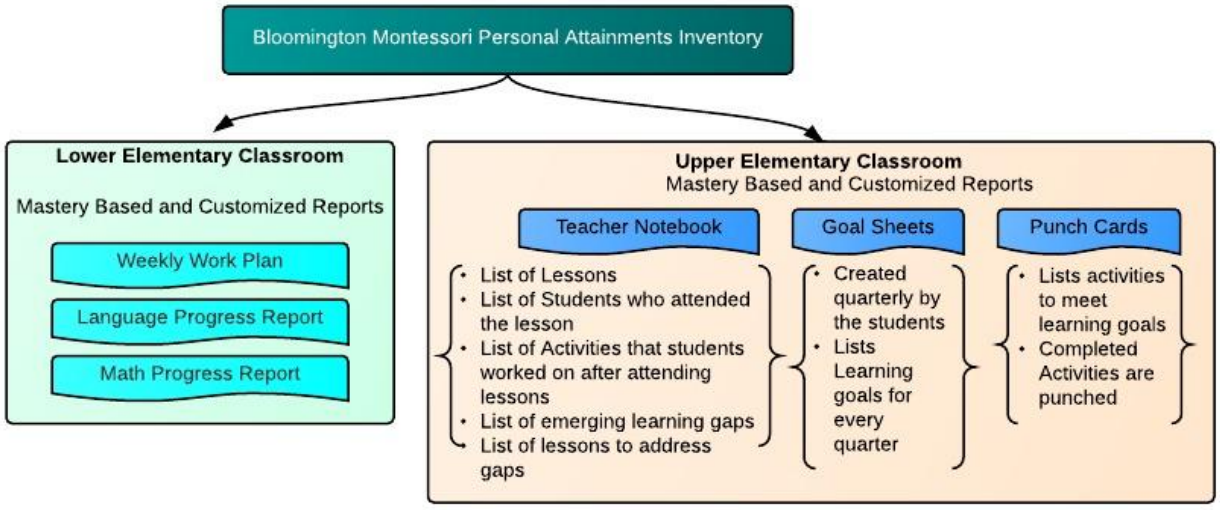

Figure 4. Personal Attainments Inventory**.**

As noted during LEC teacher interviews and observed in the LEC classrooms, students maintained a *Weekly Work Plan*, which was a grid that listed out Language, Math, Culture, Electives, and Research tasks for the entire week. Every Friday, students filled out the grid for the following week where they specified the activities that they wanted to work on to progress towards mastery of a particular concept/lesson. Occasionally, a teacher would recommend a practice activity depending on observed learning gaps.

In the LEC, students learned Language, Mathematics, and research skills. To track progress in these topics, each student was assigned a *Language Progress Report* and a *Math Progress Report*. No grades were given to the students in these progress reports; it was a mastery-based system. As stated by one of the LEC teachers, AM:

> We don't give grades; they just fix it till it is right and then when it's right, we sign it off. The only thing we actually grade is the weekly spelling test, which is ten words, and we give them a score like 6/10 or 8/10 or 10/10. [The scores from the spelling tests are averaged on the *Language Progress Report*.] Other than that,

> they just do it till they get it right. And once all their work is fixed and completed, we sign it off. So when they start on a word [or a topic listed on the progress report], we put a little slash next to that work on our clipboard, and then when we grade the work. If they have corrections to make, we put a little C. And then once they have made the corrections, we turn the slash into an X. (Personal Interview, December 8, 2011)

In the UEC, as noted during classroom observations and teacher interviews, a system similar to PIES' description of a *Personal Attainments Inventory* tracked student progress via: (i) a Notebook; (ii) a Goals Sheet; and (iii) a Punch Card. The *Notebook*, was described by UEC teacher DM, was managed by the teachers. It listed all the lessons that had been given to each student, the activities that each student worked on after having experienced a lesson, and gaps that emerged that would require additional lessons. The Goals Sheets, however, were managed by students. At the beginning of every quarter, students selected their goals. Activities were then identified that would help them achieve the listed goals and were recorded on their *Punch Cards*. Activities were then punched off as students complete them throughout the quarter. The recordkeeping in the UEC, as with the LEC, was mastery-based.

Planning for Student Learning

The purpose of the *Planning for Student Learning* function, as described by the PIES design theory, is to assist in the development of students' learning goals and learning contracts. BMS had a similar system in place. Analysis of the observation and interview data revealed the following similar sub functions: *(a) Current Options*, (b) *Short-Term Goals*, (c) *Projects*, (d) *Teams and Roles*, and (e) *Contracts*.

As stated earlier, BMS planed its curriculum and instruction based largely on the *Montessori Scope and Sequence* document. EM noted that this document, which was designed several years ago, offered a rough guideline of what students, teachers, and parents could expect every year. However, based on both the LEC and UEC teacher interviews, this document was continuously adapted. DM explains below how instructional materials, based on the *Montessori Scope and Sequence* document, were used in the classroom:

> As far as planning to use [instructional materials], we base that on the needs of the children at the time it is ready for them. That's one way that we do it. Another way that we do it is as an extension of how we interpret Montessori philosophy and what we believe, given the changes in the world, the advancements in technology, the availability of materials. Maria Montessori herself would be evolving, changing, and introducing [new instructional materials] in a modern Montessori classroom. (Personal Interview, October 13, 2011)

Each year, the *Montessori Scope and Sequence* document was influenced by advancements in technology, social, political, and cultural changes in the world and by expectations of parents and teachers.

Current options. According to the PIES design theory, the purpose of the *Current Options* sub function is to assist the planning process. It allows students and teachers to select learning goals from a collection of attainable learning options. These options are available to the learner based on the goals that they have already accomplished (the skills that they have already mastered), as listed in their *Personal Attainments Inventory.*

As observed and corroborated through interviews in the UEC, the *Montessori Scope and Sequence* function was similar to the PIES' *Current Options* function. The *Current Options* in PIES are based on the skills that the student has mastered. They are informed, according to the PIES design theory, by the *Personal Attainments Inventory*. In

both the UEC and the LEC, learning goals personalized for individual students were based on educational attainments as outlined in the *Montessori Scope and Sequence* document. The practice of creating learning goals, which were based on personalized educational attainments of individual students, was consistent with the description of the sub function of *Current Options* in the PIES design theory. Therefore, the list of learning goals, based on the *Montessori Scope and Sequence* document, was similar to the "full range of attainments that are current options for the student" in PIES (Reigeluth et al., 2008, p. 34).

Short-term goals. A sub function of the *Planning for Student Learning* function is *Short-Term Goals*. This sub function allows users to "specify the learning goals that the student will accomplish during the next contract period … [by selecting from] current options the attainments to pursue now, based on requirements, long-term goals, interests, opportunities and so forth" (Reigeluth et al., 2008, p. 34).

In the UEC, the teachers divided the learning goals for the entire academic year into a sub-set of learning goals for the upcoming quarter. Once the range of learning goals for the quarter was made available, students in the UEC were expected to identify their individual short-term (quarterly) goals. Once these goals were selected, they were approved by the teacher to ensure that the student was prepared and had the necessary skills to accomplish the selected goals. DM illustrates below the process by which students identified their individual goals based of the *Current Options* (learning goals).

> At the beginning of every quarter, [every student] has a *Goals Sheet*. They choose their goals [and] they finalize their goals. So they have basically made a work-plan for the entire quarter, which is roughly six to seven weeks. Then they translate [the goals] to those orange *Punch Cards* you've seen us punching. And

> then it's up to them to keep track of how they are keeping up with their work (DM, Personal Communication, October 5, 2011).

The PIES design theory states that *Short Term Goals* have a variable contract period that is typically two months long but should be shorter if students are younger. As observed and recorded in the UEC, students' learning goals, akin to PIES' Short-Term Goals, "have a variable contract period", which was two months long.

Unlike the UEC, the LEC did not have a function similar to Short-*Term Goals* as described by the PIES design theory.

Projects. The *Projects* function as described by the PIES design theory is a "tool [that] will help the student, teacher, and parents to identify projects or other means available in the school or community or online that will enable the student to attain the short-term goals" (Reigeluth et al., 2008, p. 34). Both LEC and UEC used projects to address student goals. Based on classroom observations as well as comments made by the teachers who were interviewed, students in the UEC and their teachers collaboratively decided on the research project that they wanted to work on. In the LEC, teachers alone decided on the projects and the activities that the students would work on.

Teams and roles. The *Teams* and the *Roles* sub functions in PIES are used to select team members to work on collaborative projects and identify and articulate the roles and responsibilities for each member of the team (Reigeluth et al., 2008, p. 34). At the UEC, according to the data collected, students worked projects individually and collaboratively. The individual and collaborative projects were selected and based on the student's self-identified goals and input from teachers and parents. For collaborative projects, students selected team members and assigned roles. The role of the teacher

during the team building and role assignment activities was to ensure that the student was heading in the direction of achieving their goals. Once teams and roles were formed, student roles and information about the teams were recorded in a notebook by the teacher.

In the LEC, students worked on individual projects that were selected by the teachers. Students did not work in teams; however, they were paired to facilitate peer mentoring. Teachers paired students based on ability and seniority. As an example, an incoming first-grade student would be paired with a second-grade student to allow the first-grader to understand and adapt to the culture and expectations of the LEC. Students, when paired with a peer, were made aware of their roles and responsibilities by the teachers.

Contracts. According to the PIES design theory, the *Contracts* function is "an agreement between a student, teacher, and parents that specifies the goals that the student wishes to achieve, the means (primarily projects) that will be used to achieve them, the teacher's and parents' roles in supporting the student, and the deadline for completing each project (negotiated with the teammates for each project)" (p. 34). Corroborated by classroom observations and teacher interviews, the *Weekly Work Plan* at the LEC and *Punch Cards* in the UEC were observed to be similar to the *Contracts* sub function. The *Weekly Work Plan* and *Punch Cards* listed all activities that the students would undertake in order to achieve their academic goals.

According to LEC teacher JM, students along with the teacher, selected the activities for their *Weekly Work Plan* to master the topics identified by the *Montessori Scope and Sequence* document. This document listed the goals that students in a

particular age-group needed to master and the sequence in which to do so. The weekly plan, therefore, was a list of activities that students agreed to work on in order to master the goals listed in the *Montessori Scope and Sequence* document. To understand how a *Weekly Work Plan* was created, consider the following description, which was recorded during an observation session conducted on Dec 8th, 2011 in the LEC:

> One of the goals in the *Montessori Scope and Sequence* document for a second grader or a 7 year old is to master the concept of prepositions. A student was given a lesson on prepositions. Then, the student, with the teacher decided the activities that he will be working on to master the concept of prepositions. The list of activities the student was to work on was included in his *Weekly Work Plan*. The student worked on all activities related to the task of mastering the concept of prepositions. At the end of the week, based on iterative assessments, the teacher decided if the student had mastered the use of prepositions. (Observation notes)

As the teacher later explained, if the student achieved mastery, he would progress to the next goal in the age/grade-specific sequence. If not, he would continue to work on the same activity until mastery was attained. The *Weekly Work Plan* also recorded the time expectations where all activities listed needed to be completed within a week. However, students who completed their weekly goals early were given additional goals. Otherwise, the tasks in their *Weekly Work Plan* were revised every Friday based on their progress.

Below is an excerpt from the interview conducted with teacher JA from the LEC where she explains how the *Weekly Work Plans* were created.

> They decide what they are going to practice. So the teacher presents lessons, and I do things like letting them vote sometimes, but for the most part the teacher generally [selects] the lessons that they're going to learn. And on Friday mornings they write a work plan for the following week that is just a grid with language, math, cultural and research work for Monday, Tuesday, Wednesday, Thursday, and Friday. [We] have writers' workshop and language circles [that] are required on Wednesday's and Fridays. [That] leaves them three days to pick between the many lessons they've learned recently and sign-up for what they'd like to practice. (Personal Interview, November 21, 2011)

In the UEC, *Goals Sheets* are interpreted and translated into activities listed on the *Punch Cards*. These *Punch Cards* were similar in function to *Contracts* described in the PIES design theory. They were created for every quarter and they listed all the projects and activities that the students would accomplish in order to achieve their goals identified *Goals Sheets*. Based on the observation and interview data, the function of the *Punch Cards* was to articulate the tasks that the student had to complete and to track the progress that the student was making on those tasks. It was a checklist of activities that the students worked through within a given timeframe.

Instruction for Student Learning

The *Instruction for Student Learning* function, according to the PIES design theory, is intended to support learner-centered instruction by enabling teachers to select or design instructional tools for students to use and to coach students during their use of those tools (Reigeluth et al. 2008, p. 35). In BMS, teachers were meant to function as observers. As administrator JK noted during his interview:

> In the Montessori setting you don't want the teacher to be teaching. You want the teacher to be an observer. You want the teacher to be a director. You want the teacher to be preparing the environment so that the children are able to extract from the environment what they need, rather than having the teacher imparting knowledge (Personal Interview, December 19, 2011).

BMS instructional strategies and practices, identified through observation and interview data, were found to be similar to sub functions of *Project Initiation, Instruction, Project Support,* and *Instructional Development* — all of which are the sub functions of *Instruction for Student Learning.*

Project initiation. The sub function of *Project Initiation*, according to the PIES design theory:

> … will provide access to more information about the project (or problem) and will help the teammates identify tasks to perform, how they will work together on each task (collaboratively on the same tasks, or cooperatively on different tasks), the resources they will need, and milestones for different tasks during the project (time management) (Reigeluth et al., 2008, p. 35).

While learning goals were identified differently at the LEC than at the UEC, as described above in the *Planning for Student Learning* section, in both classes, the activities/projects to achieve those learning goals were chosen similarly, i.e., by the students. However, students at the LEC did not work collaboratively in teams. Once a student had decided on his/her project/activity, the teachers guided the student towards appropriate supportive materials.

In the UEC, at "the end of each quarter, as students [completed] their work, they [participated] in a large-group educational activity that [was] originated, selected and voted on by the whole class" (Bloomington Montessori, n.d.). The above quote illustrates the process of intersession, during which students collectively decided the projects that they were going to work on and the peers with whom they were going to collaborate. Students individually pitched ideas, which had to be approved by all students. They were also responsible for selecting and designating individual roles. The role of the teachers during these group projects was to coordinate the effort, provide resources and lessons if needed, and facilitate group interactions.

Instruction. Once projects and project members have been decided, the PIES design theory recommends that the *Instruction* function, a sub function of the *Instruction for Student Learning* function, will provide students access to instruction that they may

need as they progress. The *Instruction* function will serve as a database for all types of instructional resources such as drill and practice, simulations, tutorials, web quests, and educational games.

Based on observation data, both the LEC and the UEC had a vast collection of instructional materials. All instructional materials, which included lessons, drill-and-practice activities, and research materials, were easily accessible by all students. Both classrooms were divided into sections, and each section was dedicated to a particular subject. For instance, there was the Math corner where students congregate for Math activities. The Math corner was also the place where all instructional materials related to Math were stored and accessed. In order to ensure that students could access these materials without adult supervision, the furniture used through-out the classroom was age appropriate. The same was true for Language, Science, Culture and Geography, and History.

PIES notes that "Debriefing and reflection on the project activities at the end of the project — and periodically during the project — will also be important to the learning process and will be facilitated by the instructional tool" (Reigeluth et al., 2008, p. 35). To corroborate this claim, it was observed that both at the LEC and the UEC, teachers and students had regular discussions about an activity or a project after and during the life-cycle of the activity or the project. Below is a quote from DM who articulates the need for a debriefing process.

> If a child does a really wonderful experiment but they never articulate what they have learned from that, I feel like something is really lost; a moment is lost. Just like we as adults can have a lot of really wonderful experiences, but if we are not someone who is introspective or reflective or who journals or who takes those

> experiences and translates them into something else, whether it be how you teach, how you counsel people, how you deal with your interpersonal relationships, how you parent, how you paint your painting, you are missing something. You have all these opportunities to translate experiences into something, and I think that we help children do that by expecting that final piece; by putting closure on things. … Well with us it is really writing up a research and that's the conclusion of what you did and documenting what you did, instead of just having the experience. (Personal Interview, October 5, 2011)

Project support. According to the PIES design theory, *Project Support*, another sub function of the *Instruction for Student Learning* function, allows teachers to track progress on a project and allows them to offer instructional assistance if a learning gap is identified. As observed and interpreted from teacher interviews, all project support functions were being accomplished by the *Weekly Work Plan* in the LEC and *Punch Cards* in the UEC.

Instructional development. *Instructional Development*, the last sub function of PIES' *Instruction for Student Learning* function, allows teachers, students, and parents to create instructional materials. Based on the data gathered in the form of observation notes and teacher interviews, in both the LEC and the UEC, instructional materials were purchased from companies that specialized in creating Montessori materials. These companies are either certified by the Association Montessori Internationale (AMI) or the American Montessori Society (AMS).

In addition, it was noted during several of the interviews that teachers also created their own instructional materials depending on student needs as well as availability of resources. Some of the instructional materials were created based on student suggestions. For example, the spelling list in the UEC was created based on words that the students suggested. Parents did not have any direct input in the creation of instructional materials.

Assessment for (and of) Student Learning

According to the PIES design theory, the *Assessment for (and of) Student Learning* function consists of: (a) *Presenting Authentic Tasks*, (b) *Evaluating Student Performance*, (c) *Providing Immediate Feedback*, (d) *Certification*, (e) *Developing Student Assessments*, and (f) *Improving Instruction and Assessment*.

Assessment functions in BMS observed to be similar to the sub functions listed above were: *Presenting Authentic Tasks, Evaluation Student Performance, Providing Immediate Feedback, Developing Student Assessments,* and *Improving Instruction and Assessments*

Presenting authentic tasks and evaluating student performance. At BMS, students learned through the use of authentic tasks. Based on observation and interview data, projects, assignments, and drill and practice activities were administered and evaluated to determine if the stated learning goals were being met. At BMS, the sub functions of *Presenting Authentic Tasks* and *Evaluating Student Performance* were inter-connected. Every task, whether academic or social, was evaluated for student performance. Students were not simply given an authentic task to practice and then given summative assessments to determine if they had mastered an objective. Instead, they were formatively evaluated both when the student asked for help and when the student submitted the completed task (which, if not satisfactory, was given back with feedback for the student to continue to work on).

Providing immediate feedback. As BMS data revealed, students continued to work on their individual learning goals at their own pace. Their work was consistently

reviewed and critiqued (*Providing Immediate Feedback)*. To illustrate the interdependent and cohesive process of learning, assessment, and feedback, below is an excerpt from an interview with EM.

> … we have a unique grading system, and we are not grading kids against each other, and we don't have like a benchmark of where we expect every fifth grader to be or every sixth grader. We try to grade or evaluate based on what we know about the child. But we look at content especially on the [research projects]. Did they cover … the essential parts of [the projects]? The second part is based on organization, spelling, mechanics, [and] things like that. And then since we do multiple drafts of the same paper, we also take a look at how many drafts it's taking kids to get a paper that's in final draft format. Now we also – we don't generally, particularly on the first draft, code it in the traditional editing way — we encourage kids to find their own errors and we give them hints. And we also evaluate them on how well they are looking at and editing their own work. (Personal Interview, October 3, 2011)

It was observed that in both the LEC and the UEC, students consistently received feedback at times when they needed it the most. It was also observed that feedback was given to students when either the student asked for help, or when the teacher intervened to offer that feedback (having identified gaps in the student's submissions). It was observed that students also received feedback from their peers.

Developing student assessment and improving instruction and assessment. As noted during classroom observations and corroborated through teacher interviews, when student-work was reviewed and assessed formatively (as previously described), teachers were able to quickly identify aspects in their instruction and assessments that could be improved. Teachers taught in teams at both the LEC and the UEC and therefore constantly collaborated to ensure that their instructional materials, methods, practices, assessment materials and evaluation strategies were effective. Teachers also collaborated and constantly consulted with the students (especially at the UEC) regarding the

effectiveness of the projects and assignments that they were working on. In some cases, students not only self- and peer-evaluated, but also actively participated in the creation of instructional and assessment materials.

To illustrate how assessment and instruction were integrated in the classroom, below is quote from EM, describing the process. The quote below illustrates how some instruction was not used to determine student progress; rather it was used to identify gaps and learning targets and content for creating instruction.

> We don't even give back [math quizzes] to the kids. We keep them to know what kind of lessons the kids need. So it's not like we are giving [them] letter grades. We don't really chart progress based on how they are doing on each one of their quizzes. But it does give us an idea of what lessons need to be taught (Personal Interview, October 3, 2011).

Secondary Roles

PIES design theory recommends the inclusion of secondary functions such as *Communication, General Student Data, School Personnel Information* and *LMS Administration* into the design of LMSs that cater to the learner-centered paradigm of learning. All PIES secondary functions were observed in BMS, with the exception of *LMS Administration*.

Communication. At BMS, teachers, administrators, parents, and students used emails and phones to communicate with each other.

General student data. These data were maintained on excel spreadsheets at the administrative level and in student binders by teachers in the classroom.

School personnel information. This information was maintained at the school level.

Related Formative Question 1(a): Improvements

The goal of the first descriptive research question was to identify functions in BMS that were similar to the functions described in the PIES design theory. Now we will address the formative component of research question 1, which asks: *What improvements can be made to the tools (functions) offered by the PIES design theory to better perform those tasks?* Therefore, the goal is now to determine, based on the similarities that have been identified, how the corresponding functions in PIES might be improved. However, it is important to keep in mind that corroborating results from subsequent cases are needed to reinforce the merits of these suggestions.

Recordkeeping for Student Learning

Based on the comparison between the recordkeeping functions observed at BMS and the *Recordkeeping for Student Learning* functions described by the PIES design theory, the following recommendations should be considered.

Standards inventory. Grounded in observation and interview data, it is recommended that the sub function of *Standards Inventory* allow for the inclusion of standards set by non-public organizations in addition to state and national standards.

As mentioned by teachers during their interviews, both *Montessori Scope and Sequence* as well as state, national, and local standards provided teachers and students a learning map through which they could address learning needs in a systematic fashion.

BMS created their own *Scope and Sequence* that guided their curriculum. State standards were only used in the design of the social studies curriculum for the UEC. For everything else, teachers referred to *the Montessori Scope and Sequence* to design their curriculum. As BMS was a private school, they had the flexibility to not have to follow the state standards. Due to this flexibility, the use of state or national standards was optional.

Based on this finding, the *Standards Inventory* could allow users the option to choose sets of standards outside of state and federal standards. Standards such as *The Montessori Scope and Sequence* or even Waldorf (Steiner) education standards are examples that could be made available to users through the PIES *Standards Inventory*. If PIES is able to offer access to a variety of standards, then depending on the type of school that uses the system —public or private — it may offer users greater flexibility in creating learning goals and learning processes.

Planning for Student Learning

Based on the comparison between the planning functions performed at BMS and the *Planning for Student Learning* functions described by the PIES design theory, improvements can be suggested for the *Projects* sub function.

Projects. According to the data, the *Projects* sub function may be renamed to *Activities*. This recommendation is largely suggested based on the finding that not all instructional activities observed and documented at BMS were project-based. The current description of the *Projects* sub function in PIES states that "typically, projects will be used as the means, but other options will sometimes be available (e.g., readings with discussions, or tutorials) (Reigeluth et al., 2008, p. 34). In other words, including

additional instructional activities is surely accounted for in the description of the *Projects* sub function; however, in the description, there is also a significant emphasis on projects being the primary means through which *Short-Term Goals* are being addressed. But in BMS, that was not the case.

As observed in both classrooms and corroborated through teacher interviews, instruction and learning at BMS did not always occur through group projects. In the LEC, students did not work on any projects; they mostly addressed their learning goals through short, individual activities and assignments. At times, a slightly longer, more elaborate assignment such as a research paper was used as a means to achieve their learning goals. In the UEC, it was only during intersession that students collaborated on group projects and worked in teams. It was only during these projects that functions similar to the PIES' *Teams* and *Roles* sub functions were observed to be in practice.

Therefore, it can be suggested that the *Projects* sub function be renamed to *Activities* and that it should be a repository of all instructional activities and means through which short-term goals can be attained.

Instruction for Student Learning

Based on the comparison between the instruction functions performed at BMS and the *Instruction for Student Learning* functions recommended by the PIES design theory, improvements can be suggested for the *Instruction* sub function.

Instruction. Having observed how instructional spaces are designed and managed at BMS, the following recommendations for designing instructional interfaces that are usable, accessible and visually appealing are being made.

Usability and Accessibility. At BMS, instructional spaces were clearly marked. Lessons and activities within the instructional spaces were carefully arranged such that they could be accessed and used without adult supervision. Height and shape of furniture within these instructional spaces were carefully selected based on the age-group of students accessing these instructional spaces. Therefore, when designing virtual instructional spaces in PIES, it is important to pay attention to the accessibility and usability of the instructional interface. Students should be able to access instructional materials, such as simulations, drill-and-practice, and web-quests, without any usability issues. The instructional interfaces should be simple to use for all students.

Ensuring a degree of visual appeal. In BMS classrooms, special attention was paid to ensure that the learning environment was appealing to the students. This was achieved through the use of colors and imagery that were age appropriate. Similarly, in the design of the instructional interface, color schemes and imagery should be carefully selected so as to ensure a degree of visual appeal for the students accessing the instructional space.

Reflection Function. The use of reflection as a widely used instructional and evaluation strategy was observed as well as corroborated through teacher interviews at BMS. Upon completion of an activity or a project, the students should have the ability in PIES to post a reflection of their learning experience. They could chose to either share the reflection with only the teacher or with the entire class. This function could be rendered in the form of a public forum or as a private message board in PIES.

Descriptive Question 2: Functions Lacking in Case 1

In this section I list the findings that answer the second descriptive research question: *"What information-age tasks identified by the PIES design theory are not being accomplished by teachers in such schools?"* Sub functions of *Personal Characteristics Inventory, Long-term Goals*, *Certification*, and *LMS Administration* were neither mentioned by the BMS teachers during their interviews, nor were they observed during classroom observations.

Personal Characteristics Inventory

Both in the LEC and the UEC, there was no organized system in place that could be compared to the *Personal Characteristics Inventory* as described in PIES. This is one of the three sub functions of the *Recordkeeping for Student Learning* function. In BMS, teachers kept track of students' personal characteristics, but only at an informal level. Observations about students were made and shared amongst teachers, who then decided on the best learning strategies. However, there were no formal records as envisioned in PIES that any teacher was able to access.

Long-Term Goals

Part of the *Planning for Student Learning* function is *Long-Term Goals.* BMS did not have a system that recorded or managed *Long-Term Goals* for students. It was not observed or noted during interviews at either the LEC or the UEC.

Certification

One of the sub functions of the *Assessment for (and of) Student Learning* function is *Certificatio*n. According to the PIES design theory, a student can achieve certification if he/she is able to demonstrate consistent performance (meeting a particular criterion) in "x out of the last y unassisted performances" (Reigeluth et al., 2008, p. 36) of a particular skill. The system will check off that attainment and link it to the evidence of that attainment. BMS did not have a system that could be classified as being similar to the PIES certification system. At BMS, once students had demonstrated mastery in a certain attainment, the attainment was checked off. The process that was followed to ensure mastery was working on the same tasks, through cycles of revision, until there were no observed errors. The skills learned through those tasks were then applied to different activities to ensure mastery as well as transfer. If a student was unable to demonstrate mastery of the skill when applied to a different task, the student was instructed again in the original task and encouraged to practice more. As DM in the UEC explained:

> I have a 5th grader now who has moved through some books really quickly; but I am noticing [through other activities that] he has forgotten a number of things. So, I have put him in what I can mini workbooks and given him some remediation. I have two 6th grade girls who are doing some fraction remediation. I would say [to them], "it looks like you would need to practice these a little more so let's approach them this way". (Personal Interview, October 5, 2011)

Therefore, mastery of a particular skill was observed, but not on x out of the last y unassisted performances.

LMS Administration

Because BMS did not use an LMS, there was no function that could be compared to the LMS *Administration* function in the PIES design theory.

Related Formative Question 2 (a): Improvements

This section lists the findings that answer the formative question vis-à-vis, *What PIES functions, if any, should be changed or removed as a consequence?* Based on the findings, the following additions to the PIES' *Certification* sub function can be suggested. Note that corroborating results from subsequent cases are needed reinforce the merits of the following suggestions.

The *Certification* sub function could be altered to include alternative methods for certification. The PIES design theory states that certification can only be achieved when an attainment can be performed a number of times without any assistance from a teacher or a peer. Such a form of assessment is true for skills that are objective and easily measured. The goal at BMS was to ensure that the student had not only mastered a said concept, but had also internalized the concept such that it became a part of their broader set of skills. This point was illustrated by UEC teacher, DM.

> I have given several set theory lessons to children who were at a certain point in the math practice series that we used where they were encountering union and intersection. And so … I know this to be a problem in that series … they do that for like one or two pages and move on. So they figure out the skills for those one or two pages and then they just forget it. So, I put it on the quiz and they were dumbfounded … you know, and most of them had completed those pages and completed them successfully. So what I learned from that is, OK, despite having a lesson, despite doing two practice pages, they didn't internalize the concepts. So if you knew intersection, which is your basic set-theory concept, they should have to move on. Therefore, we planned a second set of lessons on those. (Personal Interview, October 5, 2011)

To attain certification, performing a certain task, unassisted, x out of y times, should not be the only criterion. "The criterion for successful performance has been met x out of the last y unassisted performance" (Reigeluth et al., 2008, p. 36) should be extended to specify that it be spaced out to ensure long-term retention. However,

Presenting Authentic Task — a sub function of the *Assessment of (and of) Student Learning function* — states:

> To truly master an attainment, the learner must be able to use it in the full variety of situations for which it is appropriate. Those authentic situations will be used as the instances for the demonstrations (or examples) and applications (practice) of the attainment. There will be a large pool of authentic instances to draw from, that will include all the types of instances. And the learner will continue to do the applications until an established criterion is met across all the desired types of instances. (p. 36)

The sub function of *Presenting Authentic Task* ensures that students have access to a full variety of tasks in order to truly master an attainment. Similarly, the sub function of *Certification* should also make explicit that certification will be granted when skills have been assessed based on their successful application over time and in varied situations to ensure transfer (near and far) and mastery.

Descriptive Question 3: Functions Lacking in PIES

This section lists the findings that answer the third descriptive question: *What tasks are being accomplished in such schools that are lacking from the PIES design theory, if any?* Functions of *Selecting Students for Group Lessons*; *Tracking Instruction*; *Peer Mentoring as an Instruction Function*; *In Step with the World; Socially, Politically, and Culturally Relevant Instruction*; and *Teacher Training* were observed and documented during interviews at BMS, but were not described in the PIES design theory.

Selecting Students for Group Lessons

In the UEC and the LEC, students were grouped for lessons based on learning needs. As explained during teacher interviews, this was done to alleviate the pressure on the teachers managing customized instruction for a class of thirty or more students.

Students were given individualized lessons when needed. Also, students were arranged into groups of two to four to ensure that they could help each other learn the new concepts that they were introduced to. Due to this grouping, the social aspect of learning endured. According to the PIES design theory, team formation, articulated in the sub function of *Teams*, is primarily driven by factors such as collaboration, common interests, and diversity (such as age, race, gender, socio-economic status, and personality traits). However, there was no mention in PIES regarding organizing peer groups based on the lack/presence of commons skills sets and knowledge.

Tracking Instruction

Teachers at BMS routinely invited students to lessons that supported their particular learning objectives. Attendance at these lessons was initially optional. If the students repeatedly failed to attend the lesson, the teachers intervened to persuade them to attend. Based on the interview data, teachers maintained student records that tracked instances of instruction that the students had been invited to and had attended. In addition, these records also tracked the number of times the students attended each instructional session, topics covered during those sessions, and areas where the students had sought assistance. This record was crucial as it helped the teachers assess and identify learning gaps and determine if instructional strategies that had used in the past were proving effective. Teachers also maintained detailed reports regarding lessons that had been given to students. As noted in the excerpt below by teacher DM, teachers took notes regarding:

> who [seemed] to listen or not listen; who seemed excited or not excited; who seemed confused. So we know when I look at these notes and it says, oh, so-and-

> so was there but was really, clearly was not grasping what was going on. I know to invite them to the next lesson. And that gives me a little more information as to why, rather than simply *needs* another lesson. (Personal Interview, October 5, 2011)

According to the PIES design theory, it is through the sub function of *Instruction* that learners will be able to access "customized learning objects of various kinds" (Reigeluth et al., 2008, p. 35) in order to learn new concepts needed to work on their projects. However, the PIES sub function of *Instruction* does not articulate if it will track what instructional objects are being used, how often, and the sequence in which they are being used. In addition, the sub function does not articulate if it will be able to track how students respond to the instructional objects that they are accessing.

Improving Instruction and Assessment, a sub function of *Assessment for (and of) Student Learning*, states the following:

> The final function of the assessment tool will be to formatively assess the instruction and assessments in the LMS. It will do so by automatically identifying areas in which students are having difficulties, and it will even have diagnostic tools that offer a menu of suggestions for overcoming those problems. Those diagnostic tools will include proven principles of instruction, such as those represented by Merrill's (in press) "First Principles of Instruction." (p. 37)

The PIES design, through the sub function of *Improving Instruction and Assessment*, does reference the idea of having mechanisms in place to improve instruction. However, it does not offer a detailed description of processes involved in improving instruction.

Peer Mentoring as an Instruction Function

As observed in both the LEC and the UEC as well as described by several teachers in their interviews, peer mentoring was practiced extensively in both classrooms.

Project work and learning activities were rarely done in groups. In fact, in the LEC students did not work in groups on any projects. However, students were routinely paired up, to provide peer support and mentoring when needed. The importance of the mentoring process in the Montessori classroom and a description of it are provided below in an excerpt from LEC teacher SM's interview.

> What's interesting is the mentoring that happens in this classroom. … the older kids do really help the younger kids a lot. And I don't think I understood when I came into this classroom how much they do, but they really do a lot. They'll tell each other what needs to be done or what needs to happen or what is expected. There are a couple of girls that are both in the second grade. One is new to … the Montessori classroom. The other one's been here last year. So she'll be honest with her … you've really only got one work done … it's almost recess … what were you doing? … they do kind of keep an eye on each other or tell each other most of the time. A lot of them will tell each other what's going on or want to help the other ones. (Personal Interview, December 6, 2011)

Students are introduced to new concepts in groups or pairs so that they can help each other. According to one of the LEC teachers:

> [Students who help each other] remember how to do the new work and get through the first few [math] problems. But then the very next day they will have their own [math] problems so that we can be sure that each of them learned the lesson without the other ones help. (AM, Personal Interview, December 8, 2011)

Socially, Politically, and Culturally Relevant Instruction

Teachers and students at BMS, when planning instructional and learning goals, routinely incorporated changes in technology, culture, politics, and society. In order to create an educational system that effectively caters to student-needs, it should be abreast of all relevant changes happening in the world, be it technological, political, social or cultural. The current design of PIES provides a mechanism (sub function of *Projects*) that could provide students with projects that are up to date with world events, but it does not

explicitly state the need for this or provide any tools to promote the integration of current, local, and world trends/events into the creation of these projects.

Teacher Training

Even though the Montessori organization offers a robust teacher training program, some teachers at BMS were trained in-house through the apprenticeship model. One of the teachers who participated in the study, SM, was in training. As stated during teacher interviews, most of the teachers at BMS were Montessori trained, but sometimes teachers and administrators decided to hire individuals who did not have a formal teaching certificate or degree.

> I haven't been teacher-trained at all, and I don't have an education degree. My undergraduate degree was in global studies with an emphasis on Eastern Europe and extensive studies in Armenian. I had always been working with kids … [And when] this job opening came around, I applied. Luckily while I was applying, I got to sub a few times. [The school administrators] say they like well-rounded people, different people who are open to different things. I was self-conscious at first about not having a teaching degree, let alone Montessori certified. But then [the principal] reassured me, and he said, "you know a lot of people in this school have the opinion that sometimes it's nice to have people who are not teacher trained because they come in without certain expectations and certain ideas. They can just go with it and bring something different to the table." [This] made me feel a lot better and it was kind of nice too. (SM, Personal Interview, December 6, 2011)

The teacher quoted above was being trained by the most senior teacher in the classroom. She had the same number of students as the other teachers. She was not only learning how to teach, but also gaining expertise on how to create instructional materials based on student needs. In addition, through her apprenticeship, she was learning about the Montessori teaching philosophy and how a learner-centered environment functioned. The current design of PIES does not offer any function that would manage a teacher training program.

Related Formative Question 3(a): Improvements

Based on the functions at BMS that were observed to be lacking in the PIES design theory, several recommendations can be suggested to improve the design of PIES. One recommendation suggested for the *Planning for Student Learning* function is to include the sub function of *Really Simple Syndication* (RSS) functionality. It is also suggested that the *Instruction for Student Learning* function include *Tracking Instruction* and *Peer Mentoring* sub functions; and the *Secondary Functions* include a *Teacher Training and Professional Development* sub function. As with previous recommendations, the following recommendations are substantiated through corroborating evidence in subsequent cases.

Planning for Student Learning

Really Simple Syndication (RSS) Functionality. The *Planning for Student Learning* function may include a function similar to Really Simple Syndication (RSS) to keep students and teachers abreast of technological, political, social, and cultural changes in society. This functionality will allow teachers and students to link to external sites, such that information relevant to the user is imported into the PIES interface without requiring the user to leave the PIES interface to search different sources. For example, teachers, currently, browse several sites such as CNN.com, History.com, PBS.org, or other informational sites to identify a topic for a lesson or a project. With the RSS functionality, teachers will then be able to link to several sites. Whenever a new story is published on any one of the linked sites, the RSS interface will be populated with the updates. Through this functionality, teachers will be able to view all the latest updates, in

their areas of interest, in one consolidated place. And this will enable students and teachers to have the information needed to create learning goals and instructional materials that are current and relevant.

Instruction for Student Learning

Tracking Instruction. A sub function called *Tracking Instruction* may be added to the *Instruction for Student Learning* function. The system will track information related to effectiveness of instructional objects and their components, the frequency and the sequence in which the instructional objects are accessed, and the manner in which students respond to instructional elements. It will also track topics on which the students have required assistance outside the instructional space, and the number of times the student has sought assistance in that particular topic. Including this functionality will help teachers and students identify lessons and activities that are not effective and relevant (or those that need improvement). It will also help them identify topics for which instructional materials need to be created.

Peer Mentoring. In *the Instruction for Student Learning* function, a sub function called *Peer Mentoring* should be added. Peer mentoring may be achieved through either pairing students for the sole purpose of mentoring each other, or they may be grouped based on learning needs and gaps. As established earlier, there are instructional advantages to using peer mentoring as a part of overall instructional practices.

In a learner-centered classroom environment, the common reasons for grouping students is to not only provide targeted instruction to small groups of students with similar learning gaps, but to also create a support network for students such that they may

help each other while they master new concepts. While this reasoning is less important for an online environment where it is conducive for students to work individually at their own pace, mentorship can still be beneficial to students' learning gains. The benefit that peer mentoring offers in a physical classroom (develop support mechanisms for students to rely on for both collaborative and individual work) is applicable in online environments.

The sub function of *Peer Mentoring* in PIES would provide opportunities for mentorship and collaboration (positive effects of group-based learning) currently not provided in PIES. *Peer Mentoring* would provide an effective way for students to develop support systems that can help them in their individual work as well.

In a previous finding, I noted that not all projects that students worked on in BMS were group-based. PIES should offer a function that will give users the opportunity to allow students to learn valuable social skills by collaborating and working with their peer, even if they choose not to use collaborative projects as a significant part of their instructional strategies. This provides further justification for the recommendation that the sub function of *Peer Mentoring* be added to the *Instruction for Student Learning* function.

Secondary Functions

Teacher training and professional development. Based on the observation and interview data, a teacher training function may be added to the *Secondary Functions* of PIES design theory. The training model that was observed at BMS was an apprenticeship model. However, at BMS there were also teachers who were traditionally trained and

certified in the Montessori method. Therefore, the teacher training function, if included in PIES, could provide features that allow for an apprenticeship training model as well as access to online training programs offered by universities and other organizations, through which aspiring or current teachers can get certified.

Descriptive Question 4: Encouraging/Discouraging Technology Use

This section lists findings that answer the fourth descriptive question: *What factors play into encouraging or discouraging teachers from using technology to accomplish the tasks?* Based on the observation and interview data, several factors that encourage and discourage technology use and implementation were identified by BMS teachers and administrators. These factors, described in more detail below, are *Perceived Usefulness*, *Perceived Ease of Use*, and *Perceived Threats*.

Perceived Usefulness

Teachers at BMS often mentioned during their interviews that if technology did not prove useful, they were not likely to use it. “When technology is lame, [it] just isn’t great. We just haven’t developed a fully thought-out curriculum by which we can address all the issues where the teacher can feel totally confident” (JK, Personal Interview, December 19, 2011). As implied by the quote above, for technology to be effective, it should be able to demonstrate its ability to aid in learning.

Based on the interview data, BMS teachers also believed that technology that was flashy or novel was not necessarily effective. “It’s so game-centered, it’s so bells and whistles, it’s so pink elephant that it’s just counter intelligence rather than intelligence building” (JK, Personal Interview, December 19, 2011).

In addition to aiding in learning, technology may be considered useful if it is able to meet a need. "For me technology has to address something in the classroom that the teacher of the current set-up doesn't address; it has to meet some unique need for it to justify its existence" (JK, Personal Interview, December 19, 2011). For example, teachers in BMS managed a lot of data on a daily basis. Traditionally, they managed their data through the use of notebooks, binders, and ledgers. DM in an interview conducted on October 5, 2011, explained that technological interventions that presented themselves as a more efficient alternative to managing large sets of data did not seem attractive when its users had to continue using the same cumbersome processes for data entry and management. Simply replacing ledgers and notebook with laptops and keyboards did not ensure that the technological innovation is now useful. She then proceeded to describe that introducing such a system into the classroom would have just meant that teachers would now have to re-invent and re-learn the entire process of entering and managing data — something that they had been effectively accomplishing through the use of notebooks, binders, and ledgers.

Therefore, in order to support the use of technology, technological interventions need to be effective by aiding in learning, meeting instructional and administrative needs, and saving time.

Perceived Ease of Use

During the interviews, teacher also highlighted that for technology innovation to be easily adopted in a classroom, it should be designed such that it is intuitive and easy to use. During an interview conducted on June 19, 2011, EM described an online grade

management system that a parent created for BMS. She stated that the system quickly fell out of use as the teachers found it difficult to use. Therefore, ensuring that technology solutions are tested and usable may help in encouraging teachers to adopt the solution successfully.

Perceived Threats

Based on the analysis of the interview data, commonly held beliefs amongst BMS teachers regarding the dangers of technology integration include: (i) *Technology is not humanistic* and (ii) *Technology is distracting*.

Technology is not humanistic. When I asked the teachers if the Montessori Model of education could be created and executed online, the answer was a unanimous *no*.

> Because [learning] requires face-to-face interaction; it requires hard work. Because with an online relationship, a sedentary, somewhat limited, relationship [is implied]. This is contrary to the [Montessori] movement, the integration, the energy, of [all] … things that are necessary for a Montessori classroom. I don't see that working. (DM, Personal Interview, October 5, 2011)

> I do not think [an online environment] would work as well. I think a big part of teaching is the interaction with children. I think in theory it could work, but … I think so much of what happens is kind of spontaneous in the Montessori environment. [In an online environment] you're not standing right there, you can't point to things in front of them and you can't walk with them to the [corner] of the room [and show them a specimen]. … [You] can pull something up on the screen but … I don't think it would work as well. (CM, Personal Interviews, October 4, 2011)

> I think I can't see it working online for a few reasons. I think … that being able to talk and really read kids and their body language plus the actual manipulation of [an] apparatus … are things that you just really need to see and touch. (EM, Personal Interview, June 19, 2011)

> [Learning is] … very personal … connected, and in-time. Working with small

> children, you really can see … their emotions. I think that can be valuable. [You] can see [when] they are getting frustrated. (JM, Personal Interviews, December 1, 2011)

All teachers interviewed, strongly believed that technology will not be able to replace the humanistic value that teachers can bring to a learning process.

Technology distracts from real learning. Technology was also perceived as a distraction from learning. As CM noted:

> [Students] are getting away from books with good information that has been researched and checked over, and they're moving towards ask.com and these [types of] websites that really don't have [good materials]. They might have accurate information, but there [are] no good places to look. [There is Wikipedia]. I go to Wikipedia all the time, but we don't encourage reports to come from Wikipedia. (Personal Interview, October 4, 2011)

Inferential Question 5: Implications of the Findings on *2012-2013 eLearning Priorities* Proposed by the Indiana Department of Education (IDOE)

2012-2013 eLearning Priorities

The *2012-2013 eLearning Priorities* (see Appendix C) was a state-driven, autonomous, and decentralized technology integration vision that the Indian Department of Education (IDOE) proposed. Based on a set of ideals and goals elaborated in the *2012-2013 eLearning Priorities*, the IDOE offered several technology programs and grants that schools could qualify for to improve students' educational outcomes. In order to qualify for these grants, the District offices needed to create *Technology Integration Plans* and have them approved by IDOE administrators.

The *2012-2013 eLearning Priorities* document listed technology integration goals

along with grants and programs that IDOE made available for schools in Indiana (Office of eLearning, 2012). The programs offered by the *2012-2013 eLearning Priorities* document sought to make progress in addressing ideas and realities (Office of eLearning, 2012) by offering programs and funding opportunities. The *2012-2013 eLearning Priorities* ideas and realities (eLPIR) were as follows:

- Strong, informed, and visionary leadership is necessary to move schools and communities toward the opportunities and advantages of digital-age learning.
- Schools are at very different places on the continuum of innovation through technology and the strategic use of available state funds will target innovation leaders and in parallel widen the circle of schools ready to capitalize on local vision and the strong desire to innovate.
- Access to high quality content is increasingly important as schools shift from traditional textbooks to a digital curriculum.
- There are many examples of schools and individuals delivering high quality instruction and achieving improved student outcomes, yet there are challenges in tapping into their expertise.
- Online and virtual learning is pervasive and poised to expand dramatically in the coming years.
- Student comfort with technology is not synonymous with being an effective and able learner in the digital age. The skills and aptitudes of students to learn in digital environments should be addressed through integrated curricula and assessed periodically.
- Indiana is a state that has the capacity to connect school to new products and services, test them in real classrooms, share the results and strategically abandon or iteratively implement. (Office of eLearning, 2012, p. 1)

The Office of eLearning offered grants to support the implementation of their eLPIR. Schools that wished to implement these eLPIR could propose plans to apply for these grants.

Implications of the Findings on eLPIR

To determine the implications of the findings from Case 1, BMS, for the *2012-2013 eLearning Priorities*, the eLPIR were thematically organized into five major categories: (1) *Leadership Development*; (2) *Networking*; (3) *Digital Resources*; (4)

Digital Learners; and (5) *Innovation*. Data collected at BMS, tentatively informed categories of *Leadership Development* and *Digital Resources*. In the following sections, I will describe each of the two categories and discuss how the findings from BMS may have informed the ideas and realities of the eLPIR.

Leadership development. According to the eLPIR, the IDOE wanted to make concerted efforts to build a cadre of people who will be instrumental in spearheading technology integration and moving "schools and communities toward the opportunities and advantages of digital-age learning" (Office of eLearning, 2012, p. 1). Based on data from BMS (detailed below), to create a leadership that would be successful in leading educational communities towards the digital-age, it was recommended that the IDOE foster leadership efforts by addressing observed mindsets that could impede the process of successful technology use and integration.

The data from BMS revealed that some teachers and administrators believed that technology could replace them. For example, administrator JK from BMS, noted:

> [A]nything new is always going to end up hitting resistance … [it's] the threat, you know, to the teachers. It's like, what does that mean for us as teachers? I mean you just reduced the job of the teachers to a software installer. (Personal Interview, December 19, 2011)

When creating implementation plans for new digital media solutions, it is suggested that concerted efforts be made to address the perceived threat that technology would replace the teacher. Efforts should be made to change teacher perception to view technology as an aid, rather than a replacement.

Digital resources. From the eLPIR of the eLearning Priorities document emerged the third category: *Digital Resources*. IDOE believed that as online and virtual learning

became more pervasive, high quality digital resources should be made available for students and teachers to use in place of traditional textbooks.

It was observed and documented during teacher interviews at BMS that teachers often questioned and distrusted the reliability and validity of online content that was free and easy to access. For example, teacher CM from Bloomington Montessori School noted:

> … [Students] are getting away from books with good information that has been researched and checked over, and they're moving towards, like, ask.com and these websites that really don't have … they might have accurate information but there's no good places to look. (Personal Interview, October 4, 2011)

If the goal of the IDOE is to create a digital curriculum, teachers' beliefs that digital content is not as legitimate and/or reliable as textbooks could impede the process of moving schools and communities toward the opportunity and advantages of digital-age learning.

Summary

To summarize, almost all the functions described in the PIES design theory were observed in the BMS classroom with the exception of the *Personal Characteristics Inventory, Long-Term Goals, Certification*, and *LMS Administration*. In addition, several functions, such as (i) *Selecting Students for Group Lessons,* (ii) *Tracking Instruction,* (iii) using *Peer Mentoring* as an *Instruction* function, and (iv) creating *Socially, Politically, and Culturally Relevant Instruction*, were observed at BMS but not described in the PIES design theory. Table 6 summarizes the findings from the current case as well as the recommendations based on the findings.

In addition to informing the design of PIES, data gathered at BMS also shed significant light on factors — *Perceived Usefulness, Perceived Ease of Use*, and *Perceived Threat* — that may encourage and discourage the use of technology in current education systems. Data from BMS were also able to inform categories of *Leadership Development* and *Digital Resources* identified in the IDOE's *2012-2013 eLearning Priorities* initiative.

All recommendations made in this chapter will be collated later in light of the findings from other cases to reveal final recommendations in Chapter 8 to improve the functions and features of PIES.

Table 6

Case 1 Summary of Findings from Descriptive Questions 1, 2, and 3 and Recommendations from Formative Questions 1(a), 2(a), and 3(a)

	Function Similar to PIES	**PIES Functions Missing in BMS**	**BMS Functions Missing in PIES**	**Recommendations**
Recordkeeping for Student Learning	Standards Inventory Personal Attainments Inventory	Personal Characteristics Inventory		Standards Inventory: Adding additional standards
Planning for Student Learning	Current Options Short-Term Goals Projects Teams and Roles Contracts	Long-Term Goals Certification	Selecting Students for Group Lessons	Projects: Rename to *Activities* to include projects and activities Certification: include methods for certifying near and far transfer Really Simple Syndication Functionality
Instruction for Student Learning	Project Initiation Instruction Project Support Instructional Development		Tracking Instruction Peer Mentoring as an Instruction function Socially, Politically, and Culturally Relevant Instruction	Instruction: Design instructional interfaces that are usable, accessible, and visually appealing Tracking Instruction Peer Mentoring
Assessment for (and of) Student Learning	Presenting Authentic Tasks Evaluating Student			

	Performance Providing Immediate Feedback Developing Student Assessments And Improving Instruction and Assessments			
Secondary Roles	Communication General Student Data School Personal School Personnel Information	LMS Administration	Teacher Training	Teacher Training and Professional Development

Chapter 5: Decatur Discovery Academy (DDA)

Case 2, Decatur Discovery Academy (DDA), part of the Metropolitan School District of Decatur Township in Indianapolis, Indiana, was a charter school established in 2005. DDA followed the Expeditionary Learning (EL) model which adopts an interdisciplinary, project-based, collaborative approach to learning (Warschauer, Grant, Real, & Rousseau, 2004). At the time the study was being conducted, DDA had employed a total of 12 teachers and 4 administrators who served 173 students in grades 7-12. Student to teacher ratio at DDA, at the time the study was conducted, was 14:1. Out of the 12 teachers who were approached to participate in the study, five teachers, AD, CD, LD, JD, and MD agreed to participate. The five teachers were then observed and interviewed over the course of one semester. None of the administrators who were approached agreed to participate. Teachers AD and MD taught mathematics lessons individually as well as collaboratively; teacher JD taught chemistry; teacher LD taught Spanish; and CD taught biology and social studies. The interview recordings and observation notes were transcribed and coded to help answer the research questions guiding this study. Each of the class sessions that were observed consisted of a minimum of five and maximum of twelve students.

Descriptive Question 1: PIES Functions Reflected in Case 2

This section addresses the following question: *What information-age tasks as identified by the PIES design theory (Reigeluth et al., 2008) are being accomplished by teachers in schools that have transitioned into the learner-centered, information-age paradigm of education***?**

The information-age tasks identified by the PIES design theory are: (i) *Recordkeeping for Student Learning*; (ii) *Planning for Student Learning*; (iii) *Instruction for Student Learning*; (iv) *Assessment for (and of) Student Learning*; and (v) *Secondary Roles* of *Communication*, *General Student Data*, *School Personnel Information*, and *LMS Administration*. Grounded in the data collected through interviews and observations at DDA, I will illustrate and elaborate the functions that were found to be similar to the functions and sub functions described by the PIES design theory.

Recordkeeping for Student Learning

The *Recordkeeping for Student Learning* function, according to the PIES design theory, consists of three sub functions: (1) *Standards Inventory*; (2) *Personal Attainments Inventory*; and (3) *Personal Characteristics Inventory*. Corroborated by the data, the sub function of *Standards Inventory* was the only sub function reflected in the record keeping processes at DDA.

According to the PIES design theory, the *Recordkeeping* for *Student Learning* function is a replacement for the current report card. The purpose of the *Recordkeeping* for *Student Learning* function is to "provide systematic and comprehensive information about what each student has learned" (Reigeluth et al., 2008, p. 33). Based on the observation and interview data, the *progress report* at DDA was found to be similar to the *Recordkeeping* for *Student Learning* function. The *progress report* listed all the learning targets (objectives crafted from state standards) that the students had to accomplish in the given semester. In the *progress report*, as DDA teacher JD noted, "you include the learning target, you include the grade for that target, … you include [the percentage of]

work completed, and then you [include] comments" (Personal Interview, April 22, 2011). The *progress report* also provided information regarding the extent of mastery that the student had achieved

Standards inventory. The purpose of PIES' *Standards Inventory,* a sub function of the *Recordkeeping for Student Learning* function, is "to inform the planning process by providing information about the required standards set at the national, state, and local levels and information about additional standards that cultivate the student's particular interests and talents" (Reigeluth et. al., 2008, p. 33). According to the data collected in the form of interviews, observation notes, and content posted on the school website, teachers followed the Indiana State Standards in planning their learning targets.

Planning for Student Learning

The PIES *Planning for Student Learning* function consists of seven sub functions: (i) *Long-Term Goals*; (ii) *Current Options*; (iii) *Short-Term Goals*; (iv) *Projects*; (v) *Teams*; (vi) *Roles*; and (vii) *Contracts*. Functions in DDA that were found to be similar to the sub function of *Planning for Student Leaning* were *Short-Term Goals, Projects, Teams, Roles,* and *Contracts.*

Short-term goals. Based on the observation and interview data, the process of creating learning targets at DDA was found to be similar to the process of creating *Short-Term Goals* in PIES. S*hort-Term Goals* in PIES are created from a student's *Current Options*. *Current Options,* in turn, is a sub function of the *Planning for Student Learning* function that is a collection of attainable learning options based on what the students have already learned. To create the student's *Short-Term Goals,* the student and teacher

together select learning goals from the list of *Current Options* in accordance with the student's needs and interests.

In DDA, however, learning targets, which were created every semester, were selected based on the grade-level state standards, irrespective of what the student had already mastered. "[We] take the Indiana state standards, and we base our learning targets off of the standards" (AD, Personal Interview, May 1, 2011). PIES *Short-Term Goals* and DDA learning targets represent immediate learning goals. However, unlike PIES, these objectives at DDA were not created with student input nor determined based on students' prior mastery. Rather they were created independently by the teachers and based solely on state standards.

Projects, teams, and roles. The *Projects* sub function in PIES presents a list of projects that students can select based on their attainments and interests; the *Teams* sub function allows users to organize teams of students to work on selected projects; and the *Roles* sub function allows users to assign and manage team members' roles and responsibilities.

In DDA, a significant component of the learning was based on collaborative or individual projects referred to as learning *expeditions*.

> *Expedition*s are long-term, in-depth studies of a single topic that explore vital guiding questions; incorporate standards; involve fieldwork, service, and adventure; and culminate in a project, product, or performance. *Expedition*s require rituals of reading, writing, problem solving, and discussion. Individual and group projects are designed to unify and ignite student learning by calling for concrete products or actions that address authentic problems (Decatur Discovery Academy, n.d.)

According to teacher interviews, when working on *expedition*s, functions similar to the ones accomplished by the *Projects*, *Teams*, and *Roles* sub functions in PIES (vis-à-vis selecting projects, creating teams, and assigning roles and responsibilities) were also accomplished by teachers in DDA. During the time the study was being conducted at DDA, two of the participating teachers, teacher CD and teacher AD, were coordinating a group project about the 1994 genocide in Rwanda. Students were grouped into teams and were assigned tasks. Teachers CD and AD organized and coordinated the entire project. They were in charge of planning the project, identifying the goals of the project, identifying the roles and assigning the roles to students, as well as ensuring that all tasks assigned were completed in a timely manner.

Contracts. Based on classroom observation data and teacher interviews, the student *progress reports* used at DDA was comparable to the *Contracts* sub function in PIES. The *Contracts* sub function will produce "an agreement between a student, teacher, and parents that specifies the goals that the student wishes to achieve, the means (primarily projects) that will be used to achieve them, the teacher's and parents' roles in supporting the student, and the deadline for completing each project (negotiated with the teammates for each project)" (Reigeluth et al., 2008, p. 34).

The *progress report* at DDA listed learning targets that the students were supposed to have achieved by the end of the semester. As described earlier, the *progress report* also served the function of a report card, making it comparable to PIES' *Inventory of Attainments*. Unlike the *Contracts* sub function, the *progress report* did not explicitly specify the deadlines by which the activities had to be completed. However, the

deadlines were implied due to the continuous replacement of learning targets at the end of each semester.

Instruction for Student Learning

The PIES *Instruction for Student Learning* function consists of the following sub functions: (i) *Project Initiation*; (ii) *Instruction*; (iii) *Project Support*; and (iv) *Instructional Development.* At DDA, all four sub functions were observed during classroom observations and documented during teacher interviews.

Project initiation. The sub function of *Project Initiation* "will provide access to more information about the project … and will help the teammates identify tasks to perform, how they will work together on each task, … the resources they will need, and milestones for different tasks during the project …" (Reigeluth et al., 2008, p. 35). In DDA, the process of initiating a project, from selecting to presenting the *expedition*, was similar to PIES sub function of *Project initiation*. It was during this process, described in more detail below, that students were given information about the project/*expedition* and the tasks that were need to be accomplished.

According to observations and interview data as well as DDA website content, the key to creating learning *expedition*s was identifying compelling topics based on learning targets. All decisions regarding planning and creating instructional materials commenced after learning targets had been identified (see quote below). Once learning targets had been identified, expeditions were chosen by the teachers, and instructional materials to support expedition-based learning (e.g., lessons, activities and quizzes) were created. Teacher CD illustrates the process in the quote below:

> [When] I [review] the biology learning targets, I make sure that everything from the state standards is included. And then I look through my *expedition*, and I am, like, OK … here's my *expedition*. Here's what I want to teach. How can I teach hierarchical organization within this *expedition*? How can I teach cells within this *expedition*? How can I teach genetics within this *expedition?* (Personal Interview, April 5, 2012)

Instruction. According to the PIES design theory, the sub function of *Instruction* will provide instructional resources for students to build skills and knowledge needed to complete their projects. Similarly, as revealed by the excerpt from teacher CD's interview transcript that is quoted above, students in DDA had access to instructional resources that were created to aid in the development of skills and knowledge needed for completing *expeditions* and addressing learning targets.

Project support. The sub function of *Project Support* in PIES allows students to track their progress in terms of project-related activities. It also allows teachers and parents to monitor how students are progressing through their activities. At DDA, as described in the data, *progress reports* were used to track students' progress in terms of goals and activities. DDA *progress reports* listed the tasks and competencies that students were working on and the extent to which the tasks had been completed and mastered.

Instructional development. The sub function of *Instructional Development,* according to the PIES design theory, "is to support teachers, staff, parents, and even students in the development of new instruction—projects, learning objects, and other instructional tools" (Reigeluth et al., 2008, p. 37). At DDA, based on teacher interviews and classroom observations, all instructional materials were created by the teachers and were managed in binders maintained by individual teachers for future reference. However, while PIES prescribed collaboration among parents, students, and teachers in

the development of instructional materials, at DDA parents and students were not a part of the instructional development process.

Assessment for (and of) Student Learning

The *Assessment for (and of) Student Learning* function consists of six sub functions: (i) *Presenting Authentic Tasks*; (ii) *Evaluating Student Performance*; (iii) *Providing Immediate Feedback*; (iv) *Certification*; (v) *Developing Student Assessments*; and (vi) *Improving Instruction and Assessment*. All sub functions listed above, with the exception of *Certification*, were observed in DDA.

The purpose of the *Assessment for (and of) Student Learning* function in PIES is to ensure mastery. In PIES, the students continue to work on their learning targets until mastery has been attained. At DDA, based on observation, the goal of the assessment process was to provide a grade for each *learning target* that was reflective of the degree of mastery the student has demonstrated in the given *learning target*. It is important to note that at the end of the year, even if the student had not attained complete mastery of a learning target, the student moved on to work on learning targets for the next academic year.

Presenting authentic tasks. The sub function of *Presenting Authentic Tasks* consists of evaluating the authentic tasks used during instruction to determine mastery. In comparison, based on observations, interviews, and content analysis of the DDA website, authentic tasks in DDA classrooms were presented within the context of *expedition*s. Student performance was routinely evaluated through various expeditions. Both PIES and DDA evaluated completed projects to determine mastery.

Evaluating student performance. The *Evaluating Student Performance* sub function in PIES is "designed to evaluate whether or not the [established] criterion was met on each performance of the authentic task on the LMS" (Reigeluth et, al., 2008, p 36). At DDA, in addition to evaluating with authentic tasks and ensuring that the established criterion was met, students were also evaluated using summative assessments such as quizzes and formative assessments such as in-class demonstrations. "I assess students in several different ways. … I assess them verbally, watching them go to the board and do problems" (AD, Personal Interview, May 1, 2011). Therefore, the evaluation process followed at DDA was reflective of the sub function of *Evaluating Student Performance* where different means were used by the teachers to determine if the criterion was met.

Providing immediate feedback. The sub function of *Providing Immediate Feedback* in PIES provides "immediate feedback of either a confirmatory or corrective nature" (p. 36). It was observed as well as documented during teacher interviews that at DDA, while working on their activities, students were given immediate feedback regarding areas of improvement.

Developing student assessments. The sub function of *Developing Student Assessments* supports "teachers and others in the development of formative and summative assessments for new instruction" (Reigeluth et al., 2008, p. 36). Observed in DDA classrooms and corroborated through teacher interviews, assessments were created individually and/or collaboratively by the teachers.

Improving instruction and assessment. The sub function of *Improving Instruction and Assessment* enables the formative evaluation of the effectiveness of instruction and assessments, "… identify areas in which students are having difficulties … [and] offer suggestions to overcome [learning difficulties]" (p. 37). According to the data, teachers at DDA routinely evaluated and improved instructional materials and assessments based on how students were progressing towards their learning targets, thus reflecting the function of *Improving Instruction and Assessment.*

Secondary Roles

Of the PIES secondary functions of *Communications*, *General Student Data*, *School Personnel Information*, and *LMS Administration*, the only function that was observed in DDA, according to the data collected at the site, was the sub function of *Communications*.

Communication. The sub function of *Communication* allows users to communicate and collaborate with the use of web-based technologies and applications. Based on teacher interviews, the applications commonly used by teachers to communicate with students, parents, and colleagues included emails and text messages. Some teachers used the email function offered by the LMS, SchoolFusion. In addition to email and text messages, some teachers used weekly newsletters to communicate with parents.

Related Formative Question 1(a): Improvements

The goal of the first descriptive question was to identify functions in DDA that were similar to the functions described in the PIES design theory. Now I will address the

formative component of research question 1, which asks: *What improvements can be made to the tools (functions) offered by the PIES design theory to better perform those tasks?* However, having analyzed practices in DDA that were similar to the functions and sub functions described by the PIES design theory, no recommendations to improving the observed functions can be suggested.

Descriptive Questions 2: Functions Lacking in Case 2

In this section, the goal is to identify PIES functions that are not reflected in DDA. In other words, this section will answer the second descriptive question: *What information-age tasks identified by the PIES design theory are not being accomplished by teachers in such schools*? Based on the observations and interview data, the functions and sub functions described in the PIES design theory found to be lacking in DDA were the *Personal Characteristics Inventory*, *Current Options*, *Long-Term Goals*, and *Certification*.

Personal Characteristics Inventory

Based on analysis of the classroom observation data and teacher interviews, DDA did not accomplish any function that resembled the *Personal Characteristics Inventory* as described by the PIES design theory. The *Personal Characteristics Inventory,* which is a sub function of *Recordkeeping for Student Learning*, "will keep track of each student's characteristics that influence learning, such as learning styles, profile of multiple intelligences, student interests, major life events, and so forth (Reigeluth et al., 2008, p. 33). At DDA, data related to student personal characteristics were not maintained. Some teachers, during their interviews, mentioned how they took into consideration individual

learning styles when teaching. However, they did not have any systems or processes in place that maintained this information in an organized fashion.

Long-term Goals

According to the PIES design theory, the sub function, *Long-Term Goals*, "will help a student, teacher, and parents to develop and revise, in a collaborative fashion, the student's long-term goals" (Reigeluth et al., 2008, p. 34). None of the functions and practices observed or described during teacher interviews at DDA matched the description of *Long-Term Goals* as described by the PIES design theory.

Current Options

PIES' *Current Options*, a sub function of *Planning for Student Learning*, assists the planning process by allowing students and teachers to select learning goals from a collection of available and attainable learning options. The *Current Options* function creates a list of attainable goals based on the goals a student has already accomplished. Upon analysis of the data, none of the classroom activities and practices resembled the sub function of *Current Options*.

Certification

One of the sub functions of *Assessment for (and of) Student Learning* is that of *Certificatio*n. A student can achieve certification if he/she is able to demonstrate performance of a learned skill successfully during "x out of the last y unassisted performances" (Reigeluth et al., 2008, p. 36). The system will then check-off that attainment and link it to the evidence of that attainment. Based on observations and teacher interviews, DDA did not have a system similar to the PIES certification function.

At DDA, at the end of the semester, a grade representing the level of mastery a student had attained in a given *learning target* was recorded in their *Progress Reports*. The goal, as mentioned during the interviews, was to attain mastery of the learning targets within the set time frame (one semester). At the end of the semester, the students were given a grade representing their degree of mastery and then, regardless of this grade, progressed to work on the next set of learning targets.

Related Formative Question 2(a): Improvements

The goal of the second descriptive question was to identify PIES functions that were not reflected in DDA. The purpose of the current section is to answer the formative component of the second question*: What PIES functions, if any, should be changed or removed as a consequence?* Based on the observation and interview data, no recommendations can be suggested for the removal of functions or sub functions in PIES.

Descriptive Question 3: Functions Lacking in PIES

This section presents the findings that answer the third descriptive question: *what tasks are being accomplished in such schools that are lacking from the PIES design theory, if any?* Based on the observations and interviews conducted at DDA, functions of *peer tutoring* as an assessment function and an *instructional organization* process were observed that were not discussed in the PIES design theory.

Peer Tutoring as an Assessment Function

In DDA classrooms, as observed and corroborated through teacher interviews, some teachers used a *peer tutoring* model to determine the extent of mastery of a learning

target. Students were routinely asked to demonstrate learning by teaching the skills they had recently acquired to a group of peers.

> I like to assess them verbally, watching them go to a board and do problems. If the child understands the problem well,[enough to be able] to teach other children, then they have gone beyond the basic level of understanding because they can literally teach somebody else how to do it … If you can teach it, then you know it. (AD, Personal Interview, May 1, 2011)

This method of evaluation was also used in an activity called *Passage*. All students were required to participate in *Passage*, which usually occurred at the end of each semester. During *Passage*, community representatives from each subject area were invited, and a committee was formed. Students were required to demonstrate their mastery of a *learning target* in front of the *Passage* committee. Below is an illustration of a Mathematics *Passage*.

> In my class, the 10th graders will do their *passage* on linear programing. So they will have a very long drawn-out math problem. … that math problem will exemplify most of the minor … learning targets in one huge math problem. For the math Passage, we will allow 20 minutes per student. So, a student will walk in, they'll get their problem, [and] they will do the problem. [Through the process of solving the problem, they will be] talking [about] it, explaining it, teaching it to that professional. The professional evaluates [the student's performance] and at the end of 20 minutes … they leave. And then the next student comes in. (AD, Personal Interview, May 1, 2011)

Instructional Organization System

Also observed in DDA was the practice whereby teachers created binders with instructional materials and resources. Content within these binders were always organized according to DDA learning targets as opposed to subjects. When preparing for a class, the teachers referred to the resources available to address the selected learning targets. They then created new materials and added them to the repository for future reference.

Related Formative Question 3(a): Improvements

In the previous section, I identified and described tasks that were being accomplished in DDA but were not described in the PIES design theory. In the current section, I answer the formative component of the third research question — *what improvements can be made to the PIES functions to perform those tasks?* Based on the above findings, two recommendations are being made: (i) adding *peer tutoring* as a sub function to the *Instruction for Student Learning* function, and (ii) adding *keyword-based search functionality* to the sub function of *Instructional Development.* However, it should be noted that to determine the merit of the following recommendations, corroborating results from previous and subsequent cases are needed.

Peer Tutoring

Peer tutoring is an effective assessment and instructional strategy (Mazur, 1997; Crouch, Watkins, Fagen, & Mazur, 2007). As observed in DDA classrooms, teachers used this strategy to help ensure student engagement and learning. This strategy was also used to acknowledge students as experts, consequently increasing motivation to learn.

In virtual environments, teachers do not face the same challenges as those faced by teachers in a face-to-face environment. The focus on ensuring student engagement and learning may be less in a virtual environment as more customized solutions are available to better address those needs. While using peer tutoring to sustain engagement may be redundant in a virtual environment, there are peripheral benefits that should not be ignored.

An empirical study conducted by Crouch, Watkins, Fagen & Mazur (2007) noted that classrooms that employed peer tutoring as an instructional and assessment strategy reported higher student satisfaction rates. They also reported higher learning gains compared to classrooms that employed the traditional lecture format. In classrooms where peer tutoring was employed as an instructional and assessment strategy, students reported enjoying the activities and the interactions that followed the peer tutoring sessions. In addition, to corroborate the Crouch et al., (2007) findings, it was observed in DDA classrooms that students were more enthusiastic, motivated, and participatory during these sessions than when attending lectures. It was clear during the observations that the students especially enjoyed the social interactions and activities that were an intrinsic component of the peer tutoring process.

Therefore, it is recommended that *peer tutoring* be added as a sub function to the *Instruction for Student Learning* function. The sub function of *Peer Tutoring* will allow users to create learning environments where students not only learn from the expertise of each other, but also enjoy the benefits of social interactions and being acknowledged as an expert among peers.

Keyword-Based Search Functionality

Validated by the findings at DDA where teachers organized instructional materials according to their learning targets, I recommend that PIES have the ability to attach keywords to instructional materials. If the sub function of *Instructional Development* would allow users to tag instructional materials with keywords related to the various learning objectives, it would make for a usable and easily retrievable repository of

resources. Such a system could be accessible not only to the teachers, but also to the students.

> You want to make sure that you've hit all those learning targets because those learning targets are based on state standards. So, if I [find]… that I have hit all those learning targets, life is good. If I [am heading] towards the middle [of the semester] and I [realize] that I am not hitting [a] *learning target*, it will be nice to be able to go to that one place in my binder that says these are the activities that you can do for this learning target. (CD, Personal Interview, April 5, 2011)

Descriptive Question 4: Encouraging/Discouraging Technology Use

This section presents answers to the fourth descriptive question, vis-à-vis, *what factors play into encouraging or discouraging teachers from using technology to accomplish the tasks?* The analysis of the observation and interview data revealed two factors that encouraged and discouraged technology use and implementation at DDA. These factors, described in more detail below, were *Perceived Usefulness* and *Perceived Ease of Use.*

Perceived Usefulness

As highlighted during teacher interviews, for technology to be successfully integrated into daily classroom activities, it has to be useful. When asked about the lack of use of the school-wide LMS (SchoolFusion) that teachers and students were expected to use, AD stated, "I think the issue was it did not meet our needs, and that's when we just ditched it and said, oh well, we'll just make spreadsheets and this is what we need" (Personal Interview, May 1, 2011). AD also noted that she did not use SchoolFusion because she believed that she was not able to effectively teach her content in an online environment. She found that the blogging and the forum functions were of no use to her as a Math teacher. "[When using a cell phone, I can] text them and [be] right there in their

hands … [with] immediate feedback … I can't walk around with SchoolFusion in my hand" (Personal Interview, May 1, 2011).

AD reaffirmed this point of view by describing her experiences:

> When I first tried to use [SchoolFusion] as a requirement, I would say, 'ok kids, how many of you have looked at SchoolFusion?' Or the parents would email us or call us with a question, and we would say, 'well, we put it where we were supposed to put it in SchoolFusion, and nobody used it.' And then my Math partner found a way that you could look in SchoolFusion and see who logged in or how many people logged in, and it was like the PTO [Parent Teacher Organization] parents would log in and that's about it. (Personal Interview, May 1, 2011)
>
> The [students] don't use SchoolFusion, number one. Number two, if I put [instructional materials] on SchoolFusion, then I have to email every child and say go look at SchoolFusion. (Personal Interview, May 1, 2011).

Technology is often viewed by teachers as being cumbersome and adding to the student's and teacher's workloads. As illustrated by JD during her interview, "before, it was, especially in a traditional school, this is your homework, and you're done. But now, this is your homework plus [you] have to post online" (Personal Interview, April 22, 2011). Teachers reported that both students and teachers perceived online instruction as an unnecessary add-on to their current responsibilities and an extra requirement that they had to fulfill.

Perceived Ease of Use

Another reason for why teachers at DDA had not successfully integrated technology into their daily educational activities was the issue of ease of use. Believing that an application "is too hard to use and that the performance benefits of usage are outweighed by the effort of using the application" (Davis, 1989, p. 320) can greatly

influence the extent to which the application is integrated. The conversation below validates the above claim.

> LD: There are features in [SchoolFusion] where they have quizzes and tests, but I really haven't used them, to be honest.
>
> Interviewer: Why don't you use them?
>
> LD: I feel like sometimes it's more trouble than it's worth to create, even though, when it comes to actually grading it, it saves a lot of time 'cause you can just hit a button and bam, everything is graded. But I have so few students this semester as compared to normally that I just grade it by hand. I don't want to take the time out to [learn it].
>
> Interviewer: Why do you think it is so difficult to use the system?
>
> LD: I think it's just the time it takes … I think it's maybe just getting acquainted with it. Once I have just like a summer or something to really sit down and to get in-depth with it, I think I'll probably use it. Probably next year … it's on my to-do list. You know what I mean. (Personal Interview, April 6, 2011).

Based on the conversation above, it is clear that the user believed that learning to use SchoolFusion would require a considerable amount of time — in this case, during a summer. Due to this perception, she was less likely to incorporate it into her daily activities. "… I think I will probably use it, probably next year, it's on my to-do list".

I also observed that applications that were badly designed and functioned inconsistently contributed greatly towards dissuading users from integrating technology. Below is an excerpt from the interview with LD where she explained why she chose not to use the email function in SchoolFusion.

> It just doesn't work. Whenever you use an individual email, it's a shot it the dark. It might work, it might not work. If you are trying to send a mass email to parents, which sounds really good in theory, a lot of time it doesn't work. (Personal Interview, April 6, 2011)

In the very same conversation, LD continued to talk about the announcement feature in SchoolFusion that she used extensively because it worked without errors.

Inferential Question 5: Implications of the Findings on *2012-2013 eLearning Priorities* proposed by the Indiana Department of Education (IDOE)

2012-2013 eLearning Priorities

As mentioned is greater detail in Chapter 4 under the Inferential Question 5 subheading, the *2012-2013 eLearning Priorities* (see Appendix C) was a list of technology integration initiatives that the IDOE wanted Indiana schools to adopt. The adoption of these initiatives was incentivized through grants that school districts could apply for.

In an effort to inform the *2012-2013 eLearning Priorities*, the list of initiatives, also referred to as the *2012-2013 eLearning Priorities* ideas and realities (eLPIR)[3], were coded to identify five categories: (1) *Leadership Development*; (2) *Networking*; (3) *Digital Resources*; (4) *Digital Learners*; and (5) *Innovation*.

Implications of the Findings on eLPIR

Data from DDA were able to inform categories of *Leadership Development* and *Innovation.* In the sections below, I will discuss how the findings from DDA influence the categories of *Leadership Development* [4] *Innovation.*

Leadership development. As described earlier, the IDOE wanted to make efforts to support the development of a group of leaders who will be responsible for spearheading technology integration efforts in Indiana schools. Data, gathered at DDA, helped identify possible inhibitors. Awareness of these inhibitors may assist

[3] See page 95 for complete list of eLPIR.
[4] See page 96 for a more detailed account of the *Leadership Development* category

administrators and leaders to make decisions that would help facilitate the technology integration efforts.

DDA, being a part of the Metropolitan School District of Decatur Township in Indiana, was included in the district-wide effort to have all schools use a Learning Management System (LMS) called SchoolFusion. SchoolFusion offered teachers a way of maintaining grades, posting quizzes, communicating with students and parents, and sharing lecture content with students. Of the four DDA teachers interviewed for this study, none of them used all the functions of SchoolFusion. Almost all teachers used alternative online grade books and digital communication tools — each individually selected by the teacher who was using it.

Teacher AD stated, "I think the issue [with SchoolFusion] was it did not meet our needs, and that's when we just ditched it and said, oh well, we'll just make spreadsheets and this is what we need" (Personal Interview, May 1, 2011). A transcribed interview conversation between the researcher and the participant corroborates my claim that teachers will not use technology tools if they do not see the value of doing so, even if the use of that technology tool is mandated at the district level.

> LD: There are features in [SchoolFusion] where they have quizzes and tests, but I really haven't used them, to be honest.
>
> Interviewer: Why don't you use them?
>
> LD: I feel like sometimes it's more trouble than it's worth to create, even though, when it comes to actually grading it, it saves a lot of time 'cause you can just hit a button and bam, everything is graded. But I have so few students this semester as compared to normally that I just grade it by hand. I don't want to take the time out to [learn it]. (Personal Interview, April 6, 2011)

The same teacher, LD, who described above how she did not see the worth of using the grading program that came with SchoolFusion, describes, in the excerpt below,

how she manages her students' learning targets by using free, web-based, grading software called Engrade. "… I use … engrade.com. It's … an online virtual grade book. … I [enter their] assignments, … [their] learning targets, … and sub-learning targets" (Personal Interview, April 6, 2011).

This observation was also supported by prior research. Brzycki and Dudt (2005) found that successful implementation of a new technology solution depends significantly on instructor buy-in. At DDA, it became evident during teacher interviews that the top-down initiative did not effectively convince teachers to adopt technology interventions. They did not find the technology to be helpful and, therefore, used alternative applications that, they felt, met their needs.

Innovation. The fifth category of *Innovation* pointed towards the efforts that the IDOE would like school districts to make to be open to upcoming research initiatives and enable development, testing, and implementation of new technology innovations in classrooms. To attain this goal, the IDOE wanted to test new products and services in real classrooms, "share the results and strategically abandon and iteratively implement" (Office of eLearning, 2012, p. 1) the selected technology products and services.

Two factors emerged, based on interview and observation data collected at DDA, regarding reasons for abandoning a particular technology. The factors that were identified were: (i) usability issues and (ii) the inability of the implemented technology to help accomplish tasks effectively.

LD, one of the teachers from DDA who participated in the study, explained why she chose not to use the email function in SchoolFusion.

> It just doesn't work. Whenever you use an individual email, it's a shot it the dark. It might work, it might not work. If you are trying to send a mass email to parents, which sounds really good in theory, a lot of time it doesn't work. (Personal Interview, April 6, 2011)

Conversely, LD also noted that:

> if you go [into SchoolFusion] and post an event and hit it, it will send all [users who signed up for the announcement service] the event. I know [because] I signed up for it and now I get emails about [what other teachers are doing] and that is something I really do like. (Personal Interview, April 6, 2011)

We notice that LD, in spite of mentioning earlier that there weren't many features in SchoolFusion that she liked to use, used the Announcement feature only because it performed its functions in the manner that it was supposed to. On the other hand, she did not use the email function, offered by the same LMS (i.e., SchoolFusion), because it did not work. Therefore, based on LD's interview data, it can be stated that if technology is not able to accomplish the tasks that it is supposed to accomplish, the technology may get abandoned by the user.

A report created by the British Educational Communications and Technology Agency (BECTA) compiled findings from empirical studies conducted in six countries over a span of 10 years (1993-2003) regarding factors that encouraged and discouraged information and communication technology (ICT) usage among teachers. The report stated that:

> A real concern for teachers when considering making use of ICT is the fear of equipment breaking down in a lesson. … Cuban et al. (2001) explain that if technical glitches occur weekly or a few times a month, then confidence in the technology's worth erodes, and this has a negative impact on the rate of teachers' take-up of ICT. (British Educational Communications and Technology Agency, 2004, p. 15)

In light of this finding, if district offices decide to test technology innovations in classrooms in order to perfect the design and "share the results and strategically abandon

or iteratively implement", it may lead to barriers in the adoption of new technology. Testing technology innovation in classrooms would require teachers to work with technology that may routinely malfunction during lessons. Based on the findings of the BECTA report as well corroborative data collected from DDA teacher interviews, repetitive technical glitches may eventually lead to teachers not trusting the innovation and may result in its rejection.

Therefore, based on past research and corroborating evidence from the current study, we can state that testing "new products and services in real classrooms" (Office of eLearning, 2012, p. 1) may lead to teachers and students viewing technology interventions as an impediment to achieving their educational goals.

Summary

Therefore to summarize, data gathered at DDA shed significant light on the factors —*Perceived Usefulness* and *Perceived Ease of Use* — that encouraged and discouraged the use of technology in current education systems.

Almost all the functions (see Table 7) described in the PIES design theory were observed in DDA, with the exception of the *Personal Characteristics Inventory, Long-Term Goals, Current Options*, and *Certification*. Several other functions were observed at DDA that were not described in the PIES design theory, such as organizing instructional materials according to learning targets and using *peer instruction* as an assessment strategy. Data gathered at DDA from teacher interviews and observations were able to inform the categories of *Leadership Development* and *Innovation* identified in the (eLPIR). These results will be collated in Chapter 8 in light of the findings from other

cases to reveal final recommendations to improve the functions and features of the PIES.

Table 7

Case 2 Summary of Findings from Descriptive Questions 1, 2, and 3 and Recommendations from Formative Questions 1(a), 2(a), and 3(a)

	Function Similar to PIES	**PIES Functions Missing in DDA**	**DDA Functions Missing in PIES**	**Recommendations**
Recordkeeping for Student Learning	Standards Inventory	Personal Characteristics Inventory		
Planning for Student Learning	Short-Term Goals Projects Teams Roles Contracts	Long-Term Goals Current Options		
Instruction for Student Learning	Project Initiation Instruction Project Support Instructional Development	Certification	Peer Tutoring Instructional Organization System	Peer Tutoring Instructional Development: Keyword-based search functionality
Assessment for (and of) Student Learning	Presenting Authentic Tasks Evaluating Student Performance Providing Immediate Feedback Developing Student Assessments Improving Instruction And Assessments			

Secondary Roles	Communication

Chapter 6: The Bloomington Project School (TBPS)

Case 3, The Bloomington Project School (TBPS), was a teacher-designed public charter school in Bloomington, Indiana, that served students from kindergarten to the 8th grade. The school was chartered in 2009 and has a current of enrollment of 231 students. The student-to-teacher ratio was approximately 18:1.

Education at TBPS was project based with a focus on interdisciplinary education and community participation. The interdisciplinary projects that the students worked on were decided upon collaboratively with teachers, administrators, parents, and the surrounding community members.

At the time the study was being conducted, TBPS employed a total of 13 full-time teachers. All 13 teachers were approached, and four agreed to participate. However, one teacher, CPSB, withdrew from the study, leaving three teachers, SPSB, JPSB, and J2PS, to ultimately participate in the study. Teachers JPSB and J2PS collaboratively taught lessons in humanities, science, and writing; and teacher SPSB taught mathematics. The participating teachers were observed and interviewed over the course of one semester. The interview and observation data were transcribed and coded in an effort to address the research questions guiding this study. Class sessions that were observed consisted of 15-30 students. Class sessions that had 20-30 students were usually led by two main teachers, an assistant teacher, a special education teacher, and volunteers who worked with the students during the lessons.

Descriptive Question 1: PIES Functions Reflected in Case 3

This section addresses the first descriptive question: *What information-age tasks as identified by the PIES design theory (Reigeluth et al., 2008) are being accomplished by teachers in schools that have transitioned into the learner-centered, information-age paradigm of education?*

The information-age tasks identified by the PIES design theory are: (i) *Recordkeeping for Student Learning*; (ii) *Planning for Student Learning*; (iii) *Instruction for Student Learning*; (iv) *Assessment for (and of) Student Learning*; and (v) *Secondary Roles* of *Communication, General Student Data, School Personnel Information,* and *LMS Administration*. Based on interview and observation data collected at TBPS, I enumerate how each of these functions, if any, is reflected in the school.

Recordkeeping for Student Learning

The *Recordkeeping for Student Learning* function, according to the PIES design theory, consists of three sub functions: (1) *Standards Inventory*; (2) *Personal Attainments Inventory*; and (3) *Personal Characteristics Inventory*. Based on observation and interview data, processes resembling all three sub functions were observed in TBPS.

The purpose of the *Recordkeeping for Student Learning* function is to "replace the current report card … [with a report that provides] … systematic and comprehensive information about what each student has learned" (Reigeluth et al., 2008, p. 33). At TBPS, the *progress report* was a document that accomplished the same function as PIES' *Recordkeeping for Student Learning* function. As observed during classroom observations and described during teacher interviews, the *progress reports* listed learning

goals. These learning goals were identified by the students in collaboration with their parents and teachers. Learning goals were organized according to the different subject areas (e.g. Community, Math, Reading, Writing, Science, and Humanities). The *progress report* also listed narratives written by the teachers that described the manner in which students were progressing towards attaining their learning goals. The learning goals were revisited and revised twice a year during a student, parent, and teacher conference. In addition, the *progress report* narratives identified students' learning styles, interests, and personality traits.

Standards inventory. The purpose of the sub function of *Standards Inventory*, according to the PIES design theory, is to provide "information about the required standards set at national, state, and local levels and information about additional standards that cultivate the student's particular interests and talents" (Reigeluth et al., 2008, p. 33). Similar to the PIES description, at TBPS, learning goals were created based on State Standards.

> Standards have to drive [the lessons], and [the students] have to meet these standards that are at the end of course assessments. Every student in Indiana has to [meet these standards]. So I say [the standards] are the needs of everyone … across the board, [and] [the students] have to meet these criteria. [But] I think we do more than just teaching standards though. … I conference with the kids to get to know them as thinkers and create goals early in the year… [We] do a conference in the fall where we meet with families, and we say these are the things that we noticed that your child could be working on. We then refer back to [the goals] throughout the year on progress reports and conferences. We report "they are making real growth on this" or "this should be now their new goal" "or "this is still something that they are not doing well" (SPSB, Personal Interview, April 13, 2012).

Personal attainments inventory. PIES design theory states that the *Personal Attainments Inventory*, in addition to keeping a record of all attainments that the student

has mastered, will also ensure that each attainment is linked to the "evidence of its accomplishment, ranging from original artifacts with a formal evaluation, to summary data from a simulation-based performance test" (Reigeluth et al., 2008, p. 33). This process was observed at TBPS to a great degree of similarity to PIES' *Personal Attainments Inventory*. Not only were lists of attainments maintained in student progress reports, but evidence of accomplishment was also managed. As teacher SPSB explained: "I scan in [student work and] … tag it with kids' names … as I am thinking about strengths and goals … (Personal Interview, April 13, 2012).

Personal characteristics inventory. The sub function of the *Personal Characteristics Inventory* keeps "track of each student's characteristics that influence learning, such as learning styles, profile of multiple intelligences, student interests, [and] major life events" (Reigeluth et al., 2008, p. 33). As observed in the classrooms and corroborated through teacher interviews, the teachers in the progress report narratives commented on students' cognitive and social development and identified student characteristics, strengths, and learning styles.

Planning for Student Learning

PIES' *Planning for Student Learning* function consists of seven sub functions: (1) *Long-Term Goals*; (2) *Current Options*; (3) *Short-Term Goals*; (4) *Projects*; (5) *Teams*; (6) *Roles*; and (7) *Contracts*. Based on the analysis of the data, with the exception of *Long-Term Goals,* all sub functions of *Planning for Student Learning* were observed at TBPS.

Current options. The sub function of *Current Options* accesses "the student's *Personal Attainment Inventory* and compare[s] it to the general *Standards Inventory* to automatically identify the full range of attainments that are current options for the student" (Reigeluth et al., 2008, p. 34). In other words, the sub function of *Current Options* allows students and teachers to select learning goals from a collection of attainable learning options (based on what the student has already learned). At TBPS this function was reflected in the process of creating activities based on learning goals that the students had attained. Students participated in projects where they applied skills that they had previously mastered through targeted lessons and classroom activities. Therefore, at TBPS, the practice of selecting goals, based on previous attainments, is akin to the *Current Options* sub function in the PIES design theory.

Short-term goals. The manner in which TBPS managed and tracked learning was similar to the sub function of *Short-Term Goals* in the PIES design theory. *Short-Term Goals* allows users to "select from the current options the attainments to pursue now, based on requirements, long-term goals, interests, [and] opportunities (Reigeluth et al., 2008, p. 34). As described in the teacher interviews, students, in collaboration with teachers and parents, created learning goals that were to be accomplished in the course of a semester. Periodically, based on student needs, these goals were revised and revisited. During these revisions, either new goals were added or existing goals were altered to ensure that students continued demonstrating educational gains. Therefore, the process of selecting learning goals (based on attainable goals) to be accomplished in the immediate future at TBPS, is similar to the sub function of *Short-Term Goals* as described by the PIES design theory.

Projects. The sub function of *Projects* in PIES allows users to "identify projects or other means available in the school or community or online that will enable the student to attain [their] short-term goals" (Reigeluth et al., 2008, p. 34). TPBS used a curriculum that was project-based, problem-based, and place-based (community-based). This curriculum was referred to as the *P3 Curriculum Framework.* In this framework, students, teachers, families and community members collaborated to identify projects that addressed a direct need in the community, thereby reflecting the sub function of *Projects* as described by the PIES design theory.

Teams. The sub function of *Teams* in the PIES design theory serves to facilitate the process through which students can form teams to collaborate on projects. At TBPS, students worked both individually and in teams. Teams were sometimes self-selected, while at other times they were selected by the teacher. This is similar to the description of the *Teams* sub function offered by the PIES design theory.

Roles. The sub function of *Roles* allows users to assign and select the roles and responsibilities of team members working on the said projects. Based on the data, at times, students self-selected their roles, while at other times it was decided by the teacher — similar to the PIES description of *Roles* where users select and assign team members' roles and responsibilities within the project. PIES design theory notes that although "in most cases, students will work together in small teams on their projects … [peers may] sometimes choose projects so that they can work together, but teachers will only allow so much of that" (Reigeluth et al., 2008, p. 34). The quote below from the interview with teacher SPS at TBPS illustrated the phenomenon noted in PIES:

> We do a lot of teaching around what you need as a learner and who you are as a learner and how do you thrive. And students really self-identify often how they will learn best. Students at first will chose what they want rather than what they need. So you will have a kid who will work with his friend even if that's not the best thing for him as a learner. We are teaching them that there are times when I need to say that I can't work with you. (Personal Interview, April 13, 2012)

Contracts. According to PIES design theory, a *Contract*:

> … will essentially be an agreement between a student, teacher, and parent that specifies the goals that the student wishes to achieve, the means that will be used to achieve them, the teachers and parents' role in supporting the student, and the deadline for completing each project. (Reigeluth et al., 2008, p. 34)

The *Contracts* function described by the PIES design theory can be compared to the goals in TBPS *Progress Reports*. The goals outlined the academic and social expectations that the students had to address. The *Progress Report* also listed the timeframe within which the goals need to be attained.

Instruction for Student learning

The sub functions of *Instruction for Student Learning,* which include (1) *Project Initiation*; (2) *Instruction*; (3) *Project Support*; and (4) *Instructional Development,* were all observed and described in teacher interviews conducted at TBPS.

Instruction and project initiation. The function of *Instruction,* as described by the PIES design theory, states:

> Once the students get organized for a project, they will begin working on it. As they work on it, they will encounter (identify) attainments they need in order to be successful. These will include such attainments or components of an attainment as: information that needs to be memorized, understandings that need to be acquired, skills that need to be developed, and various kinds of affective development. (Reigeluth et al., 2008, p. 35)

Each week, students participated in different projects and activities to master the selected learning goals for that week. For example, the goal for one of the weeks during

which I observed was to learn about feudalism in Europe. In Social Studies, for that week, students learned about feudalism, the legacy of Rome, and the rise and structure of feudalism. In Writing, they wrote a play on the topic of Feudalism. In Science, they learned about organisms that caused diseases in Europe during the same time period. While students were working on these projects and activities, they also participated in direct instruction where they learned the skills and knowledge needed to complete their projects. Below, a quote from an interview with a teacher at TBPS illustrates how instructional function at TBPS is similar to that described in the PIES design theory.

> I think in all units … our goal is to be inquiry and project based. But there are some things that we need to teach directly. There is some direct instruction that has to happen. … So maybe an overarching question [is] … how has colonization affected [Africa]? But in order to [answer that question], we have to know how colonization started in Africa. So then maybe there are a few direct instruction lessons to get to the heart of that, and then the kids can do some discovery. (J2PS, Personal Interview, April 12, 2011)

This process is consistent with the description of the PIES sub function of *Instruction*, where instruction is created for students based on "the attainments they need in order to be successful" (Reigeluth et al., 2008, p. 35).

Project support. According to the PIES design theory, the sub function of *Project Support* helps "the students … manage the project and [helps] the teacher and parents to monitor and support the students' work on the project" (p. 35). As revealed during teacher interviews and classroom observations, information about the projects, the activities relevant to the projects, and the resources (instruction and instructional materials) needed to support the projects, were maintained by teachers using *Google Docs*.

Instructional development. The sub function of *Instructional Development* in PIES allows users to develop new instruction in the form of "projects, learning objects, and other instructional tools" (p. 35). Instruction at the TBPS was designed in a systemic fashion. At the beginning of every academic year, teachers and administrators collectively decided on a theme for the year. Learning objectives that students would accomplish and projects and instructional activities that they would partake in were based on the selected theme. An excerpt from the interview with teacher J2PS illustrates the process.

> … [The teachers and administrators] meet at the beginning of the year and come up with a theme for the whole year. Last year our overarching emphasis was on power, how power moves and changes, and how people use power. This year our overarching theme is impact. All of this is embedded, and woven and connected into our units of study. (Personal Interview, April 12, 2012)

Therefore, the process of developing instruction at TBPS resembles the *Instructional Development* sub function described by the PIES design theory.

Assessment for (and of) Student Learning

The *Assessment for (and of) Student Learning* function in PIES consists of six sub functions: (i) *Presenting Authentic Tasks*; (ii) *Evaluating Student Performance*; (iii) *Providing Immediate Feedback*; (iv) *Certification*; (v) *Developing Student Assessments*; and (vi) *Improving Instruction and Assessment*. Analysis of classroom observations and teacher interviews revealed that all processes described in the *Assessment for (and of) Student Learning* function were reflected in the assessment functions at TBPS.

Presenting authentic tasks. PIES design theory describes *Presenting Authentic Tasks* as, "[t]he same authentic tasks that are used during instruction will be used for student assessment" (Reigeluth et al., 2008, p. 36). Teachers at TBPS evaluated student

progress through project-based formative assessments; thus, reflecting the sub function of the *Presenting Authentic Tasks*. In addition to project-based formative assessment, progress was measured through summative evaluations such as weekly tests and quizzes.

Evaluating student performance. According to the PIES design theory, another sub function of the *Assessment for (and of) Student Learning* function is *Evaluating Student Performance*. The purpose of this sub function is to determine if students have met the criterion on each performance of the authentic task (Reigeluth et al., 2008).

TBPS students were given summative assessments to prepare them for state mandated standardized tests. "Every five or six weeks, our kids do a formal assessment. So, really a lot of that is to see what they have learned at the end of a big unit. It is also to prepare them for [standardized tests] (Personal Interview, April 13, 2012). However, they were also formatively evaluated while they were working on their projects and activities: "I am sitting there, watching them [work on their projects], and I am guiding and directing [them] along the way" (Personal Interview, April 13, 2012). Therefore, the process involved in evaluating students' performance in TBPS is similar to the process described by the sub function of *Evaluating Student Performance* in PIES.

Providing immediate feedback. The sub function of *Providing Immediate Feedback* allows the user to provide:

> … immediate feedback of either a confirmatory or corrective nature. This immediate feedback will often even be given during the performance for the greatest effect on learning, in which case it will be similar to coaching, scaffolding, or guiding the learner's performance or it could be given at the end of the performance. (Reigeluth et al., 2008, p. 36)

At TBPS, according to the data gathered through teacher interviews and classroom observations, teachers were actively involved in providing immediate feedback to the students while they were working on project related activities. The process of providing feedback at TBPS was similar to the description of the sub function of *Providing Immediate Feedback*. To ensure that teachers were able to effectively provide immediate feedback, lessons in TBPS classrooms were kept short. “I make sure that my lesson is short enough that I am able to walk around and check-in” (SPSB, Personal Interview, April 13, 2012).

Certification. According to the PIES design theory, *Certification* is the sub function that ensures that a student has mastered an attainment based on the number of demonstrated unassisted successes in an attainment. At TBPS, teachers ensured that students mastered a particular attainment by assessing their performance in several different ways, and not singularly noting the number of times that the same task had been successfully repeated. As one teacher stated, “at our school, we really value multiple forms of assessments.” Another teacher, JPSB, described the reason why they preferred to evaluate their students in multiple ways.

> We just want to see if our kids can kind of talk about what they know and bring in these terms and vocabulary that we have covered. I want to see if the kids get it. I want to see what they remember and what they can do on their own. (Personal Interview, April 9, 2012)

Thus, based on the data, teachers at TBPS ensured that students could demonstrate the attainment of a skill in more ways than one. There was a great emphasis on transfer and application of that learning.

Developing student assessments and improving instruction and assessments. The last two sub functions of *Assessment for (and of) Student Learning* in PIES are *Developing Student Assessments* and *Improving Instruction and Assessment.* As the titles suggest, the former function allows users to create student assessments and evaluations, and the latter allows users to improve existing assessments and instructional materials based on student performance. As mentioned during teacher interviews, teachers at TBPS routinely used assessments to identify learning gaps.

> I make sure I serve learning. I feel that assessments also help me as an educator perfect my practice. It is not necessarily to pass or fail kids. It's to see where they are and how to better improve instruction. (Personal Interview, April 9, 2012)

Therefore, similar to the sub functions of *Developing Student Assessments* and *Improving Instruction and Assessment*, TBPS teachers created and revised lessons and activities based on learning gaps and student assessments.

Secondary Roles

The *Secondary Roles* function, according to the PIES design theory, consists of four sub functions: (1) *Communications*, (2) *General Student Data*, (3) *School Personnel Information*, and (4) *LMS Administration*. At TBPS, these functions were observed during classroom observations and described during interviews.

Communications. At TBPS, teachers communicated with parents using weekly newsletters, email, conferences, and phone calls. They communicated with individual students during class through individual conferences, daily announcements, and daily check-ins regarding desired behavior and learning outcomes. Teachers used web-based

applications such as *Google Docs* and *Evernote* to share resources and information among them.

LMS administration. Based on observation data and information made available through the school website, TBPS did not use a designated LMS for their educational needs. The school did, however, use a web-based school management system (SMS) called RenWeb. RenWeb was used mainly by administrators to maintain information (e.g., family information, emergency contact information, attendance, and lunch requirements). Parents were encouraged to access the system and ensure that all information was up to date.

General student data and school personnel information. Based on data made available on the school website, student personal information and school personnel information were maintained at the administrative level using *RenWeb*.

Related Formative Question 1(a): Improvements

The goal of the first research question was to identify functions in TBPS that were similar to the functions described in PIES design theory. I will now address the formative component of research question one, which asks: *What improvements can be made to the tools (functions) offered by the PIES design theory to better perform those tasks?* Therefore, the goal is now to determine, based on the similarities that have been identified, whether the corresponding functions in PIES may be improved. As mentioned earlier, corroborating results from other cases should be considered when determining the merits of the following suggestions.

Recordkeeping for Student Learning

Based on the comparison between the recordkeeping functions performed at TBPS and the *Recordkeeping for Student Learning* functions described by the PIES design theory, the sub function of *Standards Inventory* may be improved.

Standards inventory. The *Standards Inventory* function, as described by the PIES design theory, aims to "inform the planning process by providing information about the required standards set at national, state, and local levels and information about additional standards that cultivate the student's particular interests and talents" (Reigeluth et al., 2008, p. 33). It will also organize these standards into maps for each domain of learning (cognitive, affective, psychomotor, and interpersonal). The *Standards Inventory* will further organize tasks relevant to each domain according to their degree of complexity.

Analysis of data gathered through interviews and observations at TBPS suggests adding a function that enables teachers to group standards according prerequisite relationships or learning hierarchies.

> [W]e kind of start with the standards; what is it that the kids have to learn. We try to group those standards together because there are standards that should be taught together that aren't in the same section of the standards. So we really have to look and say these standards can go together [and] tie them together. … We really try to tie them together in some kind of meaningful way. It is not just lesson after lesson after lesson. They really complement each other and build [on each other]. [Organizing standards in such a way] gives kids … context and schema. (SPS, Personal Interview, April 13, 2012)

It is important to note that *Projects* (a sub function of the *Planning for Student Learning* function) allows users to identify projects according to the standards that the projects address. "This tool will identify, say, a dozen projects rank ordered by the

number of short-term goals (attainments) that each addresses" (Reigeluth et al., 2008, p. 34). In other words, the sub function of *Projects* allows projects that are already created, to be identified according to the short-term goals that they address.

At TBPS, teachers performed the function of organizing standards in a manner that reflected learning hierarchies prior to starting the planning process. In keeping with the goal of the sub function of *Standards Inventory*, which is to the inform the planning process, the sub function of *Standards Inventory* should, therefore, allow users to organize standards, not only according to learning domains, but also according to prerequisite relationships or learning hierarchies.

Instruction for Student Learning

Based on the comparison between the instruction functions performed at TBPS and the *Instruction for Student Learning* functions described by the PIES design theory, two improvements are recommended: (i) allowing interdisciplinary instructional development and (ii) providing access to design guides and templates. Again, the validity of these suggestions depends greatly on recommendations made in cases one, two, and four.

Interdisciplinary Instructional Development. The PIES design theory states that "[a] powerful authoring system will support the creation of new instructional tools by providing instructional guidance and even automatic development and programming of the instruction similar to Merrill's ID Expert" (Reigeluth et al., 2008, p. 36).

At TBPS, teachers collaborated to implement a curriculum and instructional materials driven by both state standards and overarching academic and/or social themes.

As SPSB noted, “we spend a lot of time here making sure that each subject really complements the other — a lot of cross-curricular stuff”. SPSB goes on to describe the process of interdisciplinary instructional development.

> I am planning reading, [CPSB] is planning writing, [JPSB] is planning science, and [J2PSB] is planning humanities. I spent last night deciding what lessons to teach which days and the kind of work [they will be doing]. … [In] the first week of June they’re going to be doing a lot of writing, so then I have to email the team and say, hey J2PSB, you come through and do the humanities pieces. We can’t do any heavy writing stuff here. You need to be doing something that is not writing. And then each of us links to the actual lessons. (Personal Interview, April 13, 2012)

Therefore, the sub function of *Instructional Development* could include a function that allows teachers to collaborate, in real time, across disciplines, while creating instructional materials.

Instructional Design Guides and Templates. When creating instructional materials and tools, teachers at TBPS reference several sources for content, lesson outlines, resources, and activities. J2PSB described how she sourced the different types of information while creating instruction:

> So here’s what an inquiry based lesson looks like. Here’s the template that one might follow. And I know how to find that stuff, but I have to go to like eight different websites, or I have to really take a lot of time to research that. It would be pretty amazing [if] I could have a template that could help guide my thinking as I am planning. … [What’s] going to work best. I don’t necessarily need already created lesson plans, but I wish there were some very teacher friendly kinds of places that were all together and I didn’t have to go out and search in different places or 20 or 30 different sites. (J2PSB, Personal Interview, April 12, 2012)

J2PSB’s description identifies a need that would be addressed by the sub function of *Instructional Development* — a “powerful authoring system [that] will support the creation of these new instructional tools by providing instructional guidance and even automatic development and programing of the instruction” (Reigeluth et al., 2008, p. 36).

It is clear that teachers desire an integrated authoring tool and they would greatly benefit from such functionality. In addition, the sub function, *Instructional Development,* may also offer a comprehensive resource repository which will allow teachers, students, and parents, access to effective lesson plans, activities, and resources.

Secondary Functions

Based on the comparison between the secondary functions (communications and data management) performed at TBPS and the *Secondary functions* described by the PIES design theory, the following recommendations are made.

Communication. At TBPS, teachers, students, and parents routinely met to review student progress and student learning goals. One of the needs of individual conferencing, described during interviews, was scheduling. Teachers at TBPS used Google Calendar to allow parents and students to schedule time to meet. A quote from SPSB's interview illustrates the process.

> Something that I really love – and Google has just started doing it – is the ability for parents to schedule conferences with teachers without me having to do it. So I can set up available times and they can come in and they can sign up and it just shows up on my calendar. (Personal Interview, April 13, 2012)

Therefore, it is suggested that the *Communications* function in the PIES design theory include a similar scheduling and calendar feature or a link to an application like Google Calendar. In this function, teachers will be able to post their available times. Students and parents would then be able to access the page to select the time that they would like to meet with the teacher. Once the appointment has been scheduled, the system will send an update notification letting the teacher know of the upcoming appointment.

Descriptive Question 2: Functions Lacking in Case 3

This section identifies PIES functions that are not reflected in TBPS in an effort to answer the second research question: *What information-age tasks identified by the PIES design theory are not being accomplished by teachers in such schools*? According to the data gathered, the only sub functions described in the PIES design theory observed to be missing in TBPS was *Long-Term Goals*.

Related Formative Question 2(a): Improvements

The purpose of this section is to list the findings that answer the formative component of the second research question, *What PIES functions, if any, should be changed or removed as a consequence?* The data do not inform the inclusion or exclusion of the sub function, *Long-Term Goals*. Therefore, there is no claim that can warrant the change or removal of the *Long-Term Goals* sub function in the PIES design theory.

Descriptive Question 3: Functions Lacking in PIES

The purpose of this section is to list the findings that answer the third research question, *what tasks are being accomplished in such schools that are lacking from the PIES design theory, if any?* The data did not reveal tasks accomplished at TBPS that were lacking in the PIES design theory.

Related Formative Question 3(a): Improvements

The purpose of this section is to answer the formative component of the third research question, vis-à-vis, w*hat improvements can be made to the PIES functions to*

perform those tasks? As the data did not reveal any tasks that were missing in PIES, no improvements can be suggested for the functions and sub functions of the PIES design theory.

Descriptive Question 4: Encouraging/Discouraging Technology Use

This section lists and discusses answers to the fourth descriptive question, *what factors play into encouraging or discouraging teachers from using technology to accomplish the tasks?* Because teachers at TBPS had integrated technology into their curriculum in various ways, the data revealed several factors that encouraged and discouraged the use of technology. Some of the factors identified that encouraged technology use at TBPS are *user-driven technology integration, perceived ease of use,* and *perceived usefulness.* The factors that discouraged technology use are the presence of a *firewall* and the *perceived lack of humanism in technology.*

Factors that Encouraged

User-driven technology integration. In TBPS, teachers selected and implemented the technology tools that they used. In contrast to the case in DDA, where technology integration initiatives were spearheaded at the district level, TBPS technology integration initiatives and decisions were made by the teachers in collaboration with the administrators.

To support and maintain technology integration, TBPS formed a "Technology Fusion Team" comprised of teachers who were professionals in the field of research in technology and learning. These teachers were given the task of (a) introducing new cutting-edge technology solutions in the school; (b) staying abreast of the latest research

in implementation and adaptation of technology in educational environments; and (c) adopting new approaches and strategies to successfully integrate technology into their curriculum. It was observed in the classroom that technology solutions were seamlessly integrated into daily curricular activities. At TBPS, technology integration was driven by teachers acting on individual basis as well as by a team of teachers comprised of technology enthusiasts.

Perceived ease of use. As mentioned in the previous chapters, believing that an application "is too hard to use and that the performance benefits of usage are outweighed by the effort of using the application" (Davis, 1989, p. 320), can greatly influence the extent to which the application is adopted. At TBPS, it was observed that when teachers were able to access and use technology with ease, they were able to effectively utilize technological solutions in their curriculum. Perception of ease of use was built through: (i) giving teachers easy access to resources and (ii) encouraging the use of web-based applications that teachers found easy to access, use, and maintain.

Access to resources. The school enabled teachers to incorporate technology by providing all teachers with personal laptops. All classrooms at TBPS had computers, giving students easy access to technology resources. Recently, the school "received almost $200,000 to implement systems thinking using technology throughout the curriculum. The computer/mobile device ratio will be 1 to 1 next year in grades 4- 7" (The Bloomington Project School, 2011).

***Web-based applications*.** Teachers and administrators at TBPS used web-based applications to address all technology needs. For example, all teachers who participated

in this study were observed to use *Gmail* and other *Google* applications such as *Google Docs, Google Forms* and *Google Calendar* to manage instruction-related tasks. Teachers were also observed to use *Evernote*, which is a free web-based application that helps users organize data for easy and effective retrieval. General student information, such as attendance, lunch, family and contact information were maintained using a web-based, school management system (SMS) called RenWeb.

The local-client model, where data is stored on a server physically housed within a district office or school, was not used at TBPS. Electing to use web-based and cloud-based applications frees administrators from the issues of onsite maintenance, back-up and server security. Companies that offer web-based and cloud-computing services take necessary precautions to prepare for events that can lead to loss of data such as natural disasters and server damage caused by hackers and viruses. In addition, when systems are web-based and cloud based, users do not need to connect to the local network through a Virtual Private Network (VPN) to access information; instead they can securely do so from any location.

Perceived usefulness. At TBPS, it was observed that during staff meetings, teachers and administrators would routinely discuss technologies that they had recently discovered. They would discuss if the newly discovered technologies/applications were helpful and if they would recommend the new technology to their colleagues. Administrators who recommended technologies/applications for the teachers to use would inquire about user-experience to identify advantages, disadvantages, and ease of using the recommended software. Therefore, as observed at TBPS, decisions regarding technology use and the types of applications to use were made exclusively to address the

needs of the school, its teachers, its students, and its parents. To further corroborate the above claim, consider the following example. RenWeb allowed users to manage all student-related, administrative information. It also gave teachers the ability to manage grades. Teachers at TBPS, however, chose not to use the RenWeb gradebook as it did not give them the flexibility and functions they desired and did not allow them to evaluate without grades. TBPS progress reports included detailed, descriptive narratives of how students were progressing. Teachers and TBPS did not give letter grades. The grade utility on RenWeb, did not provide teachers with the opportunity to enter detailed narratives, and therefore was not used by the teachers.

Due to TBPS's guiding philosophy of building a community that is conscientious about the environment and its preservation, school policy mandated that paper-based media be kept to a minimum. As noted in the Family Handbook, which is given to families of all children enrolled in TBPS:

> The Project School uses email as a primary form of communication. Using email not only saves precious time, since we can hit send instead of standing in front of the copy machine, but more important is the BPS core belief to use resources wisely and be committed to using technology well. By not using paper, ink, toner, and all of the dollars/resources that go along with making copies, we save BPS and the planet valuable resources. We understand that not everyone has access to email and are happy to make copies for anyone who needs this. (The Bloomington Project School, 2012, p. 12)

At TBPS, as observed, technology integration was not a policy of the school; rather, technology was viewed as a solution to implement policies, mandates, and philosophies of the school.

Factors that Discouraged

In spite of the prolific use of technology, teachers were able to identify factors, such as the *use of firewalls* and the *perceived lack of humanism in technology* that diminished the use of technology.

Firewalls. Although teachers at TBPS understood the importance and the necessity of firewalls, they believed that technology use could increase if students had uninterrupted access to online information. As one of the teachers stated during her interview: "imagine students have access to computers all day long and they basically can go get any information they want at any point – there's no firewall" (J2PS, Personal Interview, April 12, 2012).

Perceived lack of humanism in technology. Several teachers mentioned that online instruction, although a viable option, did not replicate the dynamic nature of teaching and learning. As J2PSB notes:

> I think teaching is really dynamic. I think learning is really dynamic. Do I think that kids can access lectures online? Absolutely! But I think it is hard and maybe this is just with my experience of participating in online teacher development where we are like listening to a lecture and then maybe like typing in what we think. I have experienced those e-classes. I think you lose what is relational in the learning process. I think learning is in part relational. I really do. (Personal Interview, April 12, 2012)

In addition to questioning the social aspect of computer-based instructional materials, TBPS teachers were also wary of the subjectivity of computer-based assessment systems. At TBPS, students were not simply graded on averages and percentages. As described earlier, their educational progress and attainments (educational, social, and cultural) were elaborated in their *Progress Report* narratives.

Inferential Question 5: Implications of the Findings on *2012-2013 eLearning Priorities* proposed by the Indiana Department of Education (IDOE)

2012-2013 eLearning Priorities

In 2012, the Indiana Department of Education (IDOE) introduced the *2012-2013 eLearning Priorities* (see Appendix C), a list of goals, in an effort to have school districts across the state of Indian adopt technology into their curricula.

Implications of the Findings on eLPIR

The *2012-2013 eLearning Priorities* document consisted of seven goals which were grouped to reveal 5 categories, namely: (1) *Leadership Development*; (2) *Networking*; (3) *Digital Resources*; (4) *Digital Learners*; and (5) *Innovation*. The data collected at TBPS, were able to inform the category of *Leadership Development*.

Leadership development. According to the eLPIR, the IDOE wanted to make concerted efforts to build a cadre of people who would be instrumental in spearheading technology integration and moving "schools and communities toward the opportunities and advantages of digital-age learning" (Office of eLearning, 2012, p. 1). Based on the interviews and observation data collected at TBPS, and discussed in more detail below, it could be posited that leaders who are implementing technology integration efforts across Indiana schools may have greater chances of success if they involve teachers in the integration effort.

TBPS was observed to have successfully implemented technology use in their school. Their student-to-computer ratio was 1:1. Their teacher-to-computer ratio was also 1:1. One of the ways in which the school ensured that technology was integrated

throughout was by making sure that the technology integration efforts were being spearheaded by the teachers themselves.

The school had a dedicated technology team comprised of two teachers who were not only adept at technology, but also passionate about new innovations and their implementation. This technology team was responsible for making suggestions to the faculty regarding new technology solutions and their implementation. All technology integration decisions were ultimately decided upon and implemented collectively by all teachers. Administrators did not make decisions regarding digital media that the teachers should be using. In addition, the researcher observed that during every staff meeting teachers would discuss technology solutions and/or applications that they had been using and found helpful as well as ones that they had used but found to be unhelpful. Teachers and administrators would routinely share this information, thus facilitating school-wide technology integration. In addition, an empirical study conducted by Brzycki and Dudt (2005) found that successful implementation of a new technology solution depended significantly on instructor buy-in.

Therefore, as demonstrated by teachers at TBPS, the cadre of people who will be instrumental in spearheading technology integration and moving “schools and communities toward the opportunities and advantages of digital-age learning” should be made aware of the advantages that their integration efforts may have if teachers are an integral part of this initiative.

Summary

Table 8 summarizes the findings for Chapter 6 (TBPS). Almost all functions described in the PIES design theory were observed in TBPS with the exception of *Long-Term Goals.* However, no additional functions other than the ones described in the PIES Design Theory were observed at TBPS. TBPS functions that were found to be similar to the PIES functions may help in improving the design of PIES. These results will be later collated, in Chapter 8, in light of the findings from other cases to reveal final recommendations to improve the functions and features of the PIES. In an effort to inform the *2012-2013 eLearning Priorities*, data from TBPS were able to highlight the need and advantages of involving the teachers in technology integration initiatives.

In addition to informing the design of PIES, data gathered at TBPS helped identify the factors that encouraged and discouraged the use of technology (see Table 9).

Table 8

Summary of findings from descriptive questions 1, 2, and 3 and recommendations from formative Questions 1(a), 2(a), and 3(a)

	Function Similar to PIES	**PIES Functions Missing in TBPS**	**TBPS Functions Missing in PIES**	**Recommendations**
Recordkeeping for Student Learning	Standards Inventory Personal Attainments Inventory Personal Characteristics Inventory			Standards Inventory: organize standards according to themes and projects
Planning for Student Learning	Current Options Short-Term Goals Projects Teams Roles Contracts	Long-Term Goals		
Instruction for Student Learning	Projects Initiation Instruction Project Support Instructional Development			Instructional Development: (1) allow interdisciplinary collaboration while creating instructional materials; and (2) offer design guides, lesson plans, activities, and resources.

Assessment for (and of) Student Learning	Presenting Authentic Tasks Evaluating Student Performance Providing Immediate Feedback Certification Developing Student Assessments Improving Instruction and Assessments	
Secondary Roles	Communications LMS Administration General Student Data School Personnel Information	Communications: dynamic scheduling application

Table 9

Case 3 Factors that Encouraged and Discouraged Technology Integration

Factors that Encouraged	Factors that Discouraged
Teacher-driven technology integrations	Firewalls
Perceived ease of use	Perceived lack of humanism in technology
Perceived usefulness	

Chapter 7: Pinnacle School (PS)

Pinnacle School (PS), Case 4 in this study, was a remedial school for students with learning disabilities. Bloomington DePaul School, which was founded in 1981, became PS in 2004. PS serves students from grades K through 12 with a student-to-teacher ratio of 7:1. According to the data collected through observations, teacher interviews, and informational content made available by the school in print and online, there was a heightened emphasis on reading and comprehension — subjects that students with learning disabilities generally struggled with.

At the time the study was being conducted, a total of 11 teachers were employed by the school, and they served a total of 76 students. All 11 teachers were approached to participate in the study, and five agreed to do so. The five Pinnacle teachers were interviewed and observed over a period of one semester. Teacher interviews and observation notes were transcribed and coded to answer the research questions guiding the study. However, one of the pinnacle teachers declined to continue to participate in the study during the first phase of the member-check. (During this phase, transcriptions of interview and observation data was sent back to participants.) Therefore interview and observation data of four teachers have been used in this case.

The four teachers who participated in the study were JPSB, BPS, KPS, and K2PS. JPSB, a Social Sciences teacher, was interviewed during the very first year of being employed by PS as a full-time teacher. Teacher KPS was a math teacher and at the time of the interview had been teaching at PS for a little more than a year. Teacher BPS, at the time of the interview, had more than 12 years of experience teaching and taught the

elementary language, arts, math and science programs at PS. Teacher K2PS taught middle school literature, writing, and drama since she joined PS six years prior to when the interviews and observations were conducted. Each of the class sessions that were observed consisted of 6-10 students.

Descriptive Question 1: PIES Functions Reflected in Case 4

This section addresses the question: *What information-age tasks as identified by the PIES design theory (Reigeluth et al., 2008) are being accomplished by teachers in schools that have transitioned into the learner-centered, information-age paradigm of education?*

The information-age tasks identified by the PIES design theory are: (i) *Recordkeeping for Student Learning*; (ii) *Planning for Student Learning*; (iii) *Instruction for Student Learning*; (iv) *Assessment for (and of) Student Learning*; and (v) *Secondary Roles* of *Communication*, *General Student Data*, *School Personnel Information*, and *LMS Administration*. Grounded in the data collected through classroom observations and teacher interviews, I will discuss in the following sections how each of these functions, if any, is reflected in PS.

Record Keeping for Student Learning

The *Recordkeeping for Student Learning* tool, according to the PIES design theory, consists of three sub functions: (1) *Standards Inventory*, (2) *Personal Attainments Inventory*, and (3) *Personal Characteristics Inventory*. The purpose of this tool is to steer away from traditional report cards and provide students and educators with reports that record educational progress and process. The only sub function observed at PS and

corroborated through interviews found to be similar to *Recordkeeping for Student Learning* sub functions was the *Personal Characteristics Inventory*.

Personal characteristics inventory. PS had a system to monitor student personal characteristics similar to the *Personal Characteristics Inventory*. The Head of School (HOS) and the PS teachers conducted several evaluations to determine not only the students' true grade levels based on their reading and writing skills, but also personality traits that informed the creation of the curriculum, instructional materials, activities, and groups. Teacher BPS illustrated the process.

> We sit down as staff and discuss the level of the students [what grade they are in and what grade they should be placed in]. [This] not only has to do with the ability level, but also has to do with [how students get along]. We do this to try and keep an even ability level. When we [have grouped and separated the students] we sit down and address the issue of instruction and what we want our main focus of topic to be for that year. (Personal Interview, March 28, 2012)

BPS, in another interview, explained how he used individual student traits, such as learning styles, grade levels, their personality, and knowledge of their academic strengths and weaknesses, to create instruction.

> When the students come in, I will do a sort of an inventory of their skill sets. We do [diagnostic testing] school-wide. But also individually on my part I go ahead and I will just start off the year by getting to know my students personality wise. Then from there I move on and give them some diagnostic tests usually of which I sort of develop myself. I will have them do some writing and some reading and from there I will see what their level is – what they're good at and what they're struggling with – and then sort of focus the individualized part of it towards those areas that they are struggling with. And of course take the areas that they are good at and try to use those, encourage them and build their self-esteem. (Personal Interview, March 28, 2012)

Planning for Student Learning

In the PIES design theory *Planning for Student Learning* consists of 7 sub functions: (1) *Long-Term Goals*; (2) *Current Options*; (3) *Short-Term Goals*; (4) *Projects*;

(5) *Teams*; (6) *Roles*; and (7) *Contract*. Analysis of the data revealed functions at PS similar to sub function of *Current Options, Short-Term Goals, Projects, Teams,* and *Roles*.

Current options. According to the PIES design theory, the sub function, *Current Options*, is to assist the planning process by providing a list of available and attainable learning options from which students and teachers can select learning goals. At PS, state standards were used to identify the grade-specific educational expectations and the student's learning goals. This process of identifying available and attainable learning options is similar to the sub function of *Current Options.* Below is an illustration, described by a school administrator, of the planning process followed at PS.

In the start of the academic year, students at PS were administered several diagnostic tests to determine their actual grade level in each subject. A student may officially be in the sixth grade, but could be reading at the fourth-grade level. The diagnostic tests determined the actual grade level of students in reading, writing, and math. Once actual grade levels were determined, grade-specific standards that they needed to work towards were identified. Therefore, the sixth-grade student who was reading at the fourth-grade level would now work towards improving his reading abilities to that of a fifth grader.

> We have a series of assessments that [Administrator] goes through to [inform] us what real grade level they're on … [You] could have a kid that writes on a 3rd grade level and reads on an 11th grade level. [But] society is set like if you are 15, you are in 9th grade. That doesn't mean anything other than that someone decided that 15 year-olds are in the 9th grade. So, my goal as a teacher is to raise their skill, and maybe I am only able to raise them up to the 4th grade if they started at the 3rd grade. (K2PS, Personal Interview, March 21, 2012)

Short-term goals. According to the PIES design theory, the sub function of *Short-Term Goals* will allow the "student, teacher, and parents to select from the [*Current Options*] the attainments to pursue now, based on requirements, long-term goals, interests, opportunities, and so forth" (Reigeluth et al., 2008, p. 34). Once the true grade level of a student was identified, students were put into ability-based groups, and immediate (short-term) goals were identified from their list of current options (described above).

Projects. The sub function, *Projects*, helps "student, teacher, and parents … identify projects or other means available in the school or community or online that will enable the student to attain the short-term goals" (p. 34) Based on observations and teacher interviews, depending on the subject matter, the use of project as an instructional method varied at PS.

> We do lots of projects. All of my projects have rubrics … [The students] are being assessed daily and weekly through their quizzes or small projects…. Then they also have formal assessments like the video projects … there's lots of different [projects] that they can do [depending on their own ability]. (K2PS, Personal Interview, March 21, 2012)

According to the teacher's interview, the teacher decided the topics and whether or not the students were going to be working in groups or individually. However, projects were identified that were school-based as well as community-based that could help students attain their short-term learning goals. Therefore, the sub function, *Projects*, was observed to be reflected in PS.

Teams and roles. According to the PIES design theory, the sub function, *Teams*, will allow users to create a team that is comprised of students with similar skills,

knowledge, and interests. Once the teams have been formed, the sub function, *Roles*, will allow users to identify and track the roles and responsibilities of each team member.

At PS, the reason for group-work was more social than academic and was, therefore, closely monitored by the teachers. As explained during interviews, teams were formed based on student ability. "When I pair [students] up, I make sure that I am pairing on ability… I have students who are here because of social anxiety issues and are not dyslexic at all" (JPSB, Personal Interview, March 22, 2012). Students with different skills and knowledge were paired such that they could help each other socially, as illustrated below.

> 60% of what I do is not really academic but is social education. Particularly with kids with [learning disabilities], they come in here and they don't really know how to get through an everyday situation appropriately. They don't have the social skills because of their learning differences. (BPS, Personal Interview, March 28, 2012)

Even though students were grouped and roles were assigned, there was no formal system where students' roles and responsibilities were tracked while they were working on a project.

Instruction for Student Learning

The *Instruction for Student Learning* function consists of the following four sub functions: (1) *Project Initiation*; (2) *Instruction*; (3) *Project Support*; and (4) *Instructional Development.* At PS, corroborated through classroom observations and teacher interviews, all four sub functions were observed to be in practice.

Project initiation. This sub function serves teachers and students by providing them information and resources necessary to begin a project.

> This tool will provide access to more information about the project (or problem) and will help the teammates identify tasks to perform, how they will work together on each task (collaboratively on the same tasks, or cooperatively on different tasks), the resources they will need, and milestones for different tasks during the project (time management). (Reigeluth et al., 2008, p. 35)

Teachers at PS routinely performed the functions described above when managing and coordinating group projects.

> When I pair [students] up, I make sure that I am pairing on ability … I may give my students, who are more adept at the reading, the longer chunkier articles that came out of the Huffington Post as opposed to the Herald Times. (JPSB, Personal Interview, March 22, 2012)

> All of my projects have rubrics. [But] they look different based on the teacher and based on the way it is used… For me I assess based on the kid and the kid's growth. So, student A may have an A but really may not be writing at the ninth grade level. I might [also] have one kid that finishes the first draft in a day. I might have another kid who takes two weeks. So eventually there is a deadline. But I don't set that until I see how much challenge it is going to be for the kid. (K2PS,Personal Interview, March 21, 2012)

Instruction. PIES design theory states that this sub function will provide students with access to projects, lessons and activities that will help them build skills and knowledge needed to complete their projects. As observed in the PS classrooms and corroborated through teacher interviews, instruction at PS was provided in the form of lectures and just-in-time instruction (similar to the sub function of *Instruction*) while students were working on their projects.

Project support. The purpose of the *Project Support* function is to help students "manage the project and [help] the teacher and parents to monitor and support the students' work on the project" (Reigeluth et al., 2008, p. 35). Based on observations and teacher interviews, when PS students worked on projects, the information regarding their progress was maintained by teachers who coordinated and monitored the projects.

Instructional development. The sub function of *Instructional Development* supports "teachers, staff, parents, and even students in the development of new instruction—projects, learning objects, and other instructional tools" (Reigeluth, et al., 2008, p. 35). At PS, according to collected data, the development of instruction was the responsibility of the teachers and the administrators. Based on state and national standards, teachers designed the yearly curricula, including learning goals, instructional materials, resources, lesson plans, and activities. Once the teachers created their curricula, they were submitted to the Head of School (HOS). The HOS and the teachers then reviewed the curricula and the instructional materials to make sure that they are appropriate, effective, and challenging for students with learning disabilities. Once the materials were approved by the HOS, they are uploaded to a central server, where they were archived and stored for future reference.

Assessment for (and of) Student Learning

The Assessment for (and of) Student Learning function consists of six sub functions: (1) *Presenting Authentic Tasks*; (2) *Evaluating Student Performance*; (3) *Providing Immediate Feedback*; (4) *Certification*; (5) *Developing Student Assessments*; and (6) *Improving Instruction and Assessment*. All these functions were observed to be in use at PS.

Presenting authentic tasks. According to the PIES design theory, "the same authentic tasks that are used during instruction will be used for student assessment. The project itself will be an authentic task" (Reigeluth, et al., 2008, p. 36). At PS, only when students worked on projects, were authentic tasks (which were embedded within the projects) used to assess student performance.

Evaluating student performance. According to the PIES design theory, "whether in a simulation or a tutorial or drill and practice, the assessment tool will be designed to evaluate whether or not the criterion was met on each performance of the authentic task" (Reigeluth et al., 2008, p. 36).

As stated during PS teacher interviews, three types of assessments were administered: diagnostic, formative, and summative. Diagnostic assessments were administered to identify student grade levels prior to instruction. Based on the results of the diagnostic assessments, students were placed into ability-based groups. Once placed, they were assessed during (formative) and upon completion (summative) of instructional activities and quizzes. Students were evaluated based upon the progress they made relative to their own learning challenges. As K2PS explained:

> We start off with formal assessment, which is what our director does, that kind of gives us a basis, and then every day I am informally assessing, looking to see how they are doing, what they need to know, and what they don't know. In terms of formal assessments, they have formal assessments every week for homework where I am looking to see how they are doing and grading them. They are being assessed daily and weekly through their homework. And then through each unit there will be some small formal assessments, whether it is a quiz or small project or something. And then through that [we] are also informally assessing them through discussion and through coursework. (Personal Interview, March 21, 2012)

A significant emphasis on drill and practice assessments was observed. All students participated in the Lexia program. Lexia follows the Orton-Gillingham approach to corrective reading and comprehension. "Orton-Gillingham is an instructional approach intended primarily for use with persons who have difficulty with reading, spelling, and writing of the sort associated with dyslexia" (Academy of Orton-Gillingham Practitioners and Educators, n.d.). As JPSB noted:

> [In the Lexia program our students] go online … [access the program, and develop their] spelling skills. It is awesome because it does what a teacher can't

> do. … [It] can sit with a student for an hour … and keep practicing the same skills over and over again. … For younger kids there are more game-based approaches. There are five levels and once you have completed them … you have completed the program. And the teachers can get online and check … [individual student] progress. (Personal Interview, March 22, 2012)

Teacher KPS used the *Khan Academy* site for drill and practice assessments as well as tutorials to customize instruction and assessment to her students.

> … *Khan Academy* … gives me a lot of feedback. I get a lot of graphs and … class reports …. I can access real-time data … up-to the minute what they have been doing, what they looked at… how they did with problem A, B, and C, how they did with the other problems, and how they struggled. (KPS, Personal Interview, March 23, 2012)

Similar to the sub function of *Evaluating Student Performance*, students at PS were evaluated through the use of simulations (accessed through *www.khanacademy.com*), tutorials, and drill and practice to determine if they were meeting criteria needed to attain their learning goals.

Providing immediate feedback. The sub function, *Providing Immediate Feedback*, allows teachers to offer just-in-time feedback to aid learning. Based on observations and interviews, because teachers at PS were constantly monitoring student performance, be it through online applications/programs or through in-class activities, they were able to provide students with targeted and immediate feedback.

Certification. The function of *Certification*, according to the PIES design theory, determines when a criterion for an attainment has been achieved and therefore can be checked off when completed.

> When the criterion for successful performance has been met on x out of the last y unassisted performances, the summative assessment will be complete and the corresponding attainment will be automatically checked off and in the student's personal inventory of attainments, and a link will be provided to the evidence for that attainment. (Reigeluth et al., 2008, p. 36)

The assessment process at PS was observed to be similar to the *Certification* process described by the PIES design theory. Students were assessed repeatedly on the same skills until mastery was demonstrated in a particular learning goal. Students were at first informally evaluated until they performed without errors. They were then evaluated formally, to demonstrate mastery of the learning goal. The quote below illustrates the process.

> [To] see if they have mastered a particular skill set … [I assess them informally]. For the formal assessments … I expect them to have that information down. I won't give them a test until I have done that. If I think [they have it] at that point in time, I will go ahead and assess that skill set. (BPS, Personal Interview, March 28, 2012)

Developing student assessments. According to the PIES design theory, the *Developing Student Assessment* sub function will support "teachers and others in the development of formative and summative assessment for new instruction" (Reigeluth et al., 2008, p. 36). Teachers at PS regularly used resources found on the Internet to create their assessments.

Improving instruction and assessment. The PIES sub function, *Improving Instruction and Assessment* will help "formatively assess instruction and assessments in the LMS" (Reigeluth et al., 2008, p. 37). As stated during the interviews, PS teachers routinely monitored the effectiveness of their instruction and assessment materials. Based on how students were performing on the formative assessments, teachers revised and altered materials they used in class.

Secondary Functions

Secondary Functions in PIES consist of four sub functions: (a) *Communication*, (b) *General Student Data*, (c) S*chool Personnel Information*, and (d) *LMS Administration.* At PS, activities similar to the PIES sub functions, listed and described below, were observed during classroom observations and described during teacher interviews.

Communication. The *Communication* sub function, as the name suggests, allows users to communicate and collaborate with each other. Based on teacher interviews, PS teachers routinely communicated with their students through the use of email, text messages, and phone calls.

General student data and school personnel information. According to the teacher interviews, *General Student Data* and *School Personnel Information* were stored in excel sheets and in binders. General student data at PS included not only student personal information like contact and emergency information, but also information regarding learning disabilities and developmental challenges.

Related Formative Question 1(a): Improvements

The goal of the first research question was to identify functions in PS that were similar to the functions described in the PIES design theory. Now we will address the formative component of research question one: *What improvements can be made to the tools (functions) offered by the PIES design theory to better perform those tasks?* Therefore the goal is now to determine, based on the similarities that have been identified, if the corresponding functions in PIES can be improved. However, based on

the interview and observation data, no improvements to the functions described in the PIES design theory are evident.

Descriptive Question 2: Functions Lacking in Case 4

In this section, the goal is to identify PIES functions that are not reflected in PS. In other words, this section will answer the descriptive research question: *What information-age tasks identified by the PIES design theory are not being accomplished by teachers in such schools?* Based on the interviews and observation data collected at PS, the sub functions described by the PIES design theory, observed to be lacking were the sub functions of *Standards Inventory*, *Personal Attainments Inventory*, *Long-Term Goals*, *Contract*, and *LMS Administration*.

Standards inventory. Although National Council of Teachers of English (NCTE) and state standards were used to guide the design of instruction and assessments at PS, no function similar to the *Standards Inventory* sub function described by PIES was observed or reported in PS. According to the PIES design theory, a significant design element of the *Standards Inventory* function is to present users a list of state, national, and local standards "organized into maps for each domain of learning based on Domain Theory" (Reigeluth et al., 2008, p. 33). "Each domain map will include (a) major attainments with boundaries, (b) categories of attainment where each category represents a pathway of learning, and (c) a difficulty-based sequence of attainment along each pathway" (p. 33). In PS, based on the data, the focus was to ensure that the student met state standards. The standards offered by the Department of Education websites, at both the state and national levels, were accessed by teachers and administrators while planning

and designing the curriculum. Therefore, standards at PS were not organized according to domains of learning, themes, scope and sequence, or projects (as observed in previous cases and prescribed by PIES).

Planning for Student Learning

The sub functions of *Long-Term Goals* and *Contracts* were not found to be in practice at PS.

Long-term goals. The sub function of *Long-Term Goals* allows users to select long-term career goals that they would like to work towards. Based on the data, no instances of students selecting long-term goals were observed at PS or mentioned during the interviews.

Contracts. According to the PIES design theory:

> A learning contract will essentially be an agreement between a student, teacher, and parents that specifies the goals that the student wishes to achieve, the means (primarily projects) that will be used to achieve them, the teacher's and parents' roles in supporting the student, and the deadline for completing each project (negotiated with the teammates for each project). (Reigeluth at al., 2008, p. 34)

The use of contracts of the nature described by the PIES design theory were not observed or reported to be used at PS.

Secondary Functions

The sub function of *LMS Administration* was not observed at PS because no LMS was observed or reported to be in use.

Related Formative Question 2(a): Improvements

This section lists the findings that answer the formative component of the second research question, *What PIES functions, if any, should be changed or removed as a*

consequence? In the case of PS, the data do not inform the inclusion or the exclusion of the sub functions of *Long-term Goals, Contracts, or LMS Administration*.

Descriptive Question 3 and Related Formative Question 3(a): Functions Lacking in PIES and Improvements

The goal of this section is to list the findings that answer the third research question: *What tasks are being accomplished in such schools that are lacking from the PIES design theory, if any*? However, data gathered at PS did not reveal any tasks that were being accomplished that were lacking in the PIES design theory. Consequently, no recommendations can be offered to inform the formative component of the third research question, *what improvements can be made to the PIES functions to perform those tasks?*

Descriptive Question 4: Encouraging/Discouraging Technology Use

This section addresses the fourth descriptive research question — *what factors play into encouraging or discouraging teachers from using technology to accomplish the tasks?* Technologies in the form of computer software that administer drill and practice activities were integrated into the PS school curriculum. It was observed that Lexia (described on page 163) was extensively used by every study, in addition to online drill and practice activities in math, grammar, and reading. It was also observed that some teachers had extensively integrated technology into their curriculum. Based on the data, *perceived usefulness* and *assumptions about the learning process* were two factors identified that encouraged or discouraged technology use and implementation at PS.

Perceived Usefulness

Below are the various ways that PS teachers used technology to address their needs.

Real-time student progress report. One of the teachers stated that technology had helped her in differentiating instruction by providing her access to real-time student progress reports (in the form of Khan Academy reports). Teachers at PS also used Lexia (described previously) which provided real-time student progress reports. Therefore, by providing a comprehensive report on how students were progressing, these types of technologies alleviate teachers' workload and provided information that informed the use of instructional strategies and interventions.

Support differentiated instruction. As observed in the classroom and noted during interviews, technology gave teachers the ability to differentiate instruction for their students. As KPS noted:

> They can listen and see somebody else teaching. Sometimes that would be a different method than what I've done. So, here's "I will show you my way," and here's another way that you can do it. But which one works for you? So we use some of the digital and online videos. (Personal Interview, March 23, 2012)

Enable drill and practice. As noted by JPSB, technology also alleviated the monotony of administering and monitoring drill and practice exercises, thereby making teachers more likely to integrate these solutions.

> It's awesome because it … can sit with a student for an hour and keep practicing the same skills over and over again, whereas we can't do that because of time constraints and you would go crazy saying the same things over and over again. (Personal Interview, March 22, 2012)

Having identified the factors that encouraged technology use at PS, I will now list factors that discouraged technology integration.

Assumptions about the Learning Process

Teachers at PS believed that students who had learning disabilities learned better when the content was presented in a visual and tactile manner. Therefore, when new concepts were to be learned, teachers believed that handing out printed, physical versions of their lessons were more effective in serving their learning goals. As JPSB noted, "I always give them handouts with basically everything I say on it. We kill a lot of trees here because we give them a visual they can constantly reference" (Personal Interview, March 22, 2012).

Inferential Question 5: Implications of the Findings on *2012-2013 eLearning Priorities* proposed by the Indiana Department of Education (IDOE)

2012-2013 eLearing Priorities

As discussed in previous chapters, in 2012 the Indiana Department of Education (IDOE) presented the *2012-2013 eLearning Priorities* (see Appendix C) which listed the technology integration initiatives that the IDOE wanted Indiana schools to adopt.

Implications of the Findings on eLPIR

In an effort to the inform the *2012-2013 eLearning Priorities*, its ideas and realities (eLPIR)[5] were coded to identify five categories: (1) *Leadership Development*; (2) *Networking*; (3) *Digital Resources*; (4) *Digital Learners*; and (5) *Innovation*. Data from Pinnacle School were then analyzed to identify factors that could inform the above-listed categories. Findings from PS were able to inform the category of *Leadership Development*.

[5] See page 95 for complete list of eLPIR.

Leadership development. The idea and realities included under the category of *Leadership Development* focused on making concerted efforts to create leaders who would be responsible for spearheading technology integration in Indiana Schools. They would also be in charge of moving "schools and communities toward the opportunities and advantages of digital-age learning" (Office of eLearning, 2012, p. 1). Based on the findings of this study, to create a leadership that would be successful in leading educational communities towards the digital-age, it is recommended that leaders be aware of certain teacher and administrator mindsets regarding technology integration.

It was observed during the study that some teachers and administrators believed that technology would replace them. As teacher BPS at Pinnacle School noted during a conversation regarding technology innovation — "I hope that you come up with a great program and I hope that you don't replace me as a teacher cause I enjoy being with kids" (Personal Interviews, March 28, 2012). Teachers believed, as observed through similar statements made in the previous cases, that technology had the potential to replace them.

Summary

In summary (also see Table 10), almost all the functions described in the PIES design theory were observed in Pinnacle School to some degree of similarity. Sub functions such as *Standards Inventory, Personal Attainments Inventory, Long-Term Goals, Contracts,* and *LMS Administration* were not observed at PS. No functions were observed in PS that were not described by the PIES design theory. Functions in PS that were found to be similar to the PIES functions did not contribute towards improving the design of PIES. However, analysis of the data did contribute towards identifying factors (see Table 11) that encouraged and discouraged the use of technology in PS. In addition,

findings from PS were also able to inform the *Leadership Development* criterion identified in the eLPIR. In Chapter 8, these results will be collated in light of the findings from previous cases to reveal final recommendations to improve the functions and features of the PIES.

Table 10

Case 4 Summary of Findings from Descriptive Questions 1, 2, and 3 and Recommendations from Formative Questions 1(a), 2(a), and 3(a)

	Function Similar to PIES	PIES Functions Missing in PS	PS Functions Missing in PIES	Recommendations
Recordkeeping for Student Learning	Personal Characteristics Inventory	Standards Inventory Personal Attainments Inventory		
Planning for Student Learning	Current Options Short-Term Goals Projects Teams Roles	Long-Term Goals Contracts		
Instruction for Student Learning	Projects Initiation Instruction Project Support Instructional Development			
Assessment for (and of) Student Learning	Presenting Authentic Tasks Evaluating Student Performance Providing Immediate Feedback Certification Developing Student Assessments			

	Improving Instruction and Assessments	
Secondary Roles	Communications General Student Data School Personnel Information	LMS Administration

Table 11

Case 4 Factors that Encouraged and Discouraged Technology Integration

Factors that Encourage	Factors that Discouraged
Perceived usefulness	Assumptions about the Learning Process

Chapter 8: Discussion

Personalized Integrated Education Systems (PIES): The Suggested Changes

The goal of the study was to inform the function and features in the PIES design theory such that it is better able to address and support the needs of a learner-centered educational environment. Based on the findings of the study, below are the suggested changes for the features and functions of PIES.

The study recommends changes to the four major functions of the PIES design theory to more effectively support the learner-centered paradigm of education. The functions described in the PIES design theory are: (1) *Recordkeeping for Student Learning*; (2) *Planning for Student Learning*; (3) *Instruction for Student Learning; (4) Assessment for (and of) Student Learning*; and (5) *Secondary Functions* of *Communications, General Student Data, School Personnel Information,* and *LMS Administration.* The following sections provide a detailed description and justification of the suggested changes, based on observations and interview data collected from the four sites that participated in this study.

Recordkeeping for Student Learning

The *Recordkeeping for Student Learning* function serves to maintain student records and replaces the traditional report card with "systematic and comprehensive information about what each student has learned" (p. 33). Table 12 summarizes several changes suggested for this function based on the observation and interview data.

Table 12

Suggested updates to PIES' Recordkeeping for Student Learning Function

Standards Inventory	**Personal Attainments Inventory**	**Personal Characteristics Inventory**
User Choice	Additional Attainment Data: (i) Lessons attended; (ii) Lesson iterations; (iii) Concepts that needed additional help; (iv) Concept iterations	No Changes Recommended
Alternative Standards	Keyword Searches	
Standards Grouping according to *The Learning Hierarchy*		

Standards inventory. The changes suggested to the *Standards Inventory* sub function include the addition of user choice, inclusion of alternative standards databases, and enabling users to organize standards according to *The Learning Hierarchy (*Haring, Lovitt, Eaton, & Hansen, 1978) (see Table 12). Standards could be organized in accordance with the stages through which the student progressed while acquiring mastery of a particular topic. These stages of acquiring knowledge have been labeled by Haring et al. (1978) as (i) *acquisition*: when the learner has learned a given skill but is not accurate or fluent in it; (ii) *fluency*: the learner has acquired the new skill and has developed fluency in it; (iii) *generalization*: the learner is able to apply the learned skills to complete a wider range tasks; (iv) *adaptation*: the learner is able to adapt the skills and apply them to new situations. The four stages are collectively referred to as *The Learning Hierarchy* (Haring et al., 1978).

User choice. According to PIES' description, the sub function, *Standards Inventory*, would be preprogramed to tap into a standards database and map the standards according to each domain of learning. Based on the observation and interview data, it is

suggested that in addition to having an automated system, teachers should have the ability to edit the domain maps to ensure they are meeting the overall vision of the school. Parents and students should also have the ability to recommend edits based on their individual and educational philosophies and goals. This practice was observed in Case 1, BMS, where parents had the opportunity to influence school-wide decisions regarding educational goals.

> [We] do look at the needs of the community. We have a pretty academic parent body. We have families with very high expectations for their children. To some extent, that dictates the direction that we go with things. We tend to have a more academic curriculum than a curriculum based on impressions or feelings or open-ended things. (DM, Personal Interview, October 13th, 2011)

Alternative standards. In addition to providing access to all national, state, and local standards, the *Standards Inventory*, based on the findings, should provide access to standards created by private educational systems, such as Montessori and Waldorf. Allowing users the ability to choose among several sets of standards and create hybrid sets of standards could make the PIES more functional and usable by both private and public schools.

Standards grouping according to learning hierarchies. As noted in the results chapters, private schools, because they do not need to follow federal and state standards, create their own standards and *Learning Maps* (e.g., *Montessori Scope and Sequence* document). In addition, charter schools, such as The Bloomington Project School (TBPS), which was required to follow federal and state standards, also created learning maps that they organized to address their own learning goals and projects. All four schools that participated in the study followed a process, whether at a school-wide level or at an individual teacher level, to organize standards. Teachers routinely collaborated in

the beginning of each academic year to organize the state standards or the learning goals (in the *Scope and Sequence* at BMS) to plan lessons and activities such that each lesson and/or activity builds on the previous lesson and/or activity.

> [We] start with the standards. [Kids] have to learn [topics identified in the standards]. [We] try to group those standards together because … there are standards that should be taught together that aren't in the same section of the standards. So we really have to look and [group the standards correctly] so that it drives [the instruction]. We then try to tie them together in some kind of a meaningful way. It is not just lesson after lesson after lesson. They really complement each other and build towards some kind of a culminating thought. It really gives the kids a reason to need to know it and to want to know it – gives them context and schema. We have to think about what are these standards that we have to teach, but then how can we do that in a meaningful way that leads towards some kind of application. (SPSB, Personal Interview, April 13th, 2012)

Therefore, the *Standards Inventory*, in addition to organizing standards according to "maps for each domain of learning" (Reigeluth et al., 2008, p. 33), could also allow users the option to organize standards according to *The Learning Hierarchy* (Haring, Lovitt, Eaton, & Hansen, 1978) in order to better facilitate the planning process.

Personal attainments inventory. The changes suggested to the *Personal Attainments Inventory* include adding additional data to the *Personal Attainments* Inventory and allowing keyword searches to sort through the information related to attainments.

Additional data. According to the PIES design theory, the *Personal Attainments Inventory* serves as a "customized mastery progress report to the student, teacher, and parents" (Reigeluth et al., 2008, p. 33). In addition, it also allows the user to check off attainments as they are reached and add additional attainments not listed in the *Standards Inventory.* The attainments are linked to evidence of accomplishments, which may include not only artifacts that the students create, but also data reflecting the various

skills that the students may have mastered using simulation-based drill and practice exercises. Essentially the *Personal Attainments Inventory* is a progress report that provides a holistic picture of the students' accomplishments and attainments. The overall goal of the *Personal Attainments Inventory* is to inform the planning process.

Based on seven teacher interviews conducted at BMS (elaborated in Chapter 4), in addition to listing the attainments, the *Personal Attainments Inventory* could serve the planning process effectively if it also included information regarding: (i) lessons that the student has been given, (ii) the number of times the student has attended the lessons, (iii) concepts that the students has required assistance with, and (iv) the number of times the student has sought assistance for that particular concept. As observed, BMS teachers routinely maintained information of this nature in order to identify learning gaps and create directed lessons and activities. Thus, including this information could greatly assist the planning process, which is a goal of the *Personal Attainments Inventory* sub function.

Keyword searches. In addition to providing details regarding the attainment process, based on the findings of this study, it is also suggested that the *Personal Attainments Inventory* have a search and sort functionality such that users can search through and detect patterns in learning to better inform decisions regarding instructional development and implementation. It was observed that teachers at BMS maintained information regarding a student's attainment process in notebooks filled with detailed notes. In order to retrieve information to inform instructional decisions, the teacher has to sift through pages of notes. During one the interviews, teacher DM described that she could use a functionality that would allow her to search and sort through all her information in order to create a more comprehensive report.

> The one thing that comes to mind immediately is streamline the record-keeping so that I could synthesize it into some kind of comprehensive report. The best example is, years ago I used to do case management with at-risk families. And we had a database in which we entered all of our case notes. I could run a series of different reports either based on keywords, like, I could do reports on abuse or neglect or substance abuse. I could run reports on the amount of time parents were taking [and so on]. Something like that would enable me to generate reports like number of lessons given, number of times conferenced with teacher, how [the students] work their head problems individually or socially. I can [then] begin to get a real picture— a comprehensive picture of what a child's day looked like. How much attention they were receiving, how much they were being listened to, how independent they were, how dependent they were, you know that kind of [information] or some kind of [a] comprehensive report that would give me a [whole] picture. (DM, personal communication, October 5th, 2011)

Therefore, if PIES allows teachers the provision to record detailed information regarding a student's attainment process, it should also have a functionality that would allow teachers to quickly retrieve information and reveal patterns to inform instructional decisions.

Personal characteristics inventory. There were no observed instances of a function similar to the PIES *Personal Characteristics Inventory* in the four schools included in this study. However, there were several instances of informal practices where students were matched to appropriate instructional interventions based on their personal characteristics that influenced learning, "such as learning styles, profile of multiple intelligences, student interests, major life events, and so forth" (Reigeluth et al., 2008, p. 33). Because it was not an organized system that tracked student personal characteristics in a systematic fashion, the instances observed were sporadic. It was observed at BMS and at TBPS that students, whose learning challenges were significant enough to attract the teacher's attention, received interventions that were matched to their needs. It took a keen, observant, and experienced teacher to identify a student who needed different interventions. It is important to note that, in the observed cases, the onus of identifying

the students' learning needs lay squarely on the teacher. Therefore, there is a likelihood that there may be students with learning needs whom the teachers may not have been able to identify and therefore not address.

It became evident during the course of the study that personal characteristics were informing, although sporadically, the decisions regarding the types of learning interventions that were being provided to the students. The *Personal Characteristics Inventory* ensures that student learning needs and challenges are documented and can therefore be accessed by all who are involved in the student's educational progress.

Therefore, this finding gives support for a sub function similar to the *Personal Characteristics Inventory* in the PIES designs theory that may help streamline the process of directing customized and appropriate learning solutions towards students based on their varied types of learning styles, interests, and abilities.

Planning for Student Learning

The *Planning for Student Learning* function as described by the PIES design theory is to help with identifying learning goals and developing plans to meet those goals. The *Planning for Student Learning* function consists of seven sub functions: (i) *Long-Term Goals*; (ii) *Current Options;* (iii) *Short-Term Goals;* (iv) *Projects*; (v) *Teams*; (vi) *Roles;* and (vii) *Contracts*. Based on the findings of this study, changes are being suggested for only the *Teams* sub function: it should allow users to organize students based on skills and for the purposes of peer mentoring (see Table 13).

Table 13

Suggested updates to PIES' Planning for Student Learning *Function*

Long-Term Goals	**Current Options**	**Short-Term Goals**	**Projects**	**Teams**	**Roles**	**Contract**
No Changes	No Changes	No Changes	No Changes	Peer Mentoring	No Changes	No Changes

Teams. According to the data, in addition to organizing students for the purposes of social interactions, as described by the PIES design theory, it is suggested that the *Teams* sub function should also allow students to be grouped to promote peer mentoring. Peer mentoring, along with grassroots content creation and informal and collaborative, real, just-in-time learning, is one of the main focuses of web 2.0 learning technologies (Gunawardena, Hermans, Sanchez, Richmond, Bohley, & Tuttle, 2009):

> In an online environment, the [zone of proximal development] is often [supported] … through help tools, tutorials, and interaction between participants of the network. Peer-to-peer mentoring as well as instructor-to-student mentoring became a key element of our [Community of Practice]. (p. 9)

Therefore, corroborated by literature in the field as well as findings from this study, a system such as PIES should include a peer mentoring function.

Instruction for Student Learning

The purpose of the *Instruction for Student Learning* function as described by the PIES design theory is to help the teacher select and/or design instructional resources for students to use and to coach students during their use of those materials (Reigeluth et al., 2008, p. 35). Based on the findings of the study, changes are suggested (see Table 14) for the *Instruction* and *Instructional Development* sub functions that would help make the *Instruction for Student Learning* function more effective and appropriate for a learner-

centered environment. The suggestions for the sub function, *Instructional Development*, include the ability to design instruction and assessments collaboratively across disciplines, provide access to design guides, and provide teachers with RSS functionality. It is also suggested that functionality that allows users to review and rate and conduct keyword-based searched be added to the sub function of *Instruction* in order to assist with organizing and retrieving topic- and attainment-specific content.

Table 14

Suggested updates to PIES' Instruction for Student Learning Function

Project Initiation	**Instruction**	**Project Support**	**Instructional Development**
No Changes	Review and Rate	No Changes	Interdisciplinary, collaborative instructional development
	Keyword Search		Instructional Design Guides
			Really Simple Syndication Functionality

Instructional development. The sub function of *Instructional Development* as described by the PIES design theory is to "support teachers, staff, parents and even students in the development of new instruction —projects, learning objects, and other instructional tools" (Reigeluth, et al., 2008, p. 35). At BMS, DDA, and TBPS, teachers routinely collaborated to create instructional materials and resources. At BMS and TBPS, it was observed that teachers collaborated across disciplines to create instructional materials and resources. It was observed at TBPS and PS that the teachers used online templates and design guides to create their in-class lessons and materials. At BMS, DDA, BPS, and PS, teachers also accessed current news and events in order to inform their lesson topics, content, and assignments.

Based on the findings of this study, the following recommendations are suggested: (i) the ability to design instruction and assessment collaboratively and across disciplines; (ii) access to design guides; and (iii) access to RSS functionality. These recommendations are discussed in detail below.

Interdisciplinary, collaborative instructional development. It was observed in most of the cases where there was a focus on mastery-based learning that instruction was created in a collaborative, interdisciplinary fashion. Therefore, it is suggested that the sub function, *Instructional Development,* allow users to collaborate across disciplines in order to create instruction and assessment. Previous empirical studies have established that interdisciplinary instruction can positively affect learning (Akerson & Flanigan, 2000; Romance & Vitale, 1992). In addition, previous empirical studies have concluded that collaborative teaching has positive effects on instructional development and planning (Albrecht, 2003; Bass, 2005; Vasquez-Montilla, Spillman, Elliott, & McGonney, 2007; Nevin, Thousand, & Villa, 2009). Therefore, in light of past research as well as findings from this study, it is suggested that the sub function of instructional development allow users to collaborate in the development of instruction across disciplines.

Instructional design guide: Based on the data, the sub function, *Instructional Development,* should consist of an instructional design guide. This design guide will assist teachers, staff, and parents in creating effective and usable instructional materials. As observed in BMS where students have complete independence in accessing and using instructional materials, careful attention was paid to housing instructional materials such that students encountered little resistance to accessing them. Through an empirical study Volery and Lords (2000) identified three critical factors that affect success of online

instruction. The first of the three factors is the design of instructional resources such that users find it easy to access and navigate. Therefore, based on my findings and previous empirical studies (Volery & Lords, 2000; Eom & Wen, 2006) virtual educational environments should be designed with ease of access in mind.

As observed in all four cases included in this study, teachers needed access to instructional content and templates to create instructional materials. Therefore, it is suggested that the design guide should also include a repository of pre-designed templates that the teacher could easily apply to their instructional content.

Really Simple Syndication Functionality: It was observed in all four cases that teachers, when creating instruction, selected instructional materials and assessments that were current and relevant. It was observed that teachers at BMS, TBPS, DDA, and PS would reference news updates and other media sources to keep their content up to date. Therefore, it is suggested that the sub function, *Instructional Development*, host a Really Simple Syndication (RSS) functionality that would allow teachers, by linking to external informational sites, to stay abreast with social, cultural, and political updates. Using PIES, teachers may choose and link to sites that they frequently browse. Once they have linked to their desired sites, the RSS interface, specific to the teacher, will be populated with any and all updates made at the linked sites.

Instruction. As described by the PIES design theory, the sub function, *Instruction*, will be a repository of all instructional materials. Observed in both the LEC and the UEC at BMS, students independently identified, with guidance from the teachers, instructional help that they required. Therefore, based on the data, the following

recommendations are being made for the sub function, *Instruction*, to better serve the needs of students in learner-centered environments.

Review and rate: **T**he *Instruction* function should consist of a review function that will allow teacher, students, and parents to rate the material for its effectiveness. During the study, it was observed at BMS, TBPS, and DDA, that teachers referenced previous instructional materials to inform their instructional planning process. At BMS instructional materials were reviewed and comments were recorded regarding how well or poorly the materials proved to be effective and exciting. Teacher DM described the practice:

> So what I learned from that is, OK, despite having a lesson, despite doing two practice pages, they didn't internalize the concepts…. Therefore we planned a second set of lessons on those. [We also recorded] who did seem to listen or not listen; who seemed excited or not excited; who seemed confused. (DM, personal communication, October 5th, 2011)

Users should also be able to add comments regarding the quality and effectiveness of the instructional materials used. Critiquing aspects of the instructional materials that are not effective can consequently lead to the creation of better learning solutions. The review and rate function should also be able to generate effectiveness reports. As observed in most of the cases, teachers depended and benefited from prior knowledge of the quality and effectiveness of the instructional materials they wanted to use. Therefore, it is suggested that the PIES' *Instruction* sub function generate reports that describe how learning is affected by use of the instructional materials. This report should not be a collection of all review comments and ratings; rather, it should be generated based on students' performances. The system should look at factors such as how quickly the majority of students demonstrate mastery upon having accessed the instructional

material; how many iterations of that material led to demonstrated mastery; and how many additional resources did the students use in conjunction with the instructional materials to master the said content. Based on the report, the instructional materials can be reviewed by the teachers and edited or removed from the database.

Keyword Search: A functionality that would allow users to search through the database of instructional materials is suggested. The functionality should also be able to index the resources such that the uniqueness of each resource is retained, and more accurate results are generated when users conduct a keyword search.

Assessment for (and of) Student Learning

According to the PIES design theory, the *Assessment for (and of) Student Learning* function, will serve the purpose of assessing and evaluating students' progress on their way to mastering their selected attainments. Based on the findings of this study, additions to the sub functions of *Evaluating Student Performance* and *Certification* have been suggested (See Table 15).

Table 15

Suggested updates to PIES' Assessment for (and of) Student Learning Function

Presenting Authentic Tasks	**Evaluating Student Performance**	**Providing Immediate Feedback**	**Certification**	**Developing Student Assessments**	**Improving Instruction and Assessment**
No Changes	Mastery-Based Evaluation	No Changes	Long-Term Retention and Transfer Debriefing and Reflection	No Changes	No Changes

Evaluating student performance. According to the PIES design theory, the

purpose of the sub function, *Evaluating Student Performance*, is to evaluate whether or not the criterion was met through a simulation, tutorial, or drill-and-practice activity on each performance of the authentic task of the LMS (Reigeluth et al., 2008). Based on the findings of this study, it is suggested that the PIES sub function, *Evaluating Student Performance*, should adopt a mastery-based evaluation process as observed in BMS and TBPS where students were evaluated for mastery.

Mastery-based evaluation. Observed in learner-centered, mastery-based classrooms, the mastery-based evaluation function should offer students examples of errors that they are making and direct them to instructional aids that explain the reasons for the incorrect responses. It is important that the system only identifies a few of the errors and directs the student to identify other instances of the same type of error in their activities. This strategy was frequently utilized at BMS.

Certification. According to the PIES design theory:

> When the criterion for successful performance has been met on x out of the last y unassisted performances, the *summative assessment* will be complete and the corresponding attainment will be automatically checked off in the student's personal *Inventory of Attainments* and a link will be provided to the evidence of that attainment. (Reigeluth et al., 2008, p. 36)

Based on the findings, it is suggested that an additional sub function should be added that evaluates whether the concept learned has been internalized and can be transferred. In addition, a sub function of *Debriefing and Reflection*, which was initially described in the sub function of *Instruction*, should be included in the sub function of *Certification*. This recommendation is largely based on the observation that reflection was used as a form of evaluation in several cases.

Long-term retention and transfer. Different activities require different forms of evaluation. Assessments in subjects such as math and grammar, which often require a right or wrong answer, can be evaluated using the *Certification* function. As noted by the original PIES design theory, activities such as simulation, tutorials, and drill-and-practice can be evaluated to ensure that students have met the requirement for mastery of the given topic. Additional criteria should be included whereby "the criterion for successful performance has been met x out of the last y unassisted performances" (p. 36) should be spaced out to ensure long-term retention. In addition, the system should include criteria whereby skills are assessed based on their successful application in varied situations to ensure near and far transfer.

Debriefing and Reflection. In his exposition of reflective thinking and its role in the learning process, John Dewey stated that "[w]e do not learn from experience. We learn from reflecting on experience (1933, p. 78). Educational philosophers such as D.A. Schön "highlighted the value of reflection in helping professionals learn about and improve their practices" (McAlpine & Weston, 2000, p. 364). Reflection has been established by several philosophers and educators as an effective and important component of the learning process (Kremer-Hayon, 1988; Kompf & Bond, 1995). In addition to literature in the field, findings of this study highlight the importance of debriefing and reflection in the learning process.

> If a child does a really wonderful experiment but they never articulate what they learned from that, I feel like something is really lost; a moment is lost. We as adults can have a lot of really wonderful experiences, but if we are not someone who is introspective or reflective or one who journals, or who takes those experiences and translates them into something else, whether it be how you teach, how you counsel people, how you deal with your interpersonal relationships, how you parent, how you paint a painting, you are missing something. You have all

> these opportunities to translate experiences into something, and I think that we help children do that by expecting that final piece, by putting closure on things. (DM, personal communication, October 5th, 2011)

Although the need and importance of debriefing and reflection have been elaborated by the PIES design theory in the sub function of *Instruction,* it is recommended that a reflection function should also be included in the sub function of *Certification*. Doing so will ensure that students have internalized the concepts being learned and have mastered the objective.

Secondary Roles

According to the PIES design theory, the function, *Secondary Roles*, offers a "set of roles necessary for an ideal learning management system" (Reigeluth et al., 2008, p. 37). Based on the findings of this study, three suggestions are being made: (i) synched communication tools; (ii) virtual conference/meeting organizer; and (iii) training and professional development (see Table 16).

Table 16

Suggested updates to PIES' Secondary Functions

Communication	**General Student Data**	**School Personnel Information**	**LMS Administration**
Synched communication tools	No Changes	Training and Professional Development	No Changes
Virtual Conference/ Meeting Scheduler			

Communication. Teachers, in all participating schools, relied heavily upon different communication tools to communicate with students, parents, colleagues, and administrators. Therefore, based on the findings, it is recommended that the sub function

of *Communication* allow users to (i) synch all communication devises and (ii) provide users a scheduling application.

Synched communication tool. One of the recommendations based on the data is that the *Communications* function should be synched with all communication tools that a user may use. For example, some users may prefer to use text messages, while others may prefer emails, discussion boards, class-wide announcements, or similar technologies. Therefore, despite the medium used for communication, all tools and devices should be synched within the PIES *Communication* function.

Virtual conference/meeting scheduler. Based on the data, it is suggested that the *Communication* sub function should allow parents, teachers, and students to virtually schedule meetings and conferences. This application will function in ways similar to *ScheduleOnce* or *Doodle*. In this system, teachers will be able to post their available times. Students and parents can then access the page to select the time at which they would like to meet with the teacher. Once the appointment has been scheduled, the system will send a notification letting the teacher, parents, and student know of the upcoming appointment.

School personnel information. According to the PIES design theory, the sub function, *School Personnel Information*, will manage data related to learning.

> These data will include general information, such as name and address, but also data related to learner-centered instruction, such as assigned students, certifications and awards received, professional development plan and progress, and the teacher's physical location. (Reigeluth et al., 2008, p. 38)

Training and Professional Development. Based on the observation and interview data from Bloomington Montessori School, it is suggested that in addition to housing

information regarding teacher professional development and progress, the sub function, *School Personnel Information*, should also include a function that will allow for an apprenticeship-based model of teacher training.

Prescriptions for Successful Technology Implementation: Lessons Learned

Creating a system such as PIES is facilitated when design specifications backed by empirical evidence are available. However, a well-designed system does not imply successful implementation; neither does top-down implementation guidelines as observed during this study and corroborated through previous empirical research (Brzycki & Dudt, 2005). For successful implementation of technology, various factors need to be taken into consideration and addressed. Factors identified through this study that may alleviate impediments to successful implementation are listed in Table 17 below.

Table 17

Prescriptions for Successful Technology Implementation

Prescriptions

• Implementation Efforts
  o Grassroots Level
  ▪ Technology teams
  ▪ Talk technology
  o District Level
  ▪ Informed and involved
  ▪ Know your technology
  • Relevance
  • How to use

• Perceived Ease of Use
• Perceived Usefulness

• Perceived Threat
  o Technology as a Distractor or Ineffective Means to Learning
  o Diminishing Role of Teacher

Implementation Efforts: Grassroots and District Level

Technology integration can be implemented either through the grassroots or through the district level. It is advised, in order to ensure successful stakeholder buy-in, technology choice and use be initiated at the grassroots. George, Lacano, and Kling (2005) demonstrated, in their longitudinal study on desktop computing, that professionals were more likely to adopt new innovations through their own social networks and peers than from formal implementation efforts. Findings from my study further bolstered the findings of George et al. It was observed in my study that schools that successfully integrated technology did so due to integration efforts that were spearheaded by teachers. Therefore, decisions regarding technology innovation will be more likely adopted if made at the local school level. Various strategies to encourage stakeholder buy-in at the grassroots are discussed in more detail.

Grassroots initiative. To initiate implementation efforts at the grassroots, two strategies, derived from the data, may be adopted: (i) Technology Teams and (ii) Technology Talks.

Technology teams. Creating small teams of technology enthusiasts who love to explore new technologies and share their enthusiasm with their colleagues may facilitate successful technology implementation. This strategy was observed during the course of the study to be highly effective in integration and implementation efforts. It was also found to be an effective technology integration strategy by Strudler and Wetzel (1999) in a study conducted to identify factors that affected technology integration at colleges of education. They identified that “active college-level technology committees comprised of teacher educators, instructional technology educators, students, and support personnel

within the college and university" served to positively affect technology integration efforts (p. 69). They also observed that the work of the technology team was to "prioritize technology needs, share promising teaching-with technology practices, and make recommendations to the dean regarding hardware and software needs for faculty, labs, and classrooms" (p. 69). Similar observations were made in the current study.

It is essential that this team is comprised of early adopters who are also part of strong interpersonal communications channels (Rodgers, 1996, 2003). The objective of this team should be to initiate discussions about new technologies and how these technologies could be implemented in their current system.

Talk technology. A practice of discussing new and upcoming technology innovations should be adopted at staff meetings. Just as issues of school safety and curriculum needs are routinely discussed, teachers and administrators should be encouraged to discuss successes, failures, and impediments in their technology use and implementation.

District-level initiative. Often, technology implementation efforts are spearheaded at district levels. At such times when technology integration has to be a top-down initiative (perhaps, due to policy mandates), stakeholder buy-in, necessary for successful implementation efforts, can be fostered through alternative strategies. The strategies recommended are listed and discussed in more detail below.

Informed and involved. It is imperative that teachers and administrators are involved in and informed of all technology decisions that are being made at the district level. Online forums and collaboration sites can be created where teachers and administrators will be able to express their views and concerns. In order to have teachers

and administrators successfully collaborate in the implementation efforts, an environment of trusting and open communication should be established.

Know your technology. In addition to collectively selecting technology innovations, efforts should be made to ensure that potential users understand the need and relevance of the technology and learn how to effectively use the innovation.

Relevance. For successful technology implementation and integration, it is important that users believe that the technology being implemented is able to meet their needs (Gibson, 2001; Culp, Honey, & Mandinach, 2005). Therefore, efforts should be made to let users identify how a system can actually be useful and advantageous. Teachers and administrators need to be able to visualize how a technology will help them effectively perform their tasks.

How to use. Technology training is important for successful implementation (Christensen, 2002; Zhao & Bryant, 2006). Ertmer in her 1999 study concluded that teachers came with varied experiences in the use of technology. Observations in this study confirmed Ertmer's claim. Some teachers were adept at adopting new technologies and incorporating new tools into their daily activities. At the same time, there were teachers who found technology extremely intimidating and viewed efforts put into learning new technologies as a waste. They came to believe that their previous methods were more efficient and effective. It is this demographic that needs to be targeted for technology training more so than those who have successfully integrated technology.

Perceived Usefulness

Davis (1989), in a study titled *Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology*, found that perceived usefulness is strongly

linked to the extent of technology usage. People "tend to use or not use an application to the extent they believe it will help them perform their job better" (p. 320). In other words, if users do not view the technology as being effective in helping them achieve their goals or address a need, they are less likely to use the innovation (Davis, 1989; Davis, Bagozzi, & Warshaw, 1989, Adams, Nelson, & Todd, 1992; Igbaria, Guimaraes, & Davis, 1995; Calisir & Calisir, 2004).

Based on the findings of this study, technology solutions that are to be used in educational environments should be proven to be effective before implementation. Teachers need to be convinced of the usefulness of educational solutions and interventions. Therefore, before technology solutions are released, they should be tested for effectiveness, and results should be shared with teachers, administrators, and parents.

Perceived Ease of Use

Davis (1989) also noted, "even if potential users believe that a given application is useful, they may, at the same time, believe that the system is too hard to use and that the performance benefits of usage are outweighed by the effort of using the application" (p. 320). Therefore, the next step towards successful technology implementation is to ensure the quality of the technology itself. Observed in the schools that participated in the study as well as corroborated through literature (British Educational Communications and Technology Agency, 2004), if the technology solution that is being introduced is unstable and badly designed (i.e. difficult to use), there is a high likelihood that these solutions will not be integrated. Therefore, technology solutions should be fully tested for use in classrooms before being released for adoption.

Perceived Threat

Technology at times can be perceived as a threat (Ringstaff, Kelley, & Dwyer, 1993; Bellamy, 1996). During the course of the study, two types of perceived threats were identified: (i) technology will diminish the role of the teacher; (ii) technology is a distractor or ineffective means to learning.

Diminish the role of the teacher. Some teachers believe that the advancement of technology poses a threat to the profession of teaching. They believe that as technology progresses and becomes more ubiquitous throughout the curricula, the need for a teacher in a classroom will be reduced to that of a technology manager. In order to address this problem, teachers need to be made aware of how the role of the teacher, due to technology integration, changes, but is not diminished, when effectively integrated into the curricula (Hannafin & Savenye, 1993). Training workshops need to be held in order to transition teachers' mindsets to accepting how they can now become more effective in addressing all their students' learning needs by successfully and effectively integrating technology into their classrooms (Christensen, 2002; Zhao & Bryant, 2006).

Technology is a distractor or ineffective means to learning. It was observed that technology was viewed by some teachers as a distraction to learning. Teachers also questioned the credibility and reliability of content that students found online. In order to minimize the effects of questionable resources, it was often observed that teachers dissuaded students from using the Internet for research.

> [Y]ou know they are doing a lot of typing, but then they are doing a lot of internet research, and I think that they are getting away from books with good information that's been researched and checked over. … [They] are moving towards [sites such as] ask.com [and] …Wikipedia. … But we don't encourage reports to be coming from Wikipedia. (CS, Personal Interview, October 11, 2011)

Printed educational content has always refereed, censured, and reviewed by experts before being made available for consumption. Since the advent of the Internet, educational content created and published online is not refereed, censured, and reviewed, to the extent needed to instill a sense of security amongst some consumers. In order to overcome the fear regarding the credibility of online content, teachers need to be trained in skills that would make them effective consumers of information. They need to be trained to identify reliable and dependable sources — skills that they can then pass on to their students. They need to be trained in the methods of triangulating information and sources. In other words, teachers first need to be confident in their own ability to conduct research online. Only then will they be able to inculcate the same values and skills among their students.

Future Research and Limitations

Future Research

During the data analysis, some recommendations regarding future research emerged.

Conduct similar case studies to add to the body of knowledge. Although this study was a collection of four case studies, additional case studies need to be conducted in order to validate findings in this study and build a body of knowledge that can then be used to design an information-age learning management system (such as PIES) that will effectively serve a variety of schools.

Role of a student and the teacher in a learner-centered environment. Traditional classroom expectations and policies are crafted based on the assumption that students lack the maturity and the discipline to function as conscientious and responsible

learners (Weimer, 2002; Mallinger, 1998). The traditional view of a teacher is one who "dominates the classroom and its elements. She prepares lesson plans for efficient use of class time, prescribes course objectives, and disseminates information clearly and effectively so that students may learn it quickly, remember it well, and reproduce it upon demand" (Braye, 1995, p. 1). On the same note, in a traditional classroom, the student is very comfortable with being the passive recipient of information, which they can regurgitate on a test to get a grade (Felder & Brent, 1996).

In a learner-centered environment, the roles and responsibilities of the teachers and the students change dramatically. The balance of power in a learner centered classroom is now shared between the teachers and students and learning decisions are made collaboratively (Weimer, 2002). The student is now expected to take responsibility for their own learning, which can be more work than being a passive recipient of information (Felder & Brent, 1996; Weimer, 2002).

As the study progressed from one school to another, it became apparent that philosophies and attitudes towards education and the practice of education varied greatly due to the philosophies and attitudes of teachers and students. Although some schools in the study had adopted a learner centered approach at the administrative level, they were not fully successful in practicing a learner-centered approach in the classroom due to the assumptions and attitudes of their teachers and students. It became clear during the course of the study that simply adopting a learner-centered approach did not guarantee that it would be implemented successfully. Teachers and students alike need to become aware of their roles and responsibilities in a learner-centered environment.

Therefore, even if an educational tool such as PIES is designed to support and address educational needs in learner-centered environments, there is no guarantee that it will be used effectively or in the same way by all schools. Success of a learner-centered environment depends greatly on its teachers and students. Therefore, in addition to informing the functions and features of the PIES design theory, additional research is needed to identify important characteristics that make teachers and students function successfully in a learner-centered environment. Effort needs to be made to ensure that teachers and students understand the changes in their roles and responsibilities once they move from a traditional classroom to a learner-centered classroom.

Limitations

One of the limitations of this study is the lack of schools that are truly learner-centered in nature. Of the four cases in the study, only two (BMS and TBPS) fit the description of a learner-centered environment completely. In the remaining three cases, separate components that could be classified as characteristics of learner-centered environments were found. Schools often associate student-centered, differentiated learning as learner-centered education. Therefore, when selecting sites to replicate this research, the researcher should be cognizant of the overlap of student-centered, differentiated learning and learner-centered education.

A Final Word

In this study, through analysis of data gathered at four participating sites, support was found for most of the functions and sub functions of the PIES design theory, and some changes were suggested for PIES to better meet the needs of leaners and educators in a learner-centered educational environment. In addition to informing PIES design

theory, contributions were provided to the body of knowledge regarding technology implementation practices and policies.

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Appendix A

Observation Rubric

Observation Rubric	
Primary Functions	
1. Record keeping	
(i) *Standards inventory*: a. Do the teachers keep track of the national and state standards? b. Do the teachers keep records that support student learning? c. What tools do the teachers use to maintain student records?	
	Observation Notes:
(ii) *Personal Attainments Inventory*: a. Do the teachers track each student's progress in meeting the state and national standards? b. What information is stored to track student progress? c. What tools are being used to track student progress?	
	Observation Notes:
(iii) *Personal Characteristics Inventory*: a. Do the teachers keep track of students learning styles, multiple intelligences, and interests? b. What information is collected to track student learning styles, multiple intelligences, and interests? c. What tools are being used to track student learning styles, multiple intelligences, and interests?	
	Observation Notes:

2. Planning	
(i) *Planning one's long-term goals*: a. How are students' long-term goals identified and recorded? b. How are the instrumental goals identified and recorded? c. How do they make sure that these instrumental goals are being accomplished?	
	Observation notes:
(ii) *Listing current option*: a. How are the attainments that are within reach of the students identified and recorded? i. What information is being collected to help identify attainments that are within the reach of the student? ii. Are any tools being used to identify current options? b. Are the personal attainments compared with the general standards inventory to identify attainments that are within reach?	
	Observation Notes:
(iii) *Short-term goals*: a. How are the immediate learning goals identified and recorded? b. What information is being collected to help identify goals? c. What tools are being used to identify and record goals?	
	Observation Notes:
(iv) *Selecting Projects*: a. How are projects, that students will be working on identified, selected, and assigned? b. What tools are being used to identify, select, and assign projects?	
	Observation Notes:

(v) *Forming teams*: a. How are project/tasks team assignments made? b. What tools are being used to make project/task team assignments?	
	Observation Notes:
(vi) *Defining roles*: a. How are roles assigned to participants in the project? b. What tools are being used in the role assignment process?	
	Observation Notes:
(vii) *Creating a contract*: a. How are learning contracts created? b. What tools are used for creating learning contracts?	
	Observation Notes:
3. Instruction	
(i) *Project Initiation*: a. What steps are taken before projects /tasks begins?	
	Observation Notes:
(ii) *Instruction*: a. How is customized instruction handled in an ongoing project? b. What tools are being used to assist in handling customized instruction?	
	Observation Notes:

(iii) *Project Support*: a. How do teachers keep track of the progress made in the projects?	
	Observation Notes:
(iv) *Instructional Development*: a. How do the teachers develop and store new instructional tools?	
	Observation Notes:
4. Assessment	
(i) *Presenting Authentic Tasks*: a. How authentic are the tasks that are used for assessing student learning? b. What tools are being used to create authentic tasks?	
	Observation Notes:
(ii) *Providing Immediate Feedback*: a. How are teachers providing feedback? b. To what extent is it summative or formative? c. What tools are being used to in providing feedback?	
	Observation Notes:
(iii) *Certification*: a. How do the teachers keep track of students' attainments and match them with their personal attainments inventory? b. What tools are being used to accomplish this task?	
	Observation Notes:

(iv) *Developing Student Assessments*: a. How do the teachers develop assessments?	
	Observation Notes:
(v) *Improving Instruction and Assessments*: a. What kinds of information do the teachers collect in order to improve their instruction and assessments? b. How do the teachers improve their instruction and assessments?	
	Observation Notes:
Secondary Functions	
1. Communications: **a. How do the teachers communicate with the students and the parents?** **b. What tools are being used for communication?**	
	Observation Notes:
2. General Student Data Management: **a. How is student data managed? What are the different categories of information (not related to student learning) stored about the student?**	
	Observation Notes:
3. School Personnel Information: **a. How is information of all school personnel managed?** **b. What kind of tools are being used to manage this information** **c. What kind of information about school personnel is being stored?**	
	Observation Notes:

Appendix B

Semi Structured Interview Protocol

Semi Structured Interview Questions
1. How do you create and manage individual student learning goals? a. What are some of the resources that you use to create and manage student learning goals? b. Do you use computer/web-based tools to create, maintain, and manage student learning goals?
2. How do you assess and manage assessment of student learning? a. Do you use student assessment results to inform student learning goals? b. Do you use any resources to accomplish this? c. Do you use computer/web-based tools to maintain and manage student assessments?
3. How to do you create and manage classroom instruction? a. Do you use computer/web-based tools to facilitate classroom instruction?
4. Is your instruction just-in-time for a project based environment or is it in more a lecture format? a. What kind of resources do you use to help you create and deliver your instruction?
5. How do you communicate with students and parents outside of the formal educational environment? a. What kind of tools do you use to facilitate communication?
6. Do you and your students use any particular learning management system (LMS)? a. If Yes i. What features in the LMS to do you find most helpful? ii. What features in the LMS do you find least helpful? iii. Are there features in your LMS that you wish you could add? Elaborate iv. Given a more learner-centered model of education, do you think that the current LMS helps you successfully meet the requirement of a learner-centered model? v. [For each of the functions or sub-functions for an information-age LMS that has not been identified and demonstrated] Does the current LMS have a feature for _____ 1. [If yes] Could you demonstrate it for me? vi. Are there any other features of the LMS that are supportive of your teaching? vii. [For each function or sub-function identified above] How effectively does the current LMS provide this function? How could it be improved? viii. Are there any other features you wish the LMS had? ix. How has the use of the LMS changed your role as a teacher? x. How have students responded to the LMS? xi. Overall have you seen improvements in students' learning? How? b. If no, i. Do you think that having a learning management system (explain and illustrate what a learning management system can do) would help you accomplish your tasks more effectively? 7. If so, what features do you think would be most crucial to learning management system that is created for a learner-centered school such as yours?

Appendix C

2012-2013 eLearning Priorities Document

The Indiana Department of Education and the eLearning Team is happy to announce its programming goals for 2012 and 2013. The slate of programming outlined below is based on the following ideas and realities.

- *Strong, informed and visionary leadership is necessary to move schools and communities toward the opportunities and advantages of digital-age learning.*
- *Schools are at very different places on the continuum of innovation through technology and the strategic use of available state funds will target innovation leaders and in parallel widen the circle of schools ready to capitalize on local vision and the strong desire to innovate.*
- *Access to high quality digital content is increasingly important as schools shift from traditional textbooks to a digital curriculum.*
- *There are many examples of schools and individuals delivering high quality instruction and achieving improved student outcomes yet there are challenges in tapping into this expertise.*
- *Online and virtual learning is pervasive and poised to expand dramatically in the coming years.*
- *Student comfort with technology is not synonymous with being an effective and able learner in the digital age. The skills and aptitudes of students to learn in digital environments should be addressed through integrated curricula and assessed periodically.*
- *Indiana is a state that has the capacity to connect schools to new products and services, test them in real classrooms, share the results and strategically abandon or iteratively implement.*

In support of these ideas and realities the following programs are being developed, launched or monitored for next steps.

Leadership Development

- **eLearning Leadership Cadre**—Formation of a group of educational technology leaders from across Indiana who will focus on strategic components of 21st century teaching and learning directly on impacting student achievement and instructional practice as well as on community and business partnerships. Additionally, the group will play an important role in offering feedback and advice to the IDOE regarding the design and implementation of eLearning initiatives. **Launched**: *January 19, 2012.*

2012-2014 eLearning Leadership Cadre Members

Pete Just	Jason Bailey	Tamra Ranard
Blake Zachary	Jason Roseberry	Phil Partenheimer
Julie Bohnenkamp	Dennis Stockdale	Lisa Cutshall
Rhonda	Brad Fischer	Dan Funston

- **Administrator Technology Boot Camps**—Program is being designed to provide school leaders with a series of opportunities to receive professional development and network with colleagues around the understanding and skills needed to be a 21st Century innovative leader. **Anticipated launch:** *Summer/Fall of 2012.*

- **Innovation Planning Grants**—The IDOE will be sponsoring a competition to provide up to 20 grants of $25,000 each to support schools interested in developing strategic plans to shape their approach for transitioning to the digital age. Schools eligible for these grants include any public school that has been in operation for more than three years and has a total enrollment of 5,000 students or less. The details of this grant program are still being designed. All recipients of this grant will be expected to produce a plan to guide the school or corporation's pivot to digital age learning and will include a third party technology needs assessment. **Anticipated Launch**: *April 1, 2012.*
- **Classroom Innovation Grants—**The IDOE will continue its strategy of investing in schools that have demonstrated active local commitment to innovation and strong progress on IDOE established metrics. Two groups of schools will be eligible for these grants.
  - Schools that competed in the last round of Classroom Innovation Grants awarded in April of 2011 receiving an overall score of 80% but not receiving funding in that round will be eligible for a classroom innovation grant of $200,000. **Anticipated grants to fund**: *6-8.*
  - Schools that were successful in the April 2011 competition will be eligible to extend their grants with a maximum award of $100,000. **Anticipated grants to fund**: *14-16.*

Schools Eligible for CIG Grants in 2012

Richland-Bean Blossom C S C	Avon Community School Corp
Shelbyville Central Schools	Peru Community Schools
Rochester Community Sch Corp	East Noble School Corp
Madison Consolidated Schools	Southern Hancock Co Com Sch Corp
East Washington School Corp	Tri-Creek School Corporation
Plymouth Community School Corp	Richmond Community Schools
Christel House Academy	Rensselaer Central School Corp
Burris Laboratory School	Delaware Community School Corp
North Daviess Com Schools	Greenwood Community Sch Corp
Smith-Green Community Schools	M S D Warren Township
Danville Community School Corp	Batesville Community School Corp.
Beech Grove City Schools	Flat Rock-Hawcreek School Corp
Center Grove Com Sch Corp	Westfield-Washington Schools
Scott County School District 2	Monroe County Com Sch Corp
Garrett-Keyser-Butler Com	The Bloomington Project School
Clark-Pleasant Com School Corp	Maconaquah School Corp
Evansville Vanderburgh Sch Corp	North Adams Community Schools
M S D Wabash County Schools	M S D Perry Township
Northeastern Wayne Schools	

The IDOE will contact eligible schools directly and will entertain 20 minute in-person or video–based presentations from applicants on the 26th, 27th and 28th of February with awards anticipated in early March. **Anticipated Launch:** *Immediately.*

Strengthening Indiana's Network of Innovators

- **Regional Conferences—**The IDOE anticipates supporting regional efforts to convene educators around 21st century learning and instruction in the digital age. Competitive grants will be awarded to organizations that have already conducted a successful regional conference since 2010. The agency will be working on behalf of these regional efforts to promote and to identify opportunities for **cross** fertilization with established professional associations such as the Indiana Computer Educators, the Hoosier Educational Computer Coordinators, and the Indiana Chief Technology Officers (CTO) Council. **Anticipated Launch**: *February 15, 2012.* For more information, please contact Yancy Unger (yunger@doe.in.gov).

Support for Digital and Online Instruction

- **Increasing Access to Digital Content—**The IDOE anticipates offering statewide access to the National Repository of Online Courses (NROC) along with professional development for schools interested in leveraging this content. **Anticipated Launch:** *April 1, 2012.*
- **eLearning Certification Program**—The IDOE anticipates working with a partner to launch a program designed to prepare teachers to teach in an online environment. This program will be a pilot and will explore content and methods of preparing Indiana educators to facilitate high quality online learning. **Anticipated Launch:** *June 1, 2012.*
- **Developing Digital Instruction Standards—**The IDOE is leading an effort to develop a set of rigorous standards aimed at guiding the preparation of teachers for online and virtual instruction. **Anticipated Launch***: January 10, 2012.*
- **Participation in Digital Learning Day**—The IDOE will actively participate in the festivities of Digital Learning Day (February 1, 2012) and extend the celebration of eLearning throughout the month of February. Full details including directions for entering your school's video entry on the IDOE's Digital Learning Day You Tube Channel are available here. **Anticipated Launch***: February 1, 2012.*

Developing 21st Century Learners

- **7th Grade Technology Skills Assessment—**The IDOE continues to monitor the progress of schools participating in the 7th grade technology skills assessment pilot. Decisions regarding the next phase of **this** assessment are anticipated on or before April 1, 2012. **Anticipated Launch:** *Ongoing*.

Pratima Dutta—Curriculum Vitae

(818) 929-7356 ❖ dpratima14@gmail.com

Experience

Instructional Designer ❖California Lutheran University, Thousand Oaks, CA
Aug 2013- Present

Learning Practices Development
Course Management System
Project Leadership
Communication and Engagement

Online Associate Instructor ❖Indiana University, Bloomington IN
Aug 2012 to Dec 2012

Graduate-level online course on leadership and systemic change management
Assist in creating online course curriculum
Monitor online discussion forums
Grade and provided feedback on assignments and forum participation
Manage student communication

Research Associate ❖Indiana University, Bloomington IN
Aug 2006 to July 2012

Design research methodology & data-collection instruments
Collect & analyze data (qualitative and quantitative)
Compile research reports & present findings
Mentor junior research associates
Design, develop, & maintain data management systems

Associate Instructor ❖ Indiana University Bloomington, IN
Aug 2006 to Jan 2009

Design, develop, & implement pre-service teacher development programs focused on integrating technology innovations

Instructional Designer ❖ NIIT, New Delhi, India
Dec 2004 to Aug 2006

Design & develop baccalaureate-level courses for online universities
Manage a team of SMEs, Graphic Designers, Editors, and QA Associates
Manage and communicated project timelines and team member roles and responsibilities

Education

Ph.D. ❖ Indiana University, Bloomington, IN
Aug 2006 to Aug 2013

Major: Instructional Systems Technology
Minor: Educational Leadership and Policy Studies
Dissertation: Improving the functions of Personalized Integrated Education Systems (PIES) for a learner-centered environment: Learning from four case studies.

M.A. ❖ Fitchburg State University, Fitchburg MA
Aug 2001 to Aug 2003

Major: English Literature

Awards

Jerrold E. Kemp Instructional Systems Technology Awards, IUB (2011)
Venture Capital Award, Global Game Jam, Miami University (2011)
L.C. Larson Professional Development Award, Instructional Systems Technology, IUB (2010)
PlayExpo, University of Wisconsin, Finalist (2010)
Johnson Center for Entrepreneurship and Innovation IDEA Competition, IUB, Finalist (2010)

Publications

Dutta, P. (Under Review). Personalized integrated education systems (PIES) for the learner centered information-age paradigm of education. (Doctoral Dissertation).

Reigeluth, C.M., Watson, W.R., Watson, S.L., Dutta, P., Chen, Z., & Powell, N.D.P. (2010). Learning management systems. In F. M. Duffy (Ed.), Dream! create! sustain!: Mastering the art & science of transforming school systems (pp. 288-314). Leading Systemic School Improvement Series. Lanham, MD: Rowman & Littlefield Education.

Dutta, P. (2003). The red convertible. The Explicator, (61), 119-121.

Dutta, P. (2003). Clarissa and Woolf. FSC Review, (01), 33-35.

Game and Online Applications

Brinkman, B., Dutta, P., Enfield, J. & Patrick, M. (2011). Growth & Decay. View on Android Marketplace. Two player word game for improving spelling and building vocabulary.

Enfield, J. & Dutta, P. (2010). Rhyme Deception. View on Android Marketplace. Fast, fun, and interactive, word game that may be used to improve spelling and vocabulary.

Enfield, J. & Dutta, P. (2010). Smuthie. **http://www.smuthie.com** Social Networking Site where users can create and share smuthies - the art resulting from the animation of images to the prominent beats of sound files. The site was designed to support participatory learning related to art and music.

Presentations

Dutta, P. & Enfield, J. (2011). Design Jams for Instructional Designers. Instructional Systems Technology Instructional Systems Technology Conference, Bloomington IN.

Enfield, J. & Dutta, P. (2010). Smuthie.com: Create, Blend, and Share: An Experiment in Social Collaboration through Art, Music, and Animation. Johnson Center for Entrepreneurship & Innovation Kelly School of Business, Indiana University, Bloomington IN.

Dutta, P. (2010). Indian Government's National Policy on Education 1968: Directives on Enrollment. The annual meeting of the American Educational Research Association, Denver, CO.

Reigeluth, C., Pascoe, S., Pascoe, D., Watson, S., Lin, C., Rodgers, C., Dutta, P., & Doblar, D. (2007). District - Wide Systemic Transformation in the Decatur School District: Progress and Research Studies. IST Conference, Bloomington, IN.