TOWSON UNIVERSITY
OFFICE OF GRADUATE STUDIES

A DELPHI STUDY TO DEVELOP AN INVENTORY OF COMPETENCIES NEEDED TO FACILITATE INSTRUCTION IN STUDENT-CENTERED, ONE-TO-ONE LEARNING ENVIRONMENTS

by

Andrea H. Parrish

A Dissertation

Presented to the faculty of

Towson University

in partial fulfillment

of the requirements for the degree

Doctor of Education in Instructional Technology

Department of Educational Technology and Literacy

Towson University
Towson, Maryland 21252
December 2017

TOWSON UNIVERSITY
COLLEGE OF GRADUATE STUDIES AND RESEARCH

DISSERTATION APPROVAL PAGE

This is to certify that the dissertation prepared by Andrea Harkins Parrish, entitled A Delphi Study to Identify an Inventory of Teaching Competencies Needed to Facilitate Instruction in Student-Centered, One-to-One Learning Environments, has been approved by this committee as satisfactory completion of the requirement for the degree of Doctor of Education in Instructional Technology, in the Department of Educational Technology and Literacy.

William Sadera — 11/14/17
Chair, Dissertation Committee — Date

William Sadera

Scot McNary — 11/14/17
Committee Member — Date

Scot McNary

Laila J Richman — 11/14/17
Committee Member — Date

Laila Richman

David Wizer — 11/14/17
Committee Member — Date

David Wizer

Janet V DeLany — 11/20/17
Dean, College of Graduate Studies and Research — Date

ACKNOWLEDGEMENTS

I would like to extend my appreciation to my dissertation committee, as each member has supported my professional growth. First, to Bill Sadera, my advisor, thank you for your high expectations, your patient guidance, and wisdom throughout the research and writing process. You have made me a better writer, a deeper thinker, and a more confident scholar. To my committee members: Scot McNary, thank you for encouraging me to pursue rigorous research methods and for building my capacity to answer tough questions; to David Wizer: thank you for your loyalty, support, and thoughtful recommendations, both in this project and within the institution; and Laila Richman: thank you for listening, for being such a knowledgeable resource on so many topics related to this research, and for being a strong advocate for me. It is the collective wisdom and support from these colleagues that has helped me to conduct research that I feel proud to share.

I would like to extend deep gratitude to my family. Len: thank you for always being my biggest supporter, for being patient, and for making thoughtful suggestions that have improved this work. To my boys, Grant and Emory: you are my heart. The final copy of this dissertation is proof that when you work hard and surround yourself with good people, you can accomplish any goal you set for yourself. To my mom and dad, Stephanie and Paul, Mimi and Pop: thank you for listening, for all the extra babysitting, and all you have done to support me and our family during this journey.

To my dear friends and the amazing Towson University (TU) faculty who have supported me through this process: thank you for making this institution a place I am

proud to call home. I look forward to many years researching and preparing teachers with you. It is my relationships with you that make me feel happy and proud each time I step on the TU campus. I'd also like to acknowledge the significant role that the Instructional Technology Doctoral Program faculty have had on my development as a researcher and scholar. These faculty model how we ought to support and instruct graduate students. Each of you create relationships with your students, you honor their experiences and background, and you model how we ought to carry ourselves as scholars. My peers and I have been the recipients of your patient guidance, your commitment to helping us create networks, and your many trips to conferences across the country to offer support. You are accustomed to lending your support 24 hours a day, seven days a week, and there is no way that your dedication to the doctoral students in this program can be measured by faculty course load. Please know that watching your quiet, yet faithful, support is something that I feel honored to be able to recognize here.

Finally, I'd like to extend a very special thank you to all of the practitioners and researchers from across the country who participated in this research. Your innovation, willingness to take risks in the classroom, and your courage to let students set the course for learning, is inspiring! I know that what we have created through this research will encourage others to follow in your path.

ABSTRACT

A DELPHI STUDY TO DEVELOP AN INVENTORY OF COMPETENCIES NEEDED TO FACILITATE INSTRUCTION IN STUDENT-CENTERED, ONE-TO-ONE LEARNING ENVIRONMENTS

Andrea H. Parrish

Today's one-to-one, student-centered learning environments have unique qualities when compared to the traditional learning spaces of the previous decades and their characteristics hold important implications for both teacher preparation and professional development. While the current trend toward one-to-one technology integration is increasing, many studies fail to clearly articulate the ways that student-centered pedagogy can be used to harness the capacity of technologies that many districts have invested in. Through the use of the Delphi method, this study utilizes a nationwide panel of subject matter experts to develop an inventory of teaching competencies needed to facilitate student-centered instruction in these environments. The resulting inventory serves as a necessary resource for examining teacher preparation programs and for developing professional development that supports school systems in successfully implementing student-centered, one-to-one technology initiatives.

Keywords: one-to-one technology, Delphi method, technology integration, K-12, teacher preparation, professional development

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I. INTRODUCTION

Today's classrooms are fundamentally different learning spaces than they were decades ago, as many are now equipped with forms of instructional technology that impact how teachers and students interact. The increased functionality, mobility, and lower costs of technology in recent years has created more classrooms where every student has a device. These factors have created renewed interest in one-to-one computing initiatives.

The prevalence of one-to-one computing initiatives is increasing, both across the United States (Project Tomorrow, 2014) and throughout the world (Richardson et al., 2013). In the Office of Educational Technology's national technology plan, the United States Department of Education (USDE) discusses one-to-one computing as a moral imperative for establishing greater equity among students (USDE, 2014). Specifically, the USDE (2014, 2017) calls on schools to create a robust infrastructure through continuous Internet access and a computerized device provided to every student. This creates a sense of urgency for researchers, schools, and communities to work together to accept this challenge.

There are unique learning conditions in one-to-one environments that distinguish them from classrooms which are otherwise rich in technology, but do not have the one-to-one device ratio (Spires, Wiebe, Young, Hollebrands, & Lee, 2009). When students can readily access information online, this requires more sophisticated improvisational skills from teachers.

Educational reform may be realized through the implementation of one-to-one technology, but not without a focus on pedagogy. The research on one-to-one computing tells us that the most successful one-to-one computing initiatives are those which focus on student-centered instructional practices and the use of technology simultaneously (Weston & Bain, 2010). Cuban (1993) argued that when we use technology to mirror past curricula and teaching approaches, we preserve the idea that technology cannot be a vehicle for change. These actions stifle innovation and do not leverage the full capacity of one-to-one technologies. One-to-one computing initiatives that do not proactively address pedagogy in their implementation do not take full advantage of the potential of both our teachers and the technology.

The body of literature on one-to-one technology has increased, but the teaching practices of educators is described generally, without attempts to consolidate these practices into a usable resource for schools and districts. This study addresses this need and capitalizes on the collective knowledge of one-to-one practitioners and researchers in the field by asking these experts to identify the teaching competencies needed to facilitate instruction in one-to-one classrooms.

Background

The topic of one-to-one technology and its impact on teaching and learning is increasingly critical. During the 2013-2014 school year, US schools were estimated to acquire approximately 3.5 million tablets for K-12 students and worldwide investments in mobile technology within schools increased by 60% from 2013 to 2014 (Chandler & Tsukayama, 2014). Richardson et al. (2013) have developed an online database which shows one-to-one technology is becoming prolific throughout the world, with more than 85 countries taking on large-scale initiatives.

One-to-one technology's impact on student achievement is a question currently being examined by researchers in the field (i.e. Bebell & O'Dwyer, 2010; Rosen & Beck-Hill, 2012; Zheng, Warschauer, Lin, & Chang, 2016). Overall, the impact of one-to-one technology on student achievement is seen as mixed, however, when a school focuses on transforming pedagogy through intensive professional development, positive results have been reported (Shapley, Sheehan, Maloney, & Caranikas-Walker, 2010). As the links between one-to-one technology and achievement continue to be explored, documentation of the specific teaching practices which elicit the most positive results are needed to enhance this knowledge base.

One-to-one technology provides added value to classroom instruction (Dunleavy, Dextert, & Heinecket, 2007). These affordances include increased collaboration among students (Maninger & Holden, 2009; Oliver & Corn, 2008), increased student motivation and engagement (Christman, 2014; Keengwe, Schnellert, & Mills, 2012), and a tendency to shift teachers' practices toward more student-centered pedagogy (Broussard, Hebert, Welch, & vanMetre, 2014; Corn, Tagsold, & Argueta, 2012; Zheng et al., 2016). Acknowledging these affordances is essential, because it allows for the practices of the most dynamic and effective one-to-one educators to be identified.

The study of one-to-one learning environments often reveals challenges too, particularly in the logistics of implementation. For instance, planning and providing adequate professional development to support teachers can be difficult (Downes & Bishop, 2015; Klieger, Ben-Hur, & Bar-Yossef, 2010) and implementing a one-to-one technology initiative with fidelity is particularly challenging in large school districts (Shapley et al., 2010). Other challenges relate to management of devices and off-task behavior or distractions to students (Chou, Block, & Jesness, 2012). It is important that the school or district have a plan for managing technical assistance to teachers, as the absence of this leaves teachers feeling unsupported (Garthweit & Weller, 2005; Peterson & Scharber, 2017). Imbriale, Schiner, and Elmendorf (2017) suggest that proactive planning to engage the entire school system and placing a strong focus on pedagogy are factors that lead to increased success. Describing these challenges is an important consideration in this research, because it helps to identify some of the issues teachers need to be prepared to address in the one-to-one classroom.

The conditions present in the one-to-one classroom are different than classrooms without this student-to-computer ratio. Current professional standards, such as the ones developed by the International Society for Technology in Education (ISTE, 2017) are designed to address the use of technology for learning where the student-to-computer ratio may not be one-to-one. While valuable, these standards were not developed to account for the unique competencies required of teachers in one-to-one classrooms.

Spires, Wiebe, Young, Hollebrands, and Lee (2012) refer to one-to-one learning environments as classrooms where there is “a 1:1 ratio of mobile learning technology devices with Internet access to students and teachers” (p. 233). The combination of student-centered pedagogy and one-to-one technology changes the dynamics of a classroom and a teacher needs to be prepared to manage factors associated with this type of pedagogy, such as increased noise levels or frequent movement around the room by students (Morrison, Ross, Morrison, Cheung, & Arthur, 2015). Teachers in the one-to-one learning environment also need to be able to monitor and facilitate instruction rather than direct it and this involves following students’ lead, capitalizing on teachable moments, improvising, and supporting student-driven inquiry (Spires et al., 2009).

These unique conditions in the one-to-one classroom require different forms of classroom management skills and techniques from teachers (Sandholtz, Ringstaff, & Dwyer, 1990). The first one-to-one classrooms described in the original Apple Classrooms of Tomorrow (ACOT) studies continue to have relevance for today’s classrooms because we are just starting to identify the teaching practices that foster the greatest success. Teachers play the most critical role in the success of one-to-one computing initiatives and teachers themselves are the most studied variable in one-to-one research studies and related papers. Since teachers are so crucial to success, they must be well prepared to enter tomorrow's classrooms, which are increasingly equipped with one-to-one technology.

Statement of the Problem

There are unique conditions that make one-to-one learning environments, where the student-to-computer ratio is equal, distinctly different from traditional technology-rich classrooms. Additionally, literature indicates that it is the combination of student-centered pedagogy with one-to-one technology that promotes the greatest instructional value (Dunleavy et al., 2007).

Given the substantial resources now being allocated to one-to-one classrooms, it is essential that we have an accurate set of competencies to guide teaching, professional development, and preparation. If we do not adequately prepare teachers to develop the knowledge and skills they will need to teach effectively in these classrooms, then we have wasted these resources and denied the benefits of them to our students. Additionally, we must clearly identify what our future teachers need to be able to do in one-to-one classrooms, otherwise our next generation of teacher candidates will be unprepared for the classrooms they enter after graduation. The current ISTE (2017) standards for educators outline what teachers need to do in order to integrate a wide range of technology, but they do not address the competencies specific to one-to-one learning environments. Ultimately, if we make student-centered pedagogy a common practice in one-to-one learning environments and we distinguish the intricacies specific to these classrooms, our students have much to gain.

Purpose of the Study

The purpose of this research is to develop a resource that can be used in schools, districts, and teacher preparation programs to prepare teachers for one-to-one classrooms. To do so, we must rely on practitioners and researchers in the field who have expertise in one-to-one computing. Using the collective knowledge of these individuals, an inventory of teaching competencies identifies the skills and the dispositions teachers need to effectively facilitate instruction in student-centered, one-to-one learning environments. The implementation of these competencies is how we achieve exemplary teaching in the one-to-one classroom.

Significance

An inventory of teacher competencies to facilitate student-centered, one-to-one learning environments has great worth for both K-12 schools and teacher preparation. A centralized focus on the instructional practices of teachers is essential because teachers are the most important element in one-to-one computing (Spires et al., 2009). In order to adequately prepare teachers for the one-to-one learning environment, we must operationalize what effective instruction looks like in these settings. It is important that educators know what is expected of them in the classroom. It is also essential for administrators to know what to look for when observing and providing feedback to their teachers. In addition, faculty in teacher preparation programs need to know how to support future teachers who will enter one-to-one learning environments.

The results on the effectiveness of one-to-one computing initiatives remain mixed (Gulek & Demitras, 2005; Lowther, Inan, Ross & Strahl, 2012; Rosen & Beck-Hill, 2012; Shapley, Sheehan, Maloney, & Caranikas-Walker, 2011), in part because *effectiveness* is often defined inconsistently. This may be due, in part, to inadequate professional development to support one-to-one implementation by teachers. The technology integration skills of teachers develop over time and with practice, rather than as the result of one experience or event (Kenton, 2009). For example, any current or future teacher cannot be expected to master their technology integration skills from one preparatory course or one isolated professional development experience. Instead, teachers develop and hone their skills over time. An inventory of teaching competencies is a useful resource for emphasizing the variety of skills that teacher must possess to successfully integrate one-to-one technology. Development of these competencies will exemplify why a one-time professional development activity could never be responsible for developing all of these competencies in a teacher. The ways teachers integrate technology in the one-to-one learning environment should be rich and deep, and this inventory shows how every facet of the planning and teaching cycle is relevant to teachers' success.

This research has important implications for teacher preparation programs, as the inventory developed provides useful information about the competencies preservice teachers need in order to be adequately prepared for one-to-one learning environments. University faculty may find the inventory useful for designing assignments, coursework, or internship experiences for future teachers. There is an increased emphasis in teacher preparation programs on clinical practice, as required by the Council for Accreditation of Education Preparation (CAEP) standards (CAEP, 2013). This inventory of competencies supports this emphasis by making the practices of teachers in one-to-one classrooms more explicit. Overall, there are multiple ways in which the results of this study will positively influence training for preservice teachers and help those preparing them to understand how one-to-one learning environments differ from other classrooms.

Research Question

This research was led by one guiding question: *What are the teaching competencies required of educators who facilitate instruction in student-centered, one-to-one learning environments?*

Research Design

In this study, the Delphi method was used to address the research question through a mix of both quantitative and qualitative analysis procedures. The underlying epistemological position of Delphi is rooted in the post-positivist stance through scientific inquiry but with a lens that allows for interpretivist features as a part of the research process (Day & Bobeva, 2005). This study uses classic Delphi methodological procedures outlined by van Zolingen and Klaassen (2003), including features of anonymity, iteration, controlled feedback, and statistical group response.

This study was implemented by collecting a panel of experts from across the country with experience in one-to-one computing. Through a series of online surveys, this expert panel provided ratings and feedback which were used to identify the resulting inventory of teaching competencies. This inventory is a valuable guide which can support current and future teachers in one-to-one classrooms.

Limitations

The results of this Delphi study are based upon the input of the experts who were recruited. As in any attempt to collect data from participants through surveys, the extent to which they committed themselves to participation does have an effect on the results. Therefore, the researcher cannot guarantee that the resulting inventory is the epitome of the competencies needed in student-centered, one-to-one learning environments, but rather is a best-effort of representing the consensus-based results of recommendations from the experts that make up the sample. While this is a standard limitation in any Delphi study, the researcher controlled for this by using well-established Delphi procedures to recruit experts through the Knowledge Resource Nomination Worksheet (KRNW) process. This process was essential for developing a panel that represented a diverse sample with multiple perspectives.

Overall, results from this study showed early consensus and high ratings of proposed competencies by the experts. This could be due, in part, to the panel's positive bias toward one-to-one computing. Many of the individuals recruited for the study had experience leading a school or district in one-to-one implementation and had provided professional development in this area. Others on the panel had taught (or were currently teaching) in a one-to-one learning environment. Many were involved in professional learning communities related to technology integration, an indicator of their positive bias toward the use of technology to improve teaching and learning. Throughout the course of the study, the researcher controlled for this by providing individualized and statistical controlled feedback to each participant. In addition, the research design followed proven techniques for Delphi methodology, such as the Rand UCLA Appropriateness Method (Fitch et al., 2001), for determining competencies which would be included in the inventory. Another hypothesis for early consensus may be due to the focus and depth of the literature review which served as the basis for the initial list of proposed competencies. Further discussion regarding the early consensus, including the panelists' decisions to identify many of the initial competencies as important, will be examined within chapter five.

A nine-point Likert scale was designed to allow for flexibility of responses, however, most participants tended to rate items within the top three points of the scale. While the scale was provided as an opportunity for experts to indicate distinct levels of importance, it may have actually contributed to the opposite phenomenon. It is not possible to know how every panel member interpreted each point on the scale. The researcher took multiple steps to control for this, including, (a), the use of an established Delphi scale designed specifically for determining consensus, (b) explicit instructions at the start of each survey to describe the levels of the scale and how to respond, and (c) providing an opportunity for panelists to explain their ratings on each survey.

The role of the researcher-participant in tasks related to qualitative analysis can also be viewed as a potential limitation in a study of this nature. The researcher played an active role in communicating with panelists and interpreting their recommendations and rationales, particularly when designing inventory items based on their feedback in Rounds One and Two. A complete description of the researchers' background and biases related to this instructional technology and one-to-one computing are provided in the section that follows.

Researcher's Reflexivity

As a college instructor and former teacher who has always embraced innovative teaching practices, my interest in pursuing this area of study is to positively influence one-to-one technology adoption and share a consensus-based understanding of how this technology is used in classrooms. My past knowledge and experiences as a college professor, professional developer, and teacher have prepared me to take an active role in this study.

As an educator originally trained to support students with the most complex disabilities, I have spent years considering how important it is for teachers to take risks and be willing to try new approaches if they are to succeed in reaching all students. In both general education and special education settings, I have observed how the use of technology combined with constructivist practices can help every student achieve. Overall, I have a positive bias toward constructivist practices, particularly when combined with one-to-one technology. I have worked in various support roles, coaching and mentoring educators to employ many of the constructivist-learning strategies that are included within this inventory. On many occasions I have found technology to be a vehicle that positively influences instruction. Given this perspective and my knowledge of the research, I have chosen to include elements of constructivism in developing the inventory, shaping the overall purpose for this study and, ultimately, the research question.

My experiences as a classroom teacher, coupled with extensive observations of K-12 instruction in classrooms at all levels, have helped me to gain a sense of the very different technology integration approaches undertaken by teachers. However, during the past several years I began to identify instruction of student-centered teachers in one-to-one classrooms as having new and special qualities. These highly engaging and innovative learning environments were worthy of further study and it is these experiences that have brought me to further examination of the research topic.

Summary

The prevalence of one-to-one computing is increasing, particularly due to increased functionality and lower costs associated with educational technologies. While one-to-one technology offers options for added value in teaching and learning, it is important that we marry pedagogical practice and one-to-one technologies through research. The purpose of this study fulfills that aim by developing an inventory of teaching competencies that delineates how student-centered instruction is accomplished in twenty-first century one-to-one classrooms. The results of this research provide an essential resource for fully preparing teachers to effectively facilitate instruction in these learning environments.

Definition of Terms

The following definitions are included in order to enhance understanding of the key terms described within this document.

Anonymity: A feature of Delphi methodology in which the participants are known to the researcher, but not to one another.

Coding: The process of aggregating text or visual data into small categories of information, seeking evidence for the code from different databases being used in a study, and then assigning a label to the code (Creswell, 2013, p. 297).

Consensus: The measurement of suitable agreement between Delphi panel experts that results in an item being added or removed from the inventory. In this study, items with a median score of one through three will be categorized as inappropriate for the inventory, scores four through six will be considered equivocal, and those items with a median score between seven and nine will be considered appropriate competencies to include.

Constructivism: An epistemological belief about learning that is based on the assumption that learners construct meaning as a result of their experiences which are rooted in authentic activity. Constructivist pedagogy is based on the premise that learning occurs through active involvement in these experiences, rather than the transmission model for instruction where students take on a passive role (Duffy & Jonassen, 1992).

Controlled feedback: A feature of Delphi methodology in which the researcher provides statistical information to a participant in order to build consensus among the panel on a particular issue.

Danielson Framework for Teaching: Developed by Charlotte Danielson, the Danielson Framework for Teaching is a "research-based set of components of instruction, aligned to the InTASC standards, and grounded in a constructivist view of teaching and learning" (Danielson, 2017). The framework divides the various elements of teaching into four domains: planning and preparation, classroom environment, instruction, and professional responsibilities.

Delphi Method: A process for organizing group communication that supports establishing experts in gaining consensus on a complex issue or problem.

Expert: A participant in a Delphi study who has been identified as having specific subject matter expertise in the complex question or issue that is being examined.

Iteration: A feature of Delphi methodology in which an iterative process of data collection and analysis is conducted, often through rounds, that is used to build group consensus on a complex issue or problem.

Knowledge Resource Nomination Worksheet (KRNW): A sampling procedure in which potential experts are identified, nominated, ranked, and selected for participation in a Delphi panel.

New learning ecology: The unique conditions of one-to-one learning environments, characterized by instant and constant access to information; intensity, relevance, and personalization of learning; highly developed teacher capacities; and highly developed student dispositions (Spires et al., 2012, pp. 234-235).

One-to-one computing: A learning model in which every student has access to their own computerized device and the Internet.

Panel: A group of identified experts who have agreed to serve as participants in a Delphi study.

Panelist: An identified expert who has agreed to serve as a participant in a Delphi study.

Pedagogy: The methods and practices that are used to teach or implement instruction in a classroom.

Ranking: A response in a Delphi survey that requires an expert to compare the relative importance of one teaching competency to other competencies within the given category.

Rating: A response in a Delphi survey that requires an expert to indicate the importance of a proposed teaching competency using a Likert scale.

Round: An iterative set of procedures in a Delphi study, characterized by dissemination of a questionnaire for data collection, an identified response window for participants, and corresponding data analysis.

Student-centered instruction: A broad teaching approach that includes substituting active learning for lectures, holding students responsible for their learning, and using self-paced and/or cooperative (team-based) learning (Felder & Brent, 1996, p. 43).

Teaching competency: A skill, set of knowledge, or disposition required for an educator to perform successfully in the classroom.

CHAPTER II. LITERATURE REVIEW

Consider two learning environments: *Classroom A* and *Classroom B*. *Classroom A* is a technology-rich learning environment, equipped with an interactive whiteboard, a document camera at the teaching station, along with intermittent access to a mobile computer cart. The teacher of *Classroom A* is free to sign up for the mobile cart of laptops whenever she chooses (unless it is already being utilized by another group), but she must plan for the use of devices in advance, usually two weeks ahead of time. *Classroom A* can be considered a dynamic learning environment in multiple ways, with the teacher allowing students to complete interactive tasks on the whiteboard or to collaborate using online tools when the laptops have been requested in advance. The teacher of *Classroom A* can capitalize on the use of technology available to her students, but most forms of technology integration in *Classroom A* must be set up for students in advance. There is an inherently dynamic, synergistic quality missing from the interactions between students and digital information in *Classroom A* because most instructional activities are designed by the teacher.

Consider now another setting: *Classroom B*. This classroom has the same technologies as the previous model, but every student has constant access to his or her own computerized device. In this classroom, students have immediate and constant access to information and they can choose to access it whenever they desire productive inquiry. In this one-to-one classroom, the teacher acts as the content expert, but is no longer required to direct every action based on tasks that she has laid out. Instead, the teacher of *Classroom B* may facilitate, mentor, and may even need to improvise, as students access dynamic digital content that relates to the learning objectives but largely driven by their own curiosities. These conditions in *Classroom B* create a dynamic ecology of interactions between information, student, and teacher, making this a fundamentally different learning space that requires highly developed teacher competencies (Spires et al., 2009).

Schools have a moral imperative to prepare students to live and work in the twenty-first century and technology provides opportunities for students to do so. One-to-one technology provides a vehicle for this educational reform because it allows students immediate access to information and offers learning experiences that are personalized and relevant to each learner within a high intensity learning environment (Spires et al., 2009). The need to identify the best instructional practices for these classrooms is critical. The most decisive element in any classroom is the teacher. As the proliferation of one-to-one technology continues, it is essential that we are able to identify the teacher competencies that can be used to guide the development of educators.

The current definition of one-to-one computing has evolved over time. Spires et al. (2012) refer to one-to-one learning environments as classrooms where there is “a 1:1 ratio of mobile learning technology devices with Internet access to students and teachers” (p. 233). The types of mobile devices used in classrooms have now expanded to include laptops, tablets, and hybrids of the two. Most current research on one-to-one technology places less emphasis on the functionality or description of the device itself and greater emphasis on how it is used pedagogically (Downes & Bishop, 2015; Lindqvist, 2015; Rosen & Beck-Hill, 2012; Storz & Hoffman, 2012). Therefore, this review will include studies that incorporate a variety of different mobile technologies with a particular focus on how they are used.

The purpose of this research is to identify what teachers need to know and be able to do to support student-centered learning in one-to-one-classrooms. The review will examine the one-to-one literature with pedagogy as a lens for understanding how classroom dynamics are affected when one-to-one technology is present. This will include a discussion of the prevalence of one-to-one technology, incorporating the history of the approach and its resurgence in recent years as technology has evolved. Using pedagogy as a lens will emphasize key affordances and challenges of one-to-one implementation highlighted in the scholarly research, because these issues point to the ways in which teachers need to be able to harness the capabilities of the technology and what issues they must be equipped to deal with in these unique learning environments. The review will conclude with a description of constructivist learning theory and the new learning ecology, developed by Spires et al. (2009), as a conceptual framework and lens for the development of teacher competencies in student-centered, one-to-one learning environments.

The results of this literature review will show that one-to-one classrooms are fundamentally different learning spaces than classrooms which are otherwise rich with technology, but do not provide a device for every student. While worthwhile and important to the field of educational technology as a whole, the current professional teaching standards, such as the ones developed by the International Society for Technology in Education (ISTE, 2017), are designed to address general technology integration in classrooms. They do not, however, account for those nuanced competencies which are required of teachers in one-to-one classrooms.

Research on one-to-one classrooms concludes that teachers are the critical component to success in these environments (Garthweit & Weller, 2005; Li, 2010; Spires et al., 2009). In the new learning ecology of one-to-one learning environments described by Spires et al., student-centered learning approaches coupled with a one-to-one technology ratio offer a powerful combination that contributes to an intellectually challenging and engaging learning environment (Spires et al., 2009, 2012). Given the differences that exist in these classrooms, it is essential that we identify the best daily practices of our most skilled one-to-one teachers. This chapter is broken down into the following sections: (1) the critical nature of one-to-one computing, (2) the impact on student achievement, (3) affordances of one-to-one technology, (4) challenges in one-to-one implementation, (5) changing classroom dynamics, (6) student-centered pedagogy, (7) the critical role of teachers, and (8) the conceptual framework which grounds this research.

The Critical Nature of One-to-One Computing

The increase in the amount of one-to-one literature has occurred as a direct result of the increase of these initiatives in schools across the nation. While one-to-one computing is a current educational trend, its original inception occurred in the 1980s with the Apple Classrooms of Tomorrow (ACOT) research (Dwyer, 1995). These early ACOT reports were the first to discuss a transition from teacher-directed to more student-centered pedagogy through one-to-one technology (Dwyer, Ringstaff, & Sandholtz, 1990; Ringstaff, Sandholtz, & Dywer, 1991). With respect to pedagogical practice and one-to-one research on technology integration, the ACOT research was well ahead of its time. Recently a greater focus on twenty-first century skills as well as the evolution in the portability, affordability, and functionality of mobile technologies has created a renewed interest in the trend. However, the systemic use of one-to-one technology to facilitate student-centered pedagogy and the discussion surrounding this continues to evolve.

U.S. schools are increasingly investing a significant amount of capital in one-to-one technology initiatives. In this context, the term “one-to-one technology initiative” refers to a school or district's decision to supply students and teachers with computing devices and, in most cases, to contribute some degree of resources (such as professional development) to support the endeavor. While some of these initiatives establish goals related to improving pedagogical practice through effective technology integration, others do not. In the 2013-2014 school year alone, U.S. schools were estimated to acquire approximately 3.5 million tablets for K-12 students. These actions are part of an overall worldwide investment in tablets for K-12 education that have increased by 60% from 2013 to 2014 (Chandler & Tsukayama, 2014). Large-scale one-to-one initiatives are also growing worldwide. Richardson et al. (2013) reviewed the prevalence of large-scale initiatives and captured them in an open online database which is constantly growing. Currently, the active database (accessible at http://jaysonrichardson.com/projects) lists over 85 countries around the world as planning or implementing large-scale one-to-one initiatives.

Adoption of mobile technology and one-to-one technology initiatives is becoming more prolific across the United States. According to a national survey of over 300,000 K-12 students in over 2,000 U.S. school districts, one-quarter of students in grades three through five and nearly one-third of students in grades six through 12 report using mobile technology to learn (Project Tomorrow, 2014). Today's K-12 students' input on how to improve schools and instruction reflects their worldview on technology impact on how they learn. When asked what could be done to create the "ultimate school," 70% of students responded with "schoolwide internet access" and 95% said that a tablet or laptop should be provided for every student (Project Tomorrow, 2014, p. 13). In an online survey conducted by Interactive Educational Systems Design, Incorporated (IESD, 2014), 332 district leaders responsible for technology reported on mobile technology use.

Seventy percent of these district leaders reported that mobile technology had been adopted in 25% or more of the schools in their district, with approximately 20% of these indicating a one-to-one technology ratio across the district (IESD, 2014). In addition, approximately 70% of these district leaders indicated that more widespread adoption of tablets or laptops was anticipated (IESD, 2014).

The adoption of mobile technology, and specifically a device for every student, has transformed from a passing trend to an imperative given by the United States Department of Education (USDE). In the 2017 update to the *National Education Technology Plan*, USDE calls on schools to both accelerate and scale up their adoption of technology for K-12 schools. In their action plan, they indicate the need for ubiquitous Internet connectivity and powerful learning devices for every student as a national priority (USDE, 2017). The USDE points to adoption of technology in only some schools as the new and 21st century version of the digital divide, wherein we create greater disparity amongst students who use technology in schools and those who do not. Specifically, the USDE sets a goal for all schools to create a “robust and comprehensive infrastructure” which includes continuous access to high-speed Internet and personal computing devices (USDE, 2017, p. 69). In their document which specifies approaches for building this infrastructure, the USDE clarifies its vision for putting a personalized computing device in the hands of every student:

> Devices that must be shared by many students or accessed only in computer labs limit the ability of students to engage in ongoing collaboration and of teachers to use high-quality digital learning materials. Students who do not have their own devices may not have access to the same level of personalized learning that enables students to learn through practices best suited to their needs and related to

> their interests and experiences. They also may not learn as productively as those in an environment where all students have access to devices whenever they need them. (USDE, 2014, p. 44)

Given the critical nature of one-to-one computing in the United States and beyond, coupled with the imperative as directed by the USDE, it is increasingly clear that one-to-one technology is more than a passing trend. The focus has now shifted from whether or not one-to-one technology should be attempted to how it can be integrated well. Given this evolution, is it imperative that research respond to the vision set forth by the USDE by identifying what teachers in one-to-one classrooms need to know and be able to do to elevate the quality of teaching and learning for all students.

The Impact on Student Achievement

As the prevalence of one-to-one computing increases, so too do the individual publications and the research syntheses of them. Many of these early syntheses, like the first review of one-to-one technology research conducted by Penuel et al. (2001) and again by Penuel (2006) discussed the lack of empirical support for one-to-one technology's impact on student achievement. Initially laptop programs were seen as avenues for increasing technology access for students and families. These programs were developed as a way to bridge the digital divide and improve connections between home and school (Penuel et al., 2001). While these early reports suggested some promise related to one-to-one technology, more significant investments in one-to-one technology in recent years have increased the expectations for impact.

One-to-one technology was not initially viewed as an educational reform effort. Therefore, increases in any student outcomes were initially difficult to attribute to the integration of technology because there were often other reform initiatives occurring in tandem with the technology distribution (Penuel et al., 2001). Many of these early studies lacked rigorous design and contained other methodological limitations, such as small sample sizes (Penuel et al., 2001; Penuel, 2006).

Research syntheses have continued to show more promising results related to one-to-one technology and its impact on student achievement. As the amount of literature increased, Penuel et al.'s (2001) review was updated to reexamine 30 more recent one-to-one publications categorized as implementation or outcome-based studies (Penuel, 2006). In this update, Penuel (2006) concluded that the literature showed the results of one-to-one initiatives were decidedly mixed, particularly in the area of student achievement. Penuel (2006) concluded that the lack of rigorous research design continued to impair potential correlations between this technology ratio and students' academic success.

Within the current literature, scholars continue to disagree about what research questions to prioritize with respect to one-to-one integration. There are those who argue that one-to-one computing cannot be expected to impact students' achievement, (Topper & Lancaster, 2013; Shapley et al., 2011), while others describe student achievement in one-to-one technology as the "holy grail for researchers in this field" and insist that these studies be given high priority (Zucker, 2004, p. 378). Regardless of this scholarly debate, those responsible for funding within school districts and school communities insist on evidence that shows a return on this investment (Chandler & Tsukayama, 2014). Weston and Bain (2010) argue that some are quick to label one-to-one initiatives as unsuccessful, mainly because these efforts often involve the most noticeable investment of financial resources, visible technology, and widespread deployment of efforts. Therefore, individuals have a tendency to be far more critical of one-to-one initiatives than other types of reform (Weston & Bain, 2010).

One-to-one studies examining student achievement vary in scope, results, and outcome measures. In one of the few studies discussing the influence of one-to-one technologies on elementary-aged students, Rosen and Beck-Hill (2012) reported that 476 fourth and fifth grade students who received instruction in one-to-one classrooms significantly outperformed control group students in reading and math on standardized tests. Gulek and Demitras (2005) demonstrated similar results in their examination of the 259 middle students. Through multiple measures, Gulek and Demitras' (2005) showed that students in one-to-one classrooms demonstrated significantly higher academic achievement in test scores, end of the year course grades, and grade point averages as compared to students in control groups (Gulek & Demitras, 2005). Bebell and Kay (2010) tied students' technology use to increased achievement, stating that students with frequent technology use in one-to-one classrooms were found to score higher on math and science assessments than students who had less frequent access to the technology.

Student achievement offers one lens for defining "success" of a one-to-one initiative. While most studies base their empirical results on standardized tests, Bebell and O'Dwyer (2010) present a rich discussion of one-to-one technology's impact on educational outcomes in their special issue on the topic, arguing that "success" in school ought to be measured in broader terms. Further, Bebell and O'Dwyer (2010) point to the reoccurring themes that link one-to-one computing with positive outcomes for students, namely increased engagement and interest in learning. Bebell and O'Dwyer (2010) also describe empirical evidence as showing "modest increases in student achievement" from one-to-one technology using more traditional measures of student achievement, such as standardized test scores (p. 4).

The most recent synthesis of one-to-one technology's impact on achievement offers promising results. Zheng et al. (2016) conducted the first meta-analysis of one-to-one literature, examining 10 one-to-one studies that measured increases in student learning as well as a research synthesis which examined 65 articles and 31 doctoral dissertations. One of the significant aspects of Zheng et al.'s work is that they computed effect size of one-to-one technology's impact on student achievement. To do so, Zheng et al. (2016) developed and applied a coding scheme for effect size computation as part of their meta-analysis. For those studies which included effect size, they categorized this data by subject area. For the studies which did not compute effect size, Zheng et al. used the data within each study to calculate effect size, offering a significant contribution in the empirical evidence related to one-to-one technology and student achievement. These effect sizes are useful because they help us begin to develop a range of anticipated effect size for one-to-one technology and student learning gains, useful as a barometer for effect size in future studies. Overall, Zheng et al. (2016) found the overall effect sizes to be small, but positive. In their results, the average effect size was found to be .16 across subject areas, with the highest effect sizes in science (.25), followed by writing (.20), math (.17), English (.15), and reading (.12) (Zheng et al., 2016). All effect sizes were found to be statistically significant, except for reading.

While the newest information on the potential effects of one-to-one technology as reported by Zheng et al. (2016) is useful, the results of the meta-analysis are presented here with caution. Specifically, the findings on effect size published by Zheng et al. (2016) provide a singular measure of one-to-one technology's impact on student achievement in various subject areas, but the results of Zheng et al.'s meta-analysis does not replace or exceed the power of results shared within other one-to-one studies described here. Israel and Richter (2011) discuss the strengths of meta-analysis, one of which is to provide a summary of the effectiveness of the intervention. In this case, Zheng et al. (2016) provide a more precise estimate of how effective one-to-one technology was at increasing student achievement within the studies that were reviewed. However, one must be cautious now to draw erroneous conclusions about the effectiveness of an intervention based on effect size alone (Israel & Richter, 2011). For example, using effect size to definitively say that one-to-one computing improves student achievement is a rather limited perspective. Rather, Zheng et al.'s results must be interpreted as one additional source of information within the body of evidence on student achievement which is discussed here.

There is some one-to-one literature that discusses more minor effects in response to very significant investments and in some cases, even a decline in pedagogical change and impact on student learning (Swallow, 2015). However, using a pedagogical lens to examine these findings offers further implications as to how pedagogy affects one-to-one technology implementation. Swallow (2015) detailed several years of a one-to-one initiative which was described as initially successful, but experienced a sharp decline in pedagogical practice during its second year of implementation. Further examination of qualitative data gleaned from teachers' and students' statements shows a lack of attention to how the quality of teaching and learning had improved. While Swallow's (2015) study provides important insight as to what can go wrong in the rollout of a one-to-one initiative, it also shows that without a pedagogical focus and a focus on efficacy, it can be challenging to center all stakeholders around teaching practices. Similarly, when Shapley et al. (2010) examined the effects of the Technology Immersion initiative in Texas on students in 21 middle schools, they found there to be no statistically significant effects in reading or math achievement. Shapley et al. (2010) offer insightful commentary as to why more frequent and innovative use of computing devices was not achieved and among these was a discussion as to how a greater focus on pedagogical practice might have improved outcomes. Those schools found to be the most successful at increasing the innovative use of the computing devices to fully immerse technology, were ones where the leaders provided professional development aimed at transforming learning through pedagogy (Shapley et al., 2010).

Many schools or districts embark on one-to-one technology initiatives with the hope of increasing student achievement. The results of this literature review show that there are a growing number of studies which examine one-to-one technology's impact on student achievement, with increasingly positive results. Student achievement is now discussed in nearly every research synthesis of one-to-one technology integration in schools (Bebell & O'Dwyer, 2010; Harper & Milman, 2015; Penuel, 2006; Zucker, 2004; Zheng et al., 2016). Pointing to the promise of one-to-one technology to support students' achievement is important to this research, because it shows the potential staying power of one-to-one technology in schools. As more analyses of student achievement results are published, it will be useful to clarify what teachers of these research studies are doing to deliver a successful intervention via the one-to-one technology. In particular, helping to address what the intervention *looks like* when it is performed by teachers will allow us to harness the power of new mobile technologies and continue this trajectory of improved achievement. An inventory of teaching competencies in one-to-one classrooms would help bring much greater focus to this issue and clarify the role of teachers in these classrooms.

Affordances of One-to-One Technology

In addition to promising results in the area of student achievement, there are unique instructional advantages of one-to-one computing environments. Many studies list these affordances along with their findings (e.g. Bebell & Kay, 2010; Broussard et al., 2014; Chou et al., 2012; Dunleavy et al., 2007; Lei & Zhao, 2008; Oliver & Corn, 2008). Understanding the instructional affordances of one-to-one technology, specifically how the technology can create greater opportunities for student-centered learning, is useful to this research because it outlines how the teacher's role is changing from director to facilitator. Many of the qualitative one-to-one implementation studies discuss this changing role of the teacher, providing support for the notion of highly developed teacher competencies discussed by Spires et al. (2009).

When utilized with student-centered learning practices, one-to-one technology is often a vehicle for increased collaborative learning opportunities amongst students and greater differentiated assessments and instructional products. Maninger and Holden (2009) as well as Oliver and Corn (2008) discuss the increased collaboration and communication between students in one-to-one classrooms. Dunleavy et al. (2007) describe these affordances as examples of added value. Specifically, one-to-one computing ratios allow the teacher to: more easily conduct formative assessments while teaching; individualize instruction; allow students to work at their own pace; and provide opportunities for networked communication (Dunleavy et al., 2007). Lindqvist (2015) studied one-to-one implementation with the purpose of identifying both affordances and barriers and found many similar advantages, including new possibilities for instructional activities, assessment, presentation formats, and student accessibility. Students were observed to work more creatively with the tools available to them, access information with greater ease, and take notes to remain engaged in instruction (Lindqvist, 2015). Teachers reported it was easier to structure their planning and teaching, add a professional touch to their instructional materials, and communicate more freely with their colleagues (Lindqvist, 2015). Most recently, Zheng et al.'s (2016) meta-analysis of 65 one-to-one studies showed the one-to-one technology ratios are linked with (a) an increase in the frequency and type of technology used in classrooms, (b) more independent work by students with less reliance on the teacher, (c) an increase in the amount and types of writing produced by students, and (d) increased opportunities for teacher-to-student and home-school communication.

One-to-one technology has also been shown to positively impact the skill development in students, as qualitative findings support students' gains in technological literacy and other related 21st century skills (Penuel, 2006). For example, in an investigation of middle school students' use of laptops, seventh and eighth graders gained technology skills and increased their ability in using technology to solve real world problems (Lei & Zhao, 2008). Students' attitudes toward technology is frequently discussed as a predictor of use and studies regularly articulate changes in student engagement and motivation that occurs within one-to-one classrooms (Bebell & Kay, 2010; Bebell & O'Dwyer, 2010; Christman, 2014; Keengwe et al., 2012; Rosen & Beck-Hill, 2012; Shapley et al., 2011).

A pervasive theme discussed in the implementation of one-to-technology is the effect that these models have on teachers' pedagogy and the shift toward a more student-centered learning environment. Whether planned as part of a strategic initiative or occurring vicariously as a result of the technology affordances, implementation studies discuss the benefits to students when a shift occurs from teacher-directed to more student-centered instruction (Broussard et al., 2014; Christman, 2014; Corn et al., 2012; Dunleavy et al., 2007; Klieger et al., 2010; Lowther et al., 2012; Storz & Hoffman, 2012; Zheng et al., 2016). Since this shift toward student-centered learning practices is so fundamental to one-to-one pedagogy, it will be discussed in greater detail later within this review.

While the growing number of implementation studies discussed here present examples of ways that one-to-one technology enhances instruction, much of the implementation literature also chronicles the challenges inherent in implementing one-to-one initiatives. In order to support teachers and administrators in developing quality learning environments, it is essential to highlight some of the challenges they may encounter. Thus, the discussion that follows focuses on some of these pedagogical challenges.

Challenges in One-to-One Implementation

This research is designed to address what teachers need to know and be able to do so that they are better equipped to handle challenges that may occur when integrating one-to-one technology. Fortunately, the one-to-one literature offers insight into the struggles faced by schools and districts who have undertaken these initiatives as there are a growing number of qualitative and mixed method studies which describe these issues from the perspectives of teachers, administrators, and students.

There are several types of challenges associated with one-to-one technology that are discussed in the literature, and unpacking each of these is helpful in identifying the competencies teachers will need to be able to address these. The first is that, despite the growing evidence that one-to-one technology can positively impact student achievement (Bebell & Kay, 2010; Gulek & Demitras, 2005; Zheng et al., 2006), there are other instances when the literature shows minimal, slow, or incremental change in student achievement versus significant and widespread gains (Lowther et al., 2012; Shapley et al., 2010; Swallow, 2015). Second, there are often context-specific issues that arise in the course of one-to-one technology initiatives and these are most often related to a district or school's organizational structure.

Logistical issues, such as device employment, dissemination of and access to digital tools, or procedures for acquiring technical support, are no less important than pedagogical issues because they have the potential to interfere with the instructional program. District leaders like Imbriale et al. (2017) discuss the need for a collective focus on pedagogy as a way to proactively set the stage for bringing the whole school system on board. There are also recommendations from consultants and other support personnel in the field that provide useful advice for how individual teachers and administrators may address the more common challenges (Peterson & Scharber, 2017).

Quality professional development is a critical factor in effective one-to-one implementation (Klieger et al., 2010), particularly because it helps to address the aforementioned challenges. We know from the research on one-to-one implementation that professional development in this area can be a challenge and that poorly planned or poorly executed training hampers teachers' progress in one-to-one integration (Downes & Bishop, 2015; Shapley et al., 2010). Overall, we also understand skills-based training during these initiatives is regarded as less impactful than efforts which focuses on content and pedagogy-specific technology integration (Penuel, 2006; Spires et al., 2012). While we have significant challenges to address within the design and implementation of professional development to support one-to-one initiatives, this research does not focus on that topic directly. There is much work to be done in advancing our collective understanding about how to implement quality professional development well, and it is an issue that cannot go without being mentioned in this discussion of day to day, one-to-one challenges that occur in schools and districts.

The current literature points to a need for research designed to address what teachers need to know and be able to do so they are better equipped to handle challenges that may occur when integrating one-to-one technology. The one-to-one literature offers much insight into the struggles faced by schools and districts who have undertaken these initiatives, as there are a growing number of qualitative and mixed method studies which describe these issues from the perspectives of teachers, administrators, and students.

Implementation and logistics. Consistency of implementation within a one-to-one initiative can be challenging and results can vary from school to school, even within the same pilot (Bebell & Kay, 2010). Many of the reasons for these issues are context-specific. For example, Downes and Bishop (2015), found that teachers attributed implementation problems to a lack of common planning time. According to a phenomenological case study conducted by Heath (2016, 2017), the greatest barriers faced by teachers attempting to implement one-to-one initiatives were bureaucratic and technological, sometimes uniquely intertwined. However, even when faced with professional development and communication challenges, teachers that had supportive school administrators, collaborative practices with fellow teachers, high self-efficacy, and positive beliefs about the impact of technology were able to overcome many of these challenges and to successfully implement one-to-one computing in their classrooms (Heath, 2016, 2017).

The larger the initiative, the more challenging it can be to implement with fidelity (Shapley et al., 2010, 2011). Shapley and colleagues conducted a series of studies that examined the implementation of the Texas Technology Immersion one-to-one laptop program. When examining a subset of schools in the third year of the Texas initiative, Shapley et al. (2011) reported implementation results to be mixed, as the disciplinary incidents of students were shown to decrease but with a decrease in students' regular attendance. A study of 21 schools in this same one-to-one initiative in year four showed that most teachers of one-to-one classrooms reported only partial levels of technology immersion (Shapley et al., 2010). The biggest implementation challenges reported were the degree to which schools varied in their implementation of the initiative and as time went on, teachers' buy-in seemed to decrease (Shapley et al., 2010). Faculty also reported challenges related to a lack of coaching and mentoring, and the need for more consistent technical assistance. These challenges are significant to this research, because these results outline the issues teachers may need to navigate in order to support the learning of students in their one-to-one classrooms. For example, teachers may need to take advantage of the technical assistance available within their building or request further support in order to integrate the technology effectively.

This need for technical assistance, or some form of systematic support for dealing with technical issues, is a key factor in successful implementation of one-to-one initiatives within schools (Penuel, 2006) as teachers have cited their feelings of frustration when technical problems are not addressed (Garthweit & Weller, 2005; Peterson & Scharber, 2017; Shapley et al., 2010). Implementation studies commonly describe challenges related to technical assistance as well as the management of students with devices. The management issues related to student use tend to include distractions caused by the technology (Chou et al., 2012; Corn et al., 2012; Holen, Hung, & Gourneau, 2017), off task behavior (Donovan, Green, & Hartley, 2010), and technical difficulties such as wireless connection problems, blocked educational websites (Peterson & Scharber, 2017) or issues with students' personal management of the devices (Lindqvist, 2015).

Past studies have shown that even though one-to-one technology may be present, it does not always lead to increased technology use in the classroom. That may mean that either there is minimal increase in the frequency of use (Larkin & Finger, 2011) or there is not an increase in the effectiveness of device use (Donovan et al., 2010; Lindqvist, 2015). In some settings, teachers may feel constrained by organizational factors set up by the district or individual school. For example, Larkin and Finger (2011) analyzed interview and survey data from both teachers and students to identify the factors that influenced the relationship between access and actual use of one-to-one technology in classrooms. Teachers shared that they had limited agency to make decisions and while they were interested in incorporating the devices through student-centered learning approaches, they felt hindered by the inflexible nature of the curriculum and a lack of time to make any instructional changes (Larkin & Finger, 2011). Teachers also cited the lack of knowledge and preparation for technology use as a limiting factor in one-to-one implementation (Larkin & Finger, 2011).

The various challenges of one-to-one technology initiatives are essential to this research because they help to provide a context for the things teachers will likely need to know and be able to do in order to mitigate challenges they could face. For example, past research indicates that additional routines and other management requirements exist when each student in the classroom has a device (Dunleavy et al., 2007; Sandholtz et al., 1990). Therefore, the classroom management competencies required of one-to-one classrooms teachers will need to be expanded to include such things as device management, monitoring students' safety online, and solving minor technical problems on the spot. These types of problems are examples of the nuanced competencies required of one-to-one classroom teachers and understanding research related to one-to-one implementation challenges provides support for the purpose of this research.

If implementation is so challenging, what recommendations exist for schools and districts to institute one-to-one computing successfully? Imbriale et al. (2017) discuss their experience implementing one-to-one computing in tandem with a systemic digital conversion in a district serving more than 111,000 students in 174 schools. They suggest implementation which focuses first on the learning environment and the use of technology and emphasizes the importance of leveraging every facet of the district's infrastructure to make this happen. What Imbriale et al. (2017) articulate in their case study of their one-to-one and digital conversion is the epitome of what we know to be true from the body of literature on this topic: these initiatives cannot be about technology alone. They must be focused on 21st century approaches to teaching and learning and this means "rethinking and updating curriculum, instruction, assessment, organizational development, infrastructure, policy, budget, and communications" (Imbriale et al., 2017, p. 4). To do otherwise is a futile effort toward systematic change. In a similar line of research based on a case study of teachers and students involved in one-to-one initiatives, Peterson and Scharber (2017) provide practical recommendations for school districts considering one-to-one initiatives. Their first, and perhaps most useful, recommendation is this: "Begin with your vision for learning, not the technology . . ." (Peterson & Scharber, 2017, p. 69).

Changing Classroom Dynamics

Today's one-to-one computing classrooms are fundamentally different learning spaces than those of the past several decades. Their uniqueness exists not only because of the ubiquitous nature of computing afforded by the device ratio but by the fluid and dynamic nature of information available for students to explore when each of them has a device in their hands. Those classrooms which incorporate one-to-one technology and student-centered learning provide a stark contrast to the paradigm where static curriculum was delivered solely by the teacher. Spires et al. (2009) term this phenomenon "the new learning ecology" (p. 4) and suggest that this new name is needed to generate a common language within the literature and in professional development. Continuous accessibility to instructional resources in one-to-one classrooms and a destabilization of information online changes teachers' practices and how students acquire knowledge (Spires et al., 2009). For example, destabilization of information occurs on websites that include conversations or frequently rotated multimedia; regularly updated or newly posted content; interactive web tools; or social media sites. The new learning ecology is based on the premise that students' immediate access to information offers an ideal context for relevant and personalized learning, new competencies required of teachers, and new dispositions for students (Spires et al., 2009).

Changes in classroom dynamics through one-to-one computing have been discussed since the first research in ACOT classrooms. In this early research, Sandholtz et al. (1990) identified that teachers progressed through three stages of classroom management, sometimes in a linear fashion but in other cases moving among the stages based on context. These stages were characterized as *survival* (when teachers were most concerned with their own ability to manage the new environment and were predominantly reactive rather than proactive), *mastery* (characterized by teachers' proactive identification of consequences to address potential issues), and the *impact* stage (when teachers' levels of expertise had increased to the point where they are able to leverage the use of technology to solve these problems) (Sandholtz et al., 1990). The research on these stages has relevance today, particularly because it provides connections as to how a teacher's development in this area effects their pedagogical skills. This foundational research also helps to explain what teachers need to know and be able to do in one-to-one classrooms. Sandholtz et al. emphasized this, stating "instructional innovation is not likely to occur until teachers have achieved a significant level of mastery over management issues" (1990, p. 3). Sandholtz et al. (1990) provide very specific examples as to how a one-to-one teachers' classroom management competencies often need to look different from educators who do not teach using this technology ratio.

If teachers progress through a different set of classroom management phases as they adjust to one-to-one learning environments, it is critical then to examine some of the changing dynamics discussed in the literature that contribute to this. In implementation studies, teachers raised issues related to discipline problems such as off-task behavior or distractions as a result of ubiquitous computer use (Corn et al., 2012; Donovan et al., 2010; Dunleavy et al., 2007; Lei & Zhao, 2008; Lindqvist, 2015; Storz & Hoffman, 2012). Donovan et al. (2010) found that increased access to technology did not always increase student engagement and that it was imperative to define engagement. Using configuration mapping in middle school one-to-one classrooms, Donovan et al. (2010) found that students were sometimes cognitively or physically engaged with their laptops, but not always with tasks that were related to the academic lesson. Therefore, while technology can increase motivation, that motivation does not always translate to academic interest. These findings articulate the management elements teachers face in one-to-one classrooms. For example, how might teachers need to harness high levels of engagement among young people who are eager to search the Internet for content, but struggling to remain self-directed enough to stay on task? Further, how would teachers need to be prepared to address digital citizenship or to help students discern reputable digital content from that that is less reliable? These are potential competencies that become paramount to learning in the one-to-one classroom.

There are other changing dynamics teachers face. For example, the use of some computer-based applications may increase competition and collaboration, requiring strong classroom management skills from the teacher (Dunleavy et al., 2007). It is necessary for teachers to develop rules and routines to support students with the management of their devices and relevant consequences to hold students accountable for these expectations. The unique nature of the new learning ecology classroom therefore requires teaching competencies that include classroom management skills.

The shift toward more student-centered practice is documented in the literature on one-to-one technology, but there is little evidence to suggest why this shift occurs. Holen et al. (2017) examined this pedagogical shift within a large high school with one-to-one technology and examined the pedagogical change using activity theory. Holen et al. (2017) offer two potential reasons for the shift from teacher-directed to student-centered instruction in these classrooms: (a) the very nature of today's one-to-one technology; and (b) the apparent adaptability of both students and teachers. In the classrooms they studied, Holen et al. (2017) found that teachers' and students' perspectives evolved toward a philosophy where the teacher served as facilitator and that when current technology is in the hands of every student they have open access to dynamic information. This meant students no longer had to rely on the teacher as the primary source of information. Students appeared very adaptable to this shift, the use of new technology came easily to them, and this allowed the teacher to step back into a facilitative role (Holen et al., 2017).

In order to support teachers in one-to-one classrooms to take full advantage of the technology now in the hands of their students, it is important that the foundational aspects of student-centered pedagogy be included in one-to-one professional development. Not only is it important for teachers to understand these ideas from a theoretical perspective, they need to receive support in taking risks, practicing these approaches, and using technology to do so as they plan and implement instruction.

Student-Centered Pedagogy

The premise of student-centered pedagogy is rooted in the theoretical view of constructivism. The constructivist view is based on the assumption that learners construct meaning from their experiences and the learning environment itself, therefore learning is fostered when teachers situate experiences within activities that are as authentic as possible (Duffy & Jonassen, 1992). Instruction, according to constructivism, is not simply about transmitting information to students, but teachers developing plans which allow learners to construct their own knowledge to meet instructional goals.

One-to-one technology offers unique opportunities for implementing constructivist practices. However, in order to do so there needs to be emphasis on teacher competencies and student dispositions that make the actions of teachers and learners markedly different from other classrooms where this device ratio is not present (Spires et al., 2009). Unfortunately, many one-to-one technology initiatives and corresponding research studies fail to begin with a dual focus on student-centered practice and technology.

The identification of a one-to-one computing initiative tells us more about students' access to technology than actual pedagogical practice (Bebell & O'Dwyer, 2010). In fact, most studies communicate very little about the pedagogical goals associated with the initiative and some even fail to address the issue of pedagogy at all. Others imply a shift in instructional practice, but without a description of whether this was intentional. This missing information is crucial because the instructional practices within a classroom are the most important feature of any one-to-one initiative. In their review of one-to-one literature Bebell and O'Dwyer (2010) describe the critical role that pedagogy plays, explaining that when schools or districts make the decision to go one-to-one they often do so because they are looking to see positive changes in the instructional environment. However, many are unsure how to achieve the instructional benefits that can be achieved through the incorporation of student-centered learning practices and one-to-one technology. More often than not, "the context and expectations range widely for one-to-one models partially because the models, by definition, only describe the ratio of technology access, not how it is being used" (Bebell & O'Dwyer, 2010, p. 12).

Baseline information about pedagogical practice prior to one-to-one deployment is helpful to achieve a clearer sense of the impact technology has had on teachers' instruction. It is crucial that those responsible for professional development understand that educators who utilize a more traditional, teacher-directed approach are effectively "being asked to adopt two innovations – the one-to-one computing environment and a more student-centered classroom" (Donovan, Hartley, & Strudler, 2007, p. 280).

Awareness of this is crucial so that the appropriate support can be offered to each teacher based on his or her individual needs.

When school and district leaders recognize the importance of this dual focus on one-to-one technology and student-centered pedagogy, we see evidence of positive results. Rosen and Beck-Hill (2012) assessed the student achievement and related factors of a constructivist one-to-one computing initiative which centered on differentiation and a digital, student-centered curriculum in four elementary schools. In the review of 476 fourth and fifth grade students and their teachers, students in one-to-one computing classrooms significantly outperformed the control group students in reading and math, decreased their unexcused absences, and decreased their discipline referrals by 62.5% while the control groups' referrals remained the same (Rosen & Beck-Hill, 2012). One of the key differences identified in this initiative was its focus on both pedagogy and one-to-one technology simultaneously. Overall, students participating in these one-to-one classrooms interacted with one another more regularly, their teachers differentiated more frequently, and there were greater opportunities for independent and individualized learning (Rosen & Beck-Hill, 2012). As compared to teachers in the control group, the one-to-one teachers appeared more responsive to the needs of their students, provided greater descriptive feedback, and their students reported increased motivation for learning and positive attitudes toward the role of computers in learning.

Awareness of the influence of pedagogy on one-to-one technology integration is important for those at various levels in schools and districts. Studies like the one conducted by Rosen and Beck-Hill (2012) demonstrate the many benefits afforded to students when teachers harness one-to-one technology as a means for practicing student-centered pedagogy. However, without a clear indication of what teachers need to know and be able to do, these results are difficult to replicate. An inventory of teaching competencies is needed to create a more common language about the best practices for instruction in one-to-one classrooms and the integration of student-centered learning practices helps to incorporate that pedagogical focus.

The Critical Role of Teachers

Teachers are the most essential component in the new learning ecology created by today's one-to-one classrooms (Spires et al., 2009). An ecology itself, is dynamic - the components within the environment impact one another and no one component operationalizes in isolation. Spires et al. (2009) argued that the one-to-one classroom operates as an ecological system where there is a constant dance between teacher, student, and technology. In these contemporary learning environments, teachers' skills are stretched beyond traditional mentoring and coaching to include facilitation, improvisation, consultation, and responsiveness to students in the moment (Spires et al., 2009). Teachers in one-to-one classrooms report frequent *teachable moments* that require them to be flexible and spontaneous (Garthweit & Weller, 2005). Teachers may also find instances where they must maintain a balance of power with their students. For example, students may provide technical support to their peers or their teacher, allowing students to temporarily take on a leadership role (Garthweit & Weller, 2005). In order to foster dynamic, twenty-first century learning environments, teachers and those preparing them need a clear understanding of the competencies needed to facilitate this type of learning. Through an identified inventory of competencies, administrators, teachers, and teacher educators can begin to discuss expectations for pedagogical practice using a common language. Identifying these teacher competencies supports those responsible for designing and implementing one-to-one initiatives at the district level because it allows teaching and learning to become the driving force between the goals of the initiative and the inventory provides those responsible with the set of knowledge, skills, and dispositions that can be incorporated into various activities.

The increasing accessibility of information in our world today has created a much wider range of learning experiences and even a highly effective teacher cannot plan for all of the possible changes that could occur during instruction. Instead, the well-prepared one-to-one classroom teacher can be responsive to his or her students' needs, help them to navigate the information they find, and leverage the use of technology as a means for individualizing the learning experience (Spires et al., 2012).

Because teachers play the most critical role in the success of one-to-one computing initiatives, they are the most studied variable in one-to-one research studies and related papers. Teacher buy-in plays a critical role in the success of one-to-one technology initiatives (Bebell & Kay, 2010; Bebell & O'Dwyer, 2010; Shapley et al., 2010), and even those who believe in the initiative may feel frustrated by colleagues who continue to demonstrate resistance (Christman, 2014). Donovan et al. (2007) utilized the Concerns-Based Adoption Model (CBAM) to identify the concerns of teachers in the early stages of a one-to-one computing initiative in a middle school. Many of the teachers participating in this research had concerns about how the addition of laptops would personally affect them and they were less concerned about issues related to student needs. Teachers were most concerned about being ready for the one-to-one initiative and they raised questions about how the technology would change their current teaching methods (Donovan et al., 2007). Overall, Donovan et al. (2007) pointed out that teachers needed to know that their opinions were valued and teachers preferred the opportunity for input in the planning stages of the one-to-one initiative.

Since teachers serve the most critical role in the implementation of any one-to-one technology initiative, they need to have a clear understanding of others' expectations for them. As these educators are our greatest assets in effective integration, it is appropriate that they serve as active developers in creating these competencies along with other professionals with knowledge and expertise in this area. Ultimately, any one-to-one program is only successful when careful attention is paid to what teachers need to know and be able to do well in their classrooms. An inventory which spells out these teaching competencies will provide a roadmap for preparing teachers to enter one-to-one classrooms and it will allow educators to critically evaluate whether they exhibit the skills needed to effectively facilitate instruction in these classrooms.

Conceptual Framework

The conceptual framework for this study is based on the constructivist paradigm and the new learning ecology within one-to-one learning environments. Together these frameworks provide a lens for the design of the study, the development of specific inventory items, and they provide theoretical support for the incorporation of student-centered learning practices with one-to-one technology.

The constructivist paradigm. The constructivist philosophy is based on the assumption that knowledge is a product of active interpretation on the part of an individual (Jonassen, 2001), thus individuals are said to construct their own personal reality based on their experiences. Unlike other paradigms which de-emphasize the impact of the individual, constructivism places the individual at the center of meaning making. How we make sense of the world, according to this epistemological belief, is based predominantly on our past experiences, with culture and social context playing an important role in our understanding of the world (Schuh & Barab, 2008). The constructivist paradigm does not reject that there is a reality, but that individuals construct reality based on their own lived experiences (Jonassen, 2001). Unlike the objectivistic paradigm which depicts knowledge as being characterized by one real truth, constructivism draws connections between an individual's perception and reality. Rather than a behavioral focus, the paradigm emphasizes the process of knowledge acquisition and the role of the individual in that process.

In traditional, teacher-directed classrooms where non-digital materials are used, students are likely to learn in a rote way with static materials such as paper and pencil, worksheets, and textbooks. Oftentimes, this traditional or objectivist instructional model is based on the student's ability to complete a pre-made, oftentimes prescribed, set of inauthentic tasks or activities. In classrooms of the past, it was common to see instruction which was based on an inflexible curriculum designed for a *typical* or *average student*, without flexible learning options, much less a twenty-first century learning model or digital technology (Meyer, Rose, & Gordon, 2014). However, many classrooms with one-to-one technology have the potential to look very different, especially when the teacher understands how to use students' devices to incorporate practices like independent inquiry, project-based learning, or creative options for writing and publishing (Bebell & O'Dwyer, 2010; Christmas, 2014; Dunleavy et al., 2007). When this occurs, we see constructivism at play, but now in a nuanced way. Therein lies the difference between a constructivist learning environment where *some* technology is present and the new twenty-first century, one-to-one constructivist learning environment, which Spires et al. (2009) terms the new learning ecology.

Constructivism revisited: The new learning ecology. In an original white paper developed by a team of researchers at North Carolina State University, Spires et al.

(2009) described how one-to-one technology has begun to shape the learning environment in twenty-first century classrooms, naming this phenomenon the new learning ecology. Spires et al. (2009) state that the “constant access to tools and rich information in the 1:1 classroom creates a new learning ecology, in which information and ideas are abundant, in flux, and constantly evolving” (p. 5). The difference here between previous practices in constructivist learning environments and the new one-to-one learning environment, is that the wireless internet coupled with the technology ratio allow for *constant* access to information. Additionally, the increased interactive nature of digital nature through web 2.0 tools means that today’s digital environments are not static, but constantly changing in terms of content and function. These factors make for much more sophisticated constructivist teaching and learning opportunities.

The original premise for the new learning ecology is built on Bronfenbrenner’s original ecological systems theory (Spires, Oliver, & Corn, 2011), with the ecological perspective initially derived from sociocultural and activity theories (Barron, 2006). These theories emphasize the interplay between the learner and other important elements in the environment. Bronfenbrenner (1986) described human development as being based on an ecology that included “progressive, mutual accommodation, throughout the life course, between an active, growing human being” (p. 188). According to Bronfenbrenner’s (1986) theory, individuals exist within several layers of systems: the microsystem (home, school, or workplace), mesosystem (the system of microsystems and their relationships, such as home to school), exosystem (two or more settings and their linkages), and the macrosystem (the broader social context or culture).

In addition to its roots in ecological systems theory, the concept of the new learning ecology by Spires et al. was also inspired by the work of John Seely Brown

(2000). Brown (2000) suggested that the introduction of the Internet in classrooms was a transformative medium which offered a two-way learning experience for students. Instead of merely pushing content *into* students, the Internet, Brown (2000) argued, allowed for a *push-pull* effect. Students may take content in from online sources, and then respond by creating a product or set of ideas that they push out again into the Internet (Brown, 2000). Thus, teaching and learning with classroom technologies can be a dynamic process. According to Brown (2000), this produced a learning ecology characterized by "an open, complex, adaptive system comprising elements that are dynamic and interdependent" (p. 19). Because teaching and learning occurs within this dynamic system, the power of the learning ecology is that the variables within it are diverse and students within these learning environments are adept at moving between different mediums as most are strong multi-taskers (Brown, 2000).

In more recent literature, Barron (2006) reintroduced the learning ecology framework, this time noting cases in which the approach could be used to explain how young people become adept at using new technologies. Barron (2006) defined this revised learning ecology as "the set of contexts found in physical or virtual spaces that provide opportunities for learning" (p. 195). In this revised perspective, the possible contexts for learning were expanded to include virtual spaces and digital resources as well as spaces in the physical classroom (Barron, 2006). The new options for seeking information from a variety of sources, far beyond the classroom teacher, make it necessary to recognize these elements as part of the learning process. To discount these interactions in the twenty-first century one-to-one classroom would not provide the full picture of how learning occurs.

The new learning ecology is a new form of the previous constructivist learning environment, but now with a twenty-first century twist. It is primarily the conditions of the one-to-one classroom that create the nuanced difference. Features like immediate and constant access and increased opportunities for intensity and relevancy in learning require that teachers have highly developed capacities to manage the flow of learning in these classrooms (Spires et al., 2009). The work of Spires et al., namely their description of teacher capacities needed in one-to-one learning environments, has provided a strong foundation for the development of the teaching competencies in this research.

Conditions of the new learning ecology. The new learning ecology is based on four conditions that are said to be present in one-to-one, student-centered classrooms, including:

1. Immediate and constant access to information and a global community;
2. Intensity, relevance and personalization of learning;
3. Highly developed teacher capacities; and
4. Highly developed student dispositions. (Spires et al., 2012, pp. 234-235)

Figure 1 shows a pictorial representation of these four conditions and how they influence one another in the one-to-one learning environment. The graphic below helps to depict the dynamic nature of these conditions and highlights a few of the teacher capacities that Spires et al. (2012) suggest are necessary to effectively implement instruction.

Immediate and constant access to information. This section will describe each of the four conditions of Spires et al.'s new learning ecology in detail. The first condition, immediate access to information, is characterized by students' on-demand access to information from a variety of digital sources, opportunities for incidental learning that is presented with this content, and the destabilization of information that is consistently

Figure 1. Four conditions of the new learning ecology. From "Toward a New Learning Ecology: Professional Development for Teachers in one-to-one Learning Environments," by H. Spires, E. Wiebe, C. A. Young, K. Hollebrands, & J. K. Lee, *Contemporary Issues in Technology and Teacher Education, 12*(2), p. 235.

available in the teaching and learning process (Spires et al., 2009). While the ubiquity of the technology is important, it is not the ubiquity alone that enhances learning - it is how the technology is used to implement the learning objectives. When students have access to relevant information in an interactive fashion and they have the opportunity to respond in ways that incorporate twenty-first century skills (such as collaboration, problem-solving, or inquiry). This is the uniqueness of the first condition in the new learning ecology.

Intensity, relevancy, and personalization of learning. The second condition is students' increased opportunities for relevant and personalized instruction (Spires et al., 2009). New technologies provide increased options for students to be at the center of the teaching and learning process. For example, productive inquiry is seen as not only an option but a prerequisite in the new learning ecology. When students are given complex problems, or allowed to participate in productive inquiry around issues that are of interest to them, this offers increased relevancy and personalization for learners. This practice facilitates constructivism because students are provided with greater opportunities for building meaning which is authentic to them.

Highly developed teacher capacities. The new learning ecology places the teacher of the one-to-one classroom in the key role, not because they are responsible for delivering all the information, but because they reinforce the interplay between the variables within the ecology through four important skills: “facilitation, improvisation, coaching, and consultation” (Spires et al., 2009, p. 9). This is the third condition present in the new learning ecology. These skills exceed the basic facilitation skills described in past constructivist theory to include more sophisticated facilitation which includes the ability to think on one’s feet by adjusting and responding to what students may uncover given new digital resources. In this role, the teacher must be prepared to accept that he or she may or may not be the expert. A teacher who is well prepared to facilitate instruction in this environment is able to seamlessly transition between the role of teacher, facilitator, and in some cases, a learner (Spires et al., 2009). The most skilled teachers are able to move between these roles while still maintaining a professional level of competence that allows he or she to support students’ individual needs and preferences.

Highly developed student dispositions. While the focus of this research has been placed squarely upon the changing role of the teacher in one-to-one classrooms, Spires et al. (2009) acknowledge that student dispositions play an important role in the learning process as well. This is the fourth and final condition described within the new learning ecology. Much of the learning that takes place in one-to-one classrooms is contingent upon the rich interactions between students as well as students’ ability to remain individually focused on a set of tasks. This requires self-directedness, self-regulation, and related dispositions that help students to be successful. Teachers who model these skills as well and coach and mentor students to cultivate these skills in themselves are making the most sufficient contributions. After all, teaching students to channel their use of technology beyond recreation to find useful information, solve important problems, and publish quality content that matters are essential components of the learning process.

Constructivism and the new learning ecology as a lens. The perspectives of constructivism and the new learning ecology have guided the methodological choices in this study and theoretically grounded the items posed to Delphi panelists in the first round of data collection. This research study was born out of the vision shared by constructivist thinkers and the developers of the new learning ecology. Their contributions and publications related to these concepts have shaped the purpose for this work and have shaped the research design.

Unlike many existing one-to-one studies, this research goes beyond identifying whether constructivist methods are present and describes the knowledge and skills that are needed in order to facilitate effective teaching using this approach. The proliferation of technology and the constant access to dynamic digital information has made it possible for pedagogy to include more student-centered approaches. These changes, coupled with the increased prevalence in one-to-one computing, has made it possible for the constructivist approach to be extended to the new learning ecology that now exists in many one-to-one classrooms throughout the country. These constructs have played a significant role in shaping this research in order to develop an inventory of competencies needed to facilitate instruction in these environments.

Summary

Data in the prevalence of one-to-one technology shows that it is an increasing trend (IESD, 2014; Richardson et al., 2013), and there has now been a universal call for schools and districts to scale their adoption of computing devices provided to students (USDE, 2017). We need a study that supports these efforts by making the work of teachers in one-to-one classrooms visible through identified competencies. The literature reviewed here shows that increases in student achievement are possible when one-to-one technology is present (Bebell & Kay, 2010; Zheng et al., 2016), but particularly when there is a pedagogical focus (Rosen & Beck-Hill, 2012). We need a study that makes this link between pedagogical practice and one-to-one technology clearer, in a way that past research has not. The literature shows that when one-to-one technology is present in classrooms, many teachers shift from teacher-directed to student-centered learning approaches (Broussard et al., 2014; Dunleavy et al., 2007), but, to date, it has been challenging to elucidate the actual practices of these teachers. We need a study that clarifies what the teacher needs to know and be able to do, in order to replicate these successful results. We know from the literature on one-to-one technology that there are unique affordances and challenges associated with one-to-one initiatives (Corn et al., 2012), but we need research that organizes these into themes and translates them into implications for teachers' practice. Finally, the literature repeatedly shows us that teachers play the most critical role in one-to-one classrooms (Garthweit & Weller, 2005), but we have yet to define that role. This study will address each of these gaps by drawing on the experts in one-to-one technology to build an inventory that clarifies the role of the one-to-one teacher and it helps to elevate the discussion of one-to-one technology past adoption and toward strong pedagogical practice.

CHAPTER III. METHODOLOGY

The growing presence of one-to-one learning environments has increased the number of individuals with knowledge in how to effectively implement this technology in the classroom. As a result of this growth, we have learned a great deal about the pedagogy of one-to-one teachers, both through research and school district reports of implementation. In this research study, we capitalize on this new knowledge by assembling a panel of experts who will develop an inventory of teaching competencies for one-to-one learning environments. This chapter provides an overview of the Delphi method and corresponding research procedures that were used to develop this inventory, including the following sections: Statement of the Problem, Purpose of the Study, Research Question, Research Design, The Delphi Method, Characteristics of Delphi Methodology, Rationale for Methodology Selection, Sample, Data Collection, Data Analysis, Pilot Study, Validity, Reliability, and Summary.

Statement of the Problem

There are unique conditions that make one-to-one learning environments, where the student-to-computer ratio is equal, distinctly different from traditional technology-rich classrooms. Additionally, literature indicates that it is the combination of student-centered pedagogy with one-to-one technology that promotes the greatest instructional value (Dunleavy et al., 2007).

Given the substantial resources now being allocated to one-to-one classrooms, it is essential that we have an accurate set of teaching competencies to guide teaching, professional development, and preparation. If we do not adequately prepare teachers to develop the knowledge and skills they will need to teach effectively in these classrooms, then we have wasted these resources and denied the benefits of them to our students.

Additionally, we must clearly identify what our future teachers need to be able to do in one-to-one classrooms, otherwise our next generation of teacher candidates will be unprepared for the classrooms they enter after graduation. The current ISTE (2017) standards for educators outline what teachers need to do in order to integrate a wide range of technology, but they do not address the competencies specific to one-to-one learning environments. Ultimately, if we make student-centered pedagogy a common practice in one-to-one learning environments and we distinguish the intricacies specific to these classrooms, our students have much to gain.

Purpose of the Study

The purpose of this research is to develop a resource that can be used in schools, districts, and teacher preparation programs to prepare teachers for one-to-one classrooms. To do so, we must rely on practitioners and researchers in the field who have expertise in one-to-one computing. Using the collective knowledge of these individuals, an inventory of teaching competencies identifies the skills and the dispositions teachers need to effectively facilitate instruction in student-centered, one-to-one learning environments. The implementation of these competencies is how we achieve exemplary teaching in the one-to-one classroom.

Research Question

This research was led by one guiding question: *What are the teaching competencies required of educators who facilitate instruction in student-centered, one-to-one learning environments?*

Research Design

In this study, quantitative and qualitative research procedures were used as part of the Delphi method to address the research question. The underlying epistemological position of the Delphi method is rooted in the post-positivist stance through scientific inquiry, but with a lens that allows for interpretivist features as a part of the research process (Day & Bobeva, 2005). This classic Delphi study incorporates the main features of Delphi research, identified by van Zolingen and Klaassen (2013) as anonymity, iteration, controlled feedback, and statistical group response.

The Delphi Method

The Delphi method was first developed as a tool for forecasting military-related issues by members of the Rand Corporation in the 1950s (Murry & Hammons, 1995; Rowe & Wright, 1999). In the literature, synonymous terms are often used to refer to this methodology, including the Delphi method, model, or technique.

In the seminal text outlining the Delphi method, Linstone and Turoff (1975) define it as a process for organizing group communication that allows a collection of experts to solve a complex problem. Linstone and Turoff (1975) describe the Delphi process as including four phases that constitute its general research design:

1. Phase One - exploration of the specific topic of discussion, characterized by the researcher gathering information pertinent to the issue;
2. Phase Two – completion of an iterative series of structured group communications which gives way to a shared understanding of how the group views an issue;
3. Phase Three - examination of any significant disagreements within the group and the underlying reasons for these differences, and;
4. Phase Four - final evaluation and analysis which is fed back to the participants for consideration.

The originators of Delphi developed the methodology with these features to address the potential challenges that arose when face-to-face communication was used to build consensus. Gordon (1994) wrote that particular characteristics of Delphi can be traced back to the limitations that the members at the Rand Corporation experienced when attempting to forecast and build consensus through other methods.

Characteristics of Delphi Methodology

While there are more recent guidelines and critical reviews for the implementation of the Delphi method, Linstone and Turoff (1975) originally referred to it as far more of an art than a science. In their systematic review of Delphi studies, Rowe and Wright (1999) acknowledged several key features of Delphi research methodology to include anonymity between participants, iteration through rounds of data collection, controlled feedback, and aggregation of results through quantitative analysis. First, and arguably the most important, is anonymity. In Delphi research, experts' identities are kept anonymous from one another so that decisions can be made based upon expert judgment, rather than group pressures or individual personalities (Rowe & Wright, 1999). The chief purpose of this anonymity is to make certain that ideas are considered solely on merit rather than ancillary factors associated with human interaction. Next, the iterative nature of the Delphi process allows experts the option to refine their opinions through multiple rounds after receiving controlled feedback from the researcher. The anonymous nature of the process allows panelists to adjust any opinions without having to admit such a change to fellow participants. The Delphi process is further characterized by controlled feedback. In order to inform individual panelists of group responses, resulting summaries from each round are shared with the experts following a thorough synthesis by the researcher (Rowe & Wright, 1999). This analysis often involves both quantitative statistical analyses of mean scores on Likert-scale items as well as a qualitative coding analysis of any open-ended responses. The researcher controls the feedback provided to the panelists by specifying only those results which fall outside of the pre-specified limits and by presenting the key themes that best represent group input from a Delphi round (Rowe & Wright, 1999). A key benefit to the iterative process and the use of controlled feedback is the opportunity for the expert to change his or her mind if they find a convincing reason to do so (van Zolingen & Klaassen, 2003). Finally, Delphi methodology is characterized by the inclusion of quantitative analysis (Rowe & Wright, 1999). After several iterations, the statistical analysis of each item is computed and final judgments of consensus are based on an equal weighting of the group members' responses. While there are no set guidelines for these analytical procedures that Dalkey refers to as the "statistical group response" (1967, p. 3), there are scholars who offer critical approaches to improve the rigor of Delphi analyses (Dajani, Sincoff, & Talley, 1979; Keeney, Hasson, & McKenna, 2001; Schmidt, 1997). Strategies used to improve the rigor of this study are discussed in the data analysis section of this chapter.

Rationale for Methodology Selection

Linstone and Turoff (1975) developed Delphi as a way to methodically address a complex problem that could not be solved solely with analytical techniques. In this study, the Delphi Method was well suited for addressing the issue of teaching in one-to-one classrooms because this is not an issue that lends itself to precise analytical techniques. An in-depth review of the literature shows that technology integration by teachers is considered a broad and complex problem (Mishra & Koehler, 2006). Delphi is also recommended when it is not feasible to meet with the group of participants face-to-face, or when time and cost prevents this. In this study, the geographic distribution of the sample group and the time constraints of these individuals lends itself well to the Delphi design, as attempting to conduct this work with another form of consensus building processes might not be realistic. Linstone and Turoff (1975) propose that the anonymity between participants in Delphi research makes it well suited for resolving disagreements that could arise amongst heterogeneous groups of experts or when there is potential for domination by individuals with advanced training and strong opinions. In this study, the Delphi Method offers a useful approach for gathering a heterogeneous group of experts and utilizing their knowledge to synthesize the most critical competencies for teaching in one-to-one classrooms.

The Delphi Method provides a viable solution for objectively exploring answers to a question that requires experts' judgment (Gordon, 1994). Specifically, this method provides an efficient approach by bringing together a group of knowledgeable individuals who have insight on a problem and the method extends beyond traditional survey research by also informing the panel of information that is collected throughout the study (Gupta & Clarke, 1996). Further, the methodology provides procedures for bringing the panel to consensus (such as through controlled feedback), without the potential drawbacks of face-to-face communication (Gupta & Clarke, 1996). These various strengths of Delphi methodology provide a rigorous alternative to traditional survey research and a structure for research design.

While the Delphi Method was originally used for technological forecasting, it has also been used for application purposes (Gupta & Clarke, 1996). In their large-scale literature review of 463 Delphi papers, Gupta and Clarke (1996) found the application form of Delphi to be most commonly used in education over any other field. The Delphi Method has been a successful approach in addressing research questions similar to the one being examined in this study. Delphi has been utilized to develop other taxonomies (Kleynen et al., 2013; Valentijn et al., 2015) and to identify competencies for teachers or students (Scarpa, 1998; Schell, 2006; Tigelaar, Dolmans, Wolfhagen, & Van der Vleuten, 2004; Yeh, Hsu, Wu, Hwang, & Lin, 2014). Delphi methodology has also been used to address issues within higher education (Cyphert & Gant, 1970; Mengual-Andres, Roig-Vila, & Blasco Vira, 2016; Na, 2006) and in K-12 education (Scott, Washer, & Wright, 2006).

The Delphi Method has been described as a viable technique for educational technology research (Nworie, 2011). Most notably, Delphi methodology is used to produce the flagship publication for emerging technology trends, the Horizon Report. Published annually, the purpose of the Horizon Report is to identify and describe emerging technology trends in the field, including higher education, K-12, libraries, and museums (The New Media Consortium (NMC), 2017). Drawing upon the knowledge of its diverse panel of experts each year, the Horizon Report serves as the field's foremost example of Delphi in action. This widely read publication has been published more than 50 times and translated into more than 50 foreign languages (NMC, 2017).

There are distinctive characteristics of Delphi that make it a viable methodology in educational technology, particularly its ability to help address evolving issues within the field. In addition to addressing research questions related to educational technology, it supplies leaders with information necessary for making decisions and developing policy (Nworie, 2011). According to Nworie (2011), Delphi is an ideal method for exploring how technology impacts change in pedagogy and the role of teachers, because it is designed to address continually evolving issues and problems. The Delphi process can be used, specifically, to help identify the roles, responsibilities, and competency levels that are needed to prepare teachers in changing learning environments (Nworie, 2011).

In alignment with Nworie's (2011) advocacy of this methodology, Delphi has been commonly used in individual educational technology studies (i.e. Elmendorf, 2012; Elmendorf & Song, 2015; Farmer, 1998; Mengual-Andres et al., 2016; Na, 2006; Scarpa, 1998; Yeh et al., 2014). The Delphi Method has been used to develop a teacher evaluation tool made up of indicators for pedagogy and technology integration in K-12 classrooms (Elmendorf, 2012; Elmendorf & Song, 2015). Mengual-Andres et al. (2016) performed a Delphi study to identify digital competencies required in higher education classrooms that were later used to develop an evaluation instrument for university faculty. Similarly, Scott et al. (2006) identified biotechnology competencies for first-year and initially certified teachers through implementation of an online, modified Delphi technique. Each of these examples include the use of Delphi in either education or instructional technology to identify specific teaching skills required for an explicit type of learning environment.

Sample

Proper sampling is critical in Delphi research (Day & Bobeva, 2005; Gordon, 1994; Nworie, 2011) as the selection of quality experts is directly related to the quality of the results (Balasubramanian & Agarwal, 2012). The overarching question guiding the selection of participants is, "How can questions be addressed to the persons most likely to answer them well?" (Gordon, 1994, p. 11). Therefore, in this study, the researcher sought a panel of experts that could best judge the competencies needed by teachers to facilitate instruction in student-centered, one-to-one learning environments.

Sampling terms. Delphi studies draw on a sample of participants, but with unique terminology that distinguishes the methodology. Participants in a Delphi study are typically referred to as experts based on the sampling criteria. Once experts have been selected to serve on a panel for a study, they may also be referred to as panelists.

Sampling procedures. Determining the level of expertise of participants and the amount of similarity between panelists is best be determined through purposeful sampling methods (Day & Bobeva, 2005). Creswell (2013) defines purposeful sampling as a strategy in which the researcher "selects individuals and sites for study because they can purposefully inform an understanding of the research problem and central phenomenon in the study" (pp. 300-301). Since the context of this research requires that the expert have very specific past experience teaching or studying this specific learning context, purposive sampling was most appropriate. It is generally regarded as the most common and appropriate sampling technique in Delphi research (Day & Bobeva, 2005; Valentijn et al., 2015).

In order to reduce the potential risk of illusory expertise and to systematize the process for identifying participants, the Knowledge Resource Nomination Worksheet (KRNW) process was utilized to identify experts for the panel (Okoli & Pawlowski, 2004). The purpose of the KRNW process is to categorize and to identify potential experts for the study as well as make sure that no sub-group of experts is overlooked in the recruiting process (Balasubramanian & Agarwal, 2012; Okoli & Pawlowski, 2004). The KRNW approach consists of four steps, each of which is depicted below in Figure 2.

KRNW step 1: Expert criteria. The first step was preparation of the nomination worksheet. This worksheet, labeled with three columns (discipline and skills, organizations, and related literature) categorized and sub-categorized potential experts to determine that all necessary perspectives are represented within the Delphi panel (Okoli & Pawlowski, 2004). The completed KRNW is included as Appendix A.

The purpose of the nomination worksheet was to identify the potential types of experts that may be recruited based on discipline and skillset and the professional organizations in the field of instructional technology that helped direct the researcher toward relevant experts at the national level. The first step in completing the worksheet included adding the types of knowledge needed and potential sources, such as the journals that frequently publish one-to-one literature. This helped to ensure that the panel of experts was not pre-determined and helped to guard against issues of bias (Delbecq, Van de Ven, & Gustafon, 1975).

Step 1: Prepare KRNW	• Identify relevant disciplines, skills, organizations, and related literature
Step 2: Populate KRNW with names	• Write in the names of individuals from relevant disciplines and organizations as well as those with relevant skills
Step 3: Nominate additional experts	• Contact experts listed within the KRNW • Ask these individuals to nominate additional experts
Step 4: Rank experts	• Categorize experts into two sub-lists by discipline (higher education with scientific expertise and K-12 with practical expertise) • Rank experts within sub-lists that have more experts in order to meet the target sample size
Step 5: Invite experts	• Invite experts from each sub-list to participate in the study • Stop soliciting experts when the target size of 30 has been reached

Figure 2. Knowledge resource nomination worksheet (KRNW) procedure for selecting experts. Adapted from "The Delphi Method as a Research Tool: An Example, Design Considerations and Applications," by C. Okoli and S. Pawlowski, 2004, *Information and Management, 42*, p. 21.

KRNW step 2: Populate worksheet. In step two of the KRNW sampling procedure the researcher filled in potential experts' names on the nomination worksheet. When detailing this process, Okoli and Pawlowski (2004) indicate the likelihood for there to be "a high degree of overlap" of experts within various areas of the worksheet (p. 20). However, the purpose for working within the columns was to consider each type of expert individually based on his or her specific merit. Proceeding through a systematic consideration of experts using these various lenses, the researcher worked to "identify as many experts as possible" (Okoli & Pawlowski, 2004, p. 20). Okoli and Pawlowski (2004) indicate that it is not uncommon during this process for a researcher to consider his or her own professional contacts, but the KRNW helps to ensure that the researcher moves beyond this step to select experts who are not limited to only one personal network. Further actions included contacting those who had connections with school districts facilitating one-to-one initiatives, reviewing journal publications to identify authors and institutions conducting research on one-to-one classrooms, as well as reaching out to national professional organizations with members who are leaders in this area.

KRNW step 3: Contact experts. After populating the nomination worksheet, step three of the sampling process commenced with personal contact, often an email message, to potential experts. The purpose of this initial contact was not to ask the potential experts to participate but to ask that they nominate other potential participants who may be vetted by the researcher using the same process described in step two of the KRNW process (Okoli & Pawlowski, 2004). Rowe and Wright (2011) advocate the use of this "person-to-person cascade approach (i.e. 'snowballing')" to recruit Delphi participants (p. 1489).

When expert researchers from the KRNW were contacted, they received a brief description of the study and were told that they have been identified as an expert in this area. As was recommended by Okoli and Pawlowski (2004), the researcher shared the biographical information that was used to gauge potential participation of these experts. In each case, the researcher included specific publications or relevant expertise that was used to identify that potential panelist as an expert in one-to-one technology. Following this, the individual was asked to nominate other potential experts. The actions taken in this portion of the KRNW process are supported by Delphi literature, particularly by Hsu and Sandford (2007) who discuss the benefit of a Delphi researcher seeking assistance from someone influential in the topic. When a researcher uses other professionals for help in recruiting experts it is likely to decrease the researcher's chance of receiving no response or being turned down during the sampling process (Hsu & Sandford, 2007).

During initial communication with potential practitioners (i.e. teachers, support specialists, administrators) being considered for the study, the potential participant was asked several basic questions related to their past experience with one-to-one technology and this information was used to rank each individual in the next step of the sampling procedure. For example, if a potential panelist indicated that he or she was responsible for professional development at their school, the researcher would ask that they clarify their level of involvement with professional development related to one-to-one computing.

KRNW step 4: Rank experts. The fourth stage in the KRNW sampling process involved ranking participants according to their qualifications in order to prioritize who would be invited to participate in the study (Okoli & Pawlowski, 2004). This included categorizing the names on the resulting KRNW into sub-lists. In this study, the KRNW worksheets included three columns: (a) K-12: individuals with practical experience teaching in a one-to-one classroom or implementing a one-to-one initiative in a school or district, (b) Professional Organizations: professional groups or non-profit organizations who may be associated with one-to-one computing, and (c) Academic Research: individuals affiliated with institutes of higher education that had previously published research on this topic and publications that frequently published research on one-to-one technology. All individuals in the pool were ranked, based on the qualities that they described in their initial correspondence or through examples of their past research.

KRNW step 5: Invite experts. In the fifth and final stage of the sampling procedure, the researcher contacted the selected experts in order to invite them to participate in the study. Given the positive response to the interest in this study, the researcher invited slightly more than the targeted sample size in order to account for any possible attrition. In typical survey research, it is not uncommon for the participant to receive a postcard or an advanced letter of notice as a form of contact prior to research participation. Personal contact with potential participants has been shown as a beneficial approach in Delphi research (Hsu & Sandford, 2007). Day and Bobeva (2005) also suggest that a more personal approach to recruiting heightens the appeal to the expert and increases the likelihood that they will choose to participate. In the final step of the KRNW in this study, the one-to-one experts were provided with an email message addressed to them personally, along with a description of the level of commitment required for their participation. Experts were asked to commit to up to four rounds of online questionnaires. Experts were told that each of the online surveys was estimated to take 30 minutes or less to complete, totaling approximately two hours of online participation over a period of four to five months. Experts were also informed they would need regular access to email communication and that they would have up to two weeks to complete each survey. In accordance with the recommendations of Delbecq et al. (1975), the Round One instrument was sent soon after initial contact with all of the panelists.

Experts. The group of experts selected were a heterogeneous mix of researchers, administrators, support personnel, and teachers. These representatives were selected from K-12 public schools, private schools, and teacher preparation programs. The literature on Delphi methodology suggests that achieving just the right balance of heterogeneity within a group of panelists is advantageous (Day & Bobeva, 2005; Linstone & Turoff, 1975; Nworie, 2011), as “panel selections must be made to ensure representation of all relevant social and cultural groups” (Linstone & Turoff, 1975, p. 582). The goal was to achieve a balance of both researchers and practitioners within this expert group, because the literature suggests risks to assembling a homogenous panel. A group of panelists whose views are too similar represents a lack of diversity in opinions and may minimize the ability of participants to weigh the varying recommendations made by others (Day & Bobeva, 2005). Conversely, a group whose views are too different from one another may not be able to reach consensus on the issues presented to them. The method used for this study was modeled after the criteria utilized in the Delphi study conducted by Valentijn et al. (2015). When creating their panel, Valentijn et al. (2015) selected experts that included individuals with scientific skills (those who had conducted research on the topic) and individuals with practical skills (those who had experience working directly with the issue in the field). A balance between these two criteria is preferred for the ideal panel (Valentijn et al., 2015). In this study, 57% of the panel had practical experience in one-to-one computing, 28% had scientific experience, and 15% had both.

Panel size. The literature on panel size in Delphi studies is mixed (Murry & Hammons, 1995) and decisions for selecting an appropriate number of panelists is based on the scope of the research, the topic being studied, and the amount of previous research that has been conducted in that area. Most small-scale Delphi studies have between 15 and 35 experts (Day & Bobeva, 2005; Gordon, 1994) but Dalkey states there may be as few as seven experts to gain consensus on opinions within a group (1967). In his discussion on the use of Delphi in educational technology research, Nworie (2011) reports that panel sizes can range between 10 and 50 experts depending on the scope of the study. Given the recommendations from the literature and the purpose of this study, the goal was to attain a sample size of approximately 30 experts who met the sampling criteria. Overall, 37 of the initial 38 potential participants fit the sampling criteria, therefore all 37 of these individuals were invited to participate.

Attrition. Past Delphi research also shows that attrition (Nworie, 2011) or non-response can be an issue (Hsu & Sandford, 2007), therefore it is often suggested that the researcher take steps to keep Delphi experts engaged at each stage of the process (Rowe & Wright, 2011). In this study, the experts were kept engaged through frequent and personalized email communication as well as a website (http://wp.towson.edu/aparrish/) that was used to provide background on the research, updates on the progress of the research, and upcoming deadlines. Clear and concise communication with the panelists was key to keeping them engaged. At each stage, the panelists were told how their responses affected the subsequent round and they were provided constructive feedback regarding their ongoing participation in achieving the research goal. Even with these efforts, there was a slight amount of attrition within this study.

Data Collection

Data for this study was collected through the dissemination of three online surveys (rounds) that were emailed to each of the Delphi panelists. Each of the surveys were created using Campus Labs, an online survey design tool available through the university. Approximately six weeks of implementation time was estimated for each Delphi round, which included two weeks for the panelists' completion of the survey, two weeks for data analysis by the researcher, and an additional two weeks for the researcher to summarize any controlled feedback and redistribute these results to begin the next round. When participants requested additional time to complete the survey, this was provided. This timeline is consistent with other Delphi research, including the two-week survey completion discussed in Scott et al. (2006) and Na's (2006) dissertation Delphi research which allowed approximately one month per round. This timeline was selected for the study because wider gaps between rounds have been shown to increase levels of attrition among Delphi panelists (Day & Bobeva, 2005).

Instrumentation

Round One survey development. Content for the initial survey instrument was developed based on a comprehensive review of relevant literature and professional standards. While a review of the research was done prior to the study to develop an impetus for the work, the researcher reviewed the literature again with the specific intent of identifying competencies that research findings suggested were necessary in one-to-one classrooms. Past Delphi instruments have also included lists of items that have been generated based on a review of literature (Kleynen et al, 2013; Mengual-Andres et al., 2016) as well as items that were identified through the use of professional standards (Mengual-Andres et al., 2016). Due to the nature of one-to-one technology research, this review included research studies, as well as relevant white papers, technology reports, and professional teacher standards, including the newly revised ISTE standards for educators (ISTE, 2017). Literature which discussed both teacher competencies and technology integration was an essential part of this review process. For example, Oliver (2010) discussed the new demands placed on teachers in the one-to-one computing environment and how these skills coincide with the ISTE standards for teachers. Within the study, which identifies the readiness of teachers in seven high schools, Oliver outlined each of the standards and the implications of these to ubiquitous computing environments (2010). Oliver's study served as an ideal starting point for developing a draft list of skills which were formulated into survey items and disseminated to the experts in Round One.

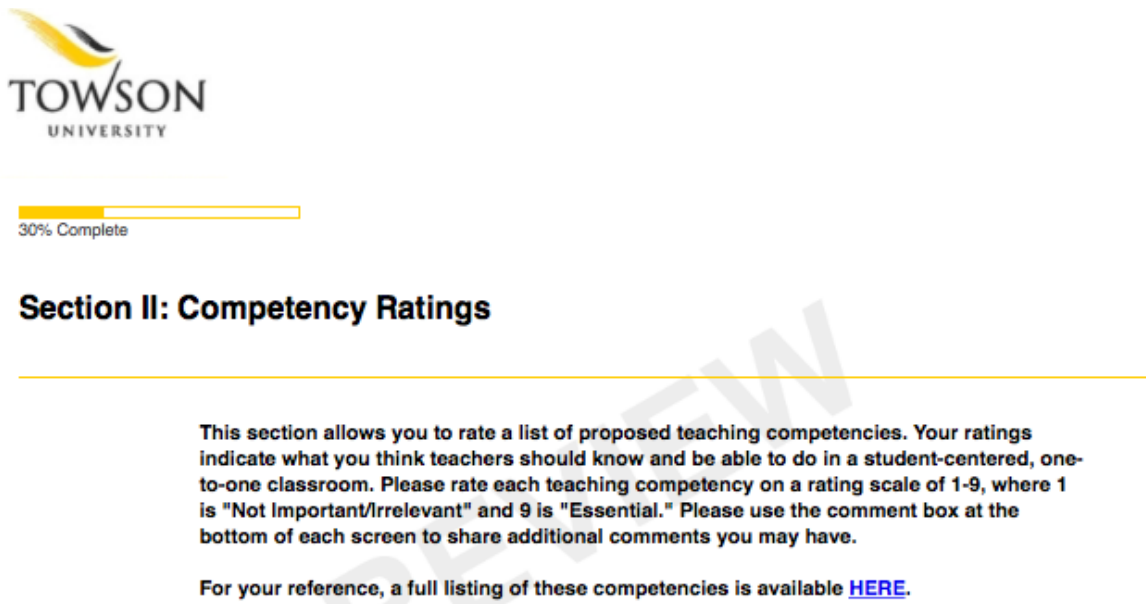
An initial item matrix displaying the references used in the literature review is provided in Appendix B. This matrix shows how each of the proposed competencies can be traced back to the original sources. The researcher began by highlighting findings from research studies or teaching skills listed within the professional standards and other reports that were relevant to teaching in the one-to-one classroom. When reviewing these materials, the researcher used a reasoning process by considering the following question: *What do teachers need to know and be able to do based on what has been examined in one-to-one classrooms?* While some Delphi studies begin with open-ended questions which are eventually shaped into a list of key items, it is not uncommon for researchers to modify this format by provided more structured items (Hsu & Sandford, 2007). In fact, Hsu and Sandford (2007) suggest that using a structured survey in Round One holds distinct advantages, including: (a) less time spent between rounds to develop the next iteration of the survey, (b) a decreased dropout rate among panelists who may not have been willing to complete multiple, open-ended responses, (c) the assurance that important statements based on literature can be included by the researcher, and (d) instrument design that has been generally shown to resonate the purpose of the study more clearly with respondents.

In order to organize these research findings based on a framework commonly used in the field, the researcher used several of the domains by Danielson (2007) to guide the categorization process. Danielson's Framework for Teaching (Danielson, 2007) was used because it has been adopted as the framework for teacher evaluation in many schools and districts nationwide. It is also an ideal choice because many practitioners are familiar with both its categorization of teaching competencies and vocabulary. Initially, the item matrix guided the categorization of research findings using the following domains: planning and preparation, instructional delivery, and classroom management. An additional technology-related skills category was added based on themes in the one-to-one literature that did not fit within the first three domains. Of all the research that was reviewed, findings from qualitative studies were the most useful in gleaning proposed competencies. Specifically, the literature that discussed barriers in one-to-one implementation was used to identify competencies that teachers would need in order to address these potential issues in the classroom. For example, teachers may need to solve problems related to hardware or software in the classroom or they may need to seek resources to solve a problem that they could not fix on their own (Donovan et al., 2010). In this way, much of the qualitative one-to-one literature grounded the initial list of competencies that was disseminated to the expert panel.

The first round consisted of 33 original items translated into a structured survey that asked panelists to review each proposed competency and rate its importance. A link to the online survey was emailed to each panelist and the instructions were provided in both text and video format. The use of video to explain the instructions was provided as an additional way for the researcher to connect with the participants and these multiple instruction formats incorporated elements of Universal Design for Learning (UDL).

The Round One survey included three sections: (1) *Background Information*, which collected basic demographic information about the panelists, including their amount of experience with one-to-one computing, (2) *Proposed Competency Ratings*, where panelists ranked the importance of each competency, and (3) *Additional Comments*, which was optional. The first screen of the online survey also included the *Informed Consent Form* which all participants signed electronically. A complete copy of the Institutional Review Board (IRB) approval and corresponding Informed Consent Form are included as Appendices C and D.

The 33 items that made up the initial list of competencies were shown in groups of four to six at a time to help panelists more easily digest the information. The survey also featured a pop-up window which allowed the panelist to view the full list of proposed competencies at once. Figure 3 provides a screenshot showing how instructions were provided at the beginning of section two and how panelists could access the full list of proposed competencies.


TOWSON UNIVERSITY

30% Complete

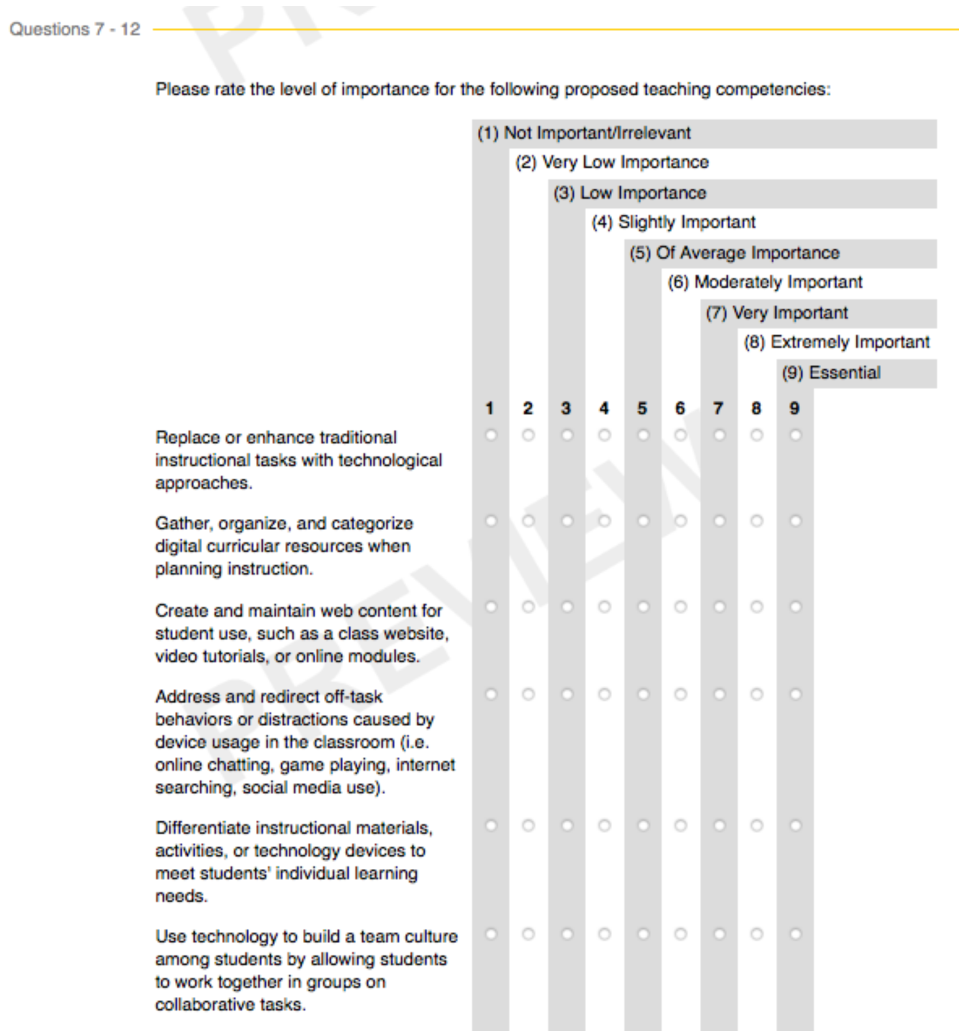
Section II: Competency Ratings

This section allows you to rate a list of proposed teaching competencies. Your ratings indicate what you think teachers should know and be able to do in a student-centered, one-to-one classroom. Please rate each teaching competency on a rating scale of 1-9, where 1 is "Not Important/Irrelevant" and 9 is "Essential." Please use the comment box at the bottom of each screen to share additional comments you may have.

For your reference, a full listing of these competencies is available HERE.

Figure 3. Screenshot of instructions and link to the list of proposed competencies in Round One.

In section two of the Round One survey, panelists viewed and rated the competencies using a nine-point Likert scale where nine was “Essential” and one was “Not Important/Irrelevant.” Figure 4 provides a screenshot of the first group of proposed competencies that panelists saw in Round One. At the bottom of each screen panelists were provided with an optional space to explain their ratings. While the full version of the Delphi survey is included in Appendix E these screenshots have been provided to show exactly what the panelist encountered when they completed the survey online. In the third section of the Round One survey panelists recommended new teaching competencies that they believed should be included but were not represented in earlier sections of the survey.



Questions 7 - 12

Please rate the level of importance for the following proposed teaching competencies:

(1) Not Important/Irrelevant
(2) Very Low Importance
(3) Low Importance
(4) Slightly Important
(5) Of Average Importance
(6) Moderately Important
(7) Very Important
(8) Extremely Important
(9) Essential

	1	2	3	4	5	6	7	8	9
Replace or enhance traditional instructional tasks with technological approaches.	○	○	○	○	○	○	○	○	○
Gather, organize, and categorize digital curricular resources when planning instruction.	○	○	○	○	○	○	○	○	○
Create and maintain web content for student use, such as a class website, video tutorials, or online modules.	○	○	○	○	○	○	○	○	○
Address and redirect off-task behaviors or distractions caused by device usage in the classroom (i.e. online chatting, game playing, internet searching, social media use).	○	○	○	○	○	○	○	○	○
Differentiate instructional materials, activities, or technology devices to meet students' individual learning needs.	○	○	○	○	○	○	○	○	○
Use technology to build a team culture among students by allowing students to work together in groups on collaborative tasks.	○	○	○	○	○	○	○	○	○

Figure 4. Screenshot of competency ratings in Round One.

Round Two survey development. The survey distributed to panelists in Round Two was a direct result of the analysis of experts' responses in Round One. While the analysis section of this chapter will outline the statistical tests used to analyze the data, this section will describe how the items and instrument for the Round Two survey were developed. Following participants' completion of the Round One survey, the results were exported from Campus Labs into SPSS for analysis so that descriptive statistics could be calculated. Using the Rand UCLA Appropriateness Method (Fitch et al., 2001) to determine consensus, those items which met the criteria for consensus could be viewed in the Round Two survey but panelists were not able to rate these competencies again as they had already been determined to be statistically appropriate for inclusion in the inventory. Items which were shown statistically to be "equivocal" and did not meet the criteria for consensus were presented to panelists in Round Two to be re-rated using the same nine-point Likert scale used in Round One.

The teaching competencies added by the panelists in Round One were qualitatively coded using an open coding process (Creswell, 2013). First, these comments were reviewed to determine which information included additional teaching competencies and which were related to the individual's personal experience with one-to-one technology. Those which were directly related to teaching competencies were identified and coded using a three-tiered system: (1) priority – comments or suggested competencies that needed to be dealt with first as they communicated the panelists' input about the content of the competencies, (2) lower importance items – comments that required the researcher to take more time to come back and review again to see if they lent themselves to revised or new competencies, and (3) information irrelevant to the research question. An example of an item in the last tier might include a panelist sharing a story about his or her experience or a general comment about the necessity of the research, both of which do not relate to the development of teaching competencies. After categorizing the data into these three areas, the researcher used an inductive process and after several rounds of coding was able to color code the recommended competencies into one of six sub-categories. Further grouping (to make certain that overlap had not occurred) yielded ten new competencies to be rated by panelists in Round Two and revisions to six of the initial competencies proposed in Round One.

Using these approaches, the researcher developed a survey for Round Two which included 16 competencies for the panelists to rate. The instrument followed the same format and distribution process. Once again, the instrument included text and video instructions and panelists were given two weeks to respond. This time, however, panelists did not have the opportunity to propose new competencies, but they were provided an optional space to clarify their rationale for ratings. A copy of the entire Round Two survey is provided in Appendix F.

One of the key defining features of Delphi methodology is providing controlled feedback to panelists in the study (van Zolingen & Klaassen, 2003). This an important part of the Delphi process because it allows a way to show an individual how his or her responses compares with the group's responses and it may offer a way of helping the members of a panel achieve consensus on an issue without putting any undue pressure on any one person (Linstone & Turoff, 1975). In this study, the researcher provided controlled feedback to panelists in Rounds Two and Three by showing them a customized box and whisker plot for any items which met the criteria for re-rating, following the Rand UCLA Appropriateness Method (Fitch et al., 2001). Each panelist received an individualized email with an attachment which showed them how their response compared to others. An example of the display used to provide controlled feedback in Round Two is displayed in Figure 5. For a full version of the feedback provided to panelists in Round Two, including the text which accompanied this box and whisker plot, see Appendix G.

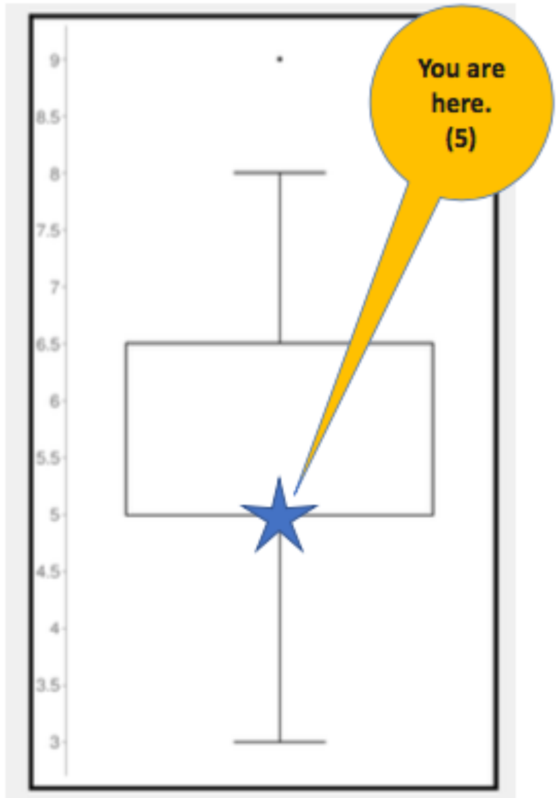


Figure 5. Example of box and whisker plot with controlled feedback from Round Two.

Round Three survey development. The last of the three surveys was developed using similar processes from Rounds One and Two, as the development of items was a direct result of the analysis of experts' responses in the previous round. Following participants' completion of the Round Two survey, the results were exported from Campus Labs into SPSS for analysis so that descriptive statistics could be calculated. Using the same method to determine consensus as in Round Two, those items which met the criteria for consensus were provided for viewing in the Round Three survey, but panelists were not asked to rate these competencies again as they had already been determined to be statistically appropriate for inclusion in the inventory. Items calculated as "equivocal" did not meet the criteria for consensus and were presented again for panelists to re-rate in Round Three. Dissemination of the Round Three survey again included controlled feedback which was provided in a similar format as Round Two, but this time with multiple items shown on a page. This change in display was directly related to the increased number of items that were ranked as equivocal. Figure 6 shows an example of the customized data display of box and whisker plots shared with each panelist. In addition, a complete template of the controlled feedback form used in Round Three is included in Appendix H.

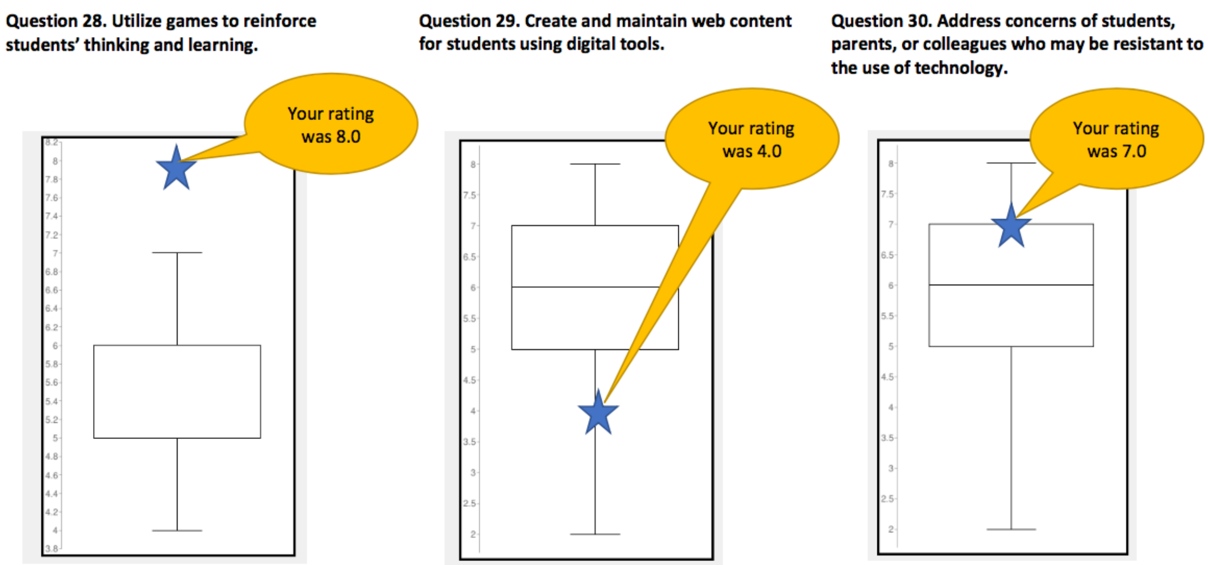


Figure 6. Example of box and whisker plots with controlled feedback from Round Three.

Using these procedures, the researcher developed the Round Three survey which included 27 competencies. After re-rating five remaining competencies from Round Two to determine consensus, panelists were this time asked to compare the competencies and rank them. The purpose for ranking the competencies was to provide a basis for ordering the final results. Mean ranking scores could therefore be used to present the items, rather than listing them arbitrarily. Ranking more than 20 competencies would be far too complex a task, therefore the researcher grouped the teaching competencies into categories. This also allowed for the panelists to view sets of ideas that shared a similar theme and offer rankings accordingly. The researcher used the Danielson Framework for Teaching (Danielson, 2007) as a guide in labeling the categories. As in previous rounds, panelists were also provided with an optional area to provide a rationale for their responses. Panelists had two weeks to complete this final survey and additional time was provided for a few participants who requested this. A copy of the survey developed for Round Three is provided in Appendix I.

Data Analysis

The analysis of data in this study has two primary purposes: (1) to calculate results that can be used to provide controlled feedback to the participants after each round, and (2) to determine whether the criteria for consensus on each item had been met (Na, 2006). Nworie (2011) indicates that Delphi researchers "define consensus and the criteria for determining when consensus has been achieved [. . .] based on the purpose of their study, the number of panelists, and duration of the study" (p. 26). This section will detail the various components of data analysis in this study.

Consensus building. The skills needed by classroom teachers to facilitate student-centered, one-to-one learning environments were assembled based on the experts' ratings of each competency that is listed within each survey. The Rand UCLA Appropriateness Method was used to determine consensus. Panelists' ratings were tabulated to determine: (a) the median score, (b) the interquartile range (IQR), or the middle 50% of the data set, and (c) the mean score. Median scores were used to determine appropriateness level; a summary of the consensus definition parameters is outlined in Table 1.

Table 1

Consensus Definition

Consensus	Parameters
Appropriate (A)	Median ≥ 7.0
Equivocal (E)	Median 4.0 – 6.9
Inappropriate (I)	Median ≤ 4.0

Items identified as equivocal were open for additional rating, those skills with an "inappropriate" rating were excluded from future rounds, and those categorized as appropriate were included in the final resulting inventory. In subsequent rounds, panelists were shown the group median, mean, and interquartile range as well as their own individual rating for that item. This is in alignment with Dalkey's (1967) recommendation to share more than just the mean score with panelists. Instructions on surveys advised experts that they could keep their initial rating or change it.

Statistical analysis of consensus data. The primary form of statistical analysis used to determine consensus was the Rand UCLA Appropriateness Method (Fitch et al., 2001). While this method was well suited for determining immediate consensus during the data collection phases of the study, there are methodologists who have criticized Delphi studies which do not include more sophisticated forms of analysis (i.e. Dajani et al., 1979; Habibi, Sarafrazi, & Izadyar, 2014; Kalaian & Kasmin, 2012; Schmidt, 1997). For example, Kalaian and Kasmin (2012) recommend that a best practice in Delphi research is to conduct multiple statistical analyses to gain insight into the panelists' responses. They do not promote relying solely on one method. Therefore, after the conclusion of the Delphi rounds, the researcher calculated the Coefficient of Concordance (or Kendall's W) for the Round Three ranking data and analyzed the results using guidelines provided by Schmidt (1997). This additional analysis provides an in-depth examination as to the levels of agreement. These results are presented and discussed further in Chapter Four.

Pilot Study

Prior to the study, a small-scale pilot of the survey instrument was conducted with three subject-matter experts. Tigelaar et al. (2004) found a similar approach useful when piloting a Delphi survey that was being distributed to approximately 75 experts in order to develop a framework of teaching competencies for faculty in higher education. Tigelaar et al. (2004) utilized three subject matter experts to provide feedback on the overall clarity of individual items to avoid any misconceptions or unambiguous wording. The experts participating in this pilot were individuals with experience in technology integration, survey research, teaching and learning. After a brief description of the purpose of the study and Delphi methodology, these experts were asked to provide feedback on the instrument's design, instructions, organization, and presentation. Pilot study participants were given a two-week deadline to provide feedback.

Results from the feedback from the pilot study participants produced a series of changes to be made to the initial survey instrument. These revisions included (a) the addition of a pop-up window showing the full list of proposed teaching competencies, (b) presenting four to six teaching competencies per screen, (c) re-wording of specific items for clarity, and (d) revising an item in the demographics section to allow participants to select more than one professional role.

Validity

Validity is the extent to which a given instrument or study measures "what it is intended to measure" (Gay, Mills, & Airasian, 2009). According to Gay et al. (2009), validity can best be determined by those with expert judgment in a topic. Thus, this research design exhibits high validity, given the thorough identification of subject matter experts who determined the competencies that would be represented in this inventory. The experts' opportunity to evaluate the competencies by rating them and then further refining them strengthens the validity of this study. Undue pressure on experts to reach consensus could have posed a threat to this validity, but this was prevented by ensuring anonymity between participants and the use of systematic procedures for controlled feedback to participants based solely on statistical analysis. Further, the heterogeneity of participants collected in this study helps to ensure the validity of these results, thus diminishing the "bandwagon effect" that may occur when all participants are accustomed to serving in a similar role and provide a potentially limited set of perspectives (Linstone & Turoff, 1975, p. 4).

Reliability

The purpose of this study was not to forecast results, but to determine competencies for one-to-one classrooms based on the opinions of this panel of experts. That may lead those with limited knowledge in Delphi methodology to assume limited replicability potential. However, the rigorous design features of this Delphi study are supported by past research which indicates the opposite. Tests of reliability, through deliberate attempts to reproduce results in previous Delphi panels using the Rand UCLA Appropriateness Method have been shown to be the highest when the expert panel includes participants from a variety of professional roles (Fitch et al., 2001). The Rand UCLA Appropriateness Method, coupled with the development of a diverse panel established through a vetted sampling technique, marries these approaches to strengthen reliability. The appropriateness criteria, as described by Fitch et al. (2001), is considered merely as a starting point for determining replicability. The power of this research design lies in combining the appropriate consensus technique along with a well-designed panel.

Summary

This study employed Delphi methodology to identify an inventory of teaching competencies needed to facilitate instruction in student-centered, one-to-one learning environments. The Delphi method was identified as the most appropriate methodology because it helps to address complex issues related to the integration of one-to-one technology and it solves logistical issues of attempting to gain consensus amongst a heterogeneous group of subject matter experts. The study was conducted by using a Delphi sampling procedure to assemble a national panel of experts in one-to-one technology who used their experience to select the competencies that they believed teachers need to teach in these learning environments. Data was collected through three rounds of online surveys and data analysis procedures included use of the Rand UCLA Appropriateness Method to determine consensus for individual inventory items. Each of the research design decisions was grounded in past Delphi literature and adjusted as appropriate to fit the purpose and scope of this research.

CHAPTER IV. RESULTS

The study sought to develop an inventory of teaching competencies needed to facilitate instruction in student-centered, one-to-one learning environments. This was achieved through the Delphi Method, wherein a national panel of subject matter experts were assembled to develop consensus about which teaching competencies are the most conducive to effective instruction in one-to-one classrooms.

The purpose of this chapter is to present the results of the three Delphi rounds that were conducted for this study. These results include both quantitative and qualitative data collected through each of the online surveys, beginning with the panel's review of proposed competencies presented in Round One. A description of how the list of competencies was refined throughout all rounds is presented in detail. This chapter consists of the following sections: Description of the Respondents, Round One, Round Two, Round Three, Results, and Summary.

Description of Respondents

The results in this study were determined based on the opinions and recommendations shared by a panel of researchers and practitioners with expert knowledge of one-to-one computing. Overall, there were 33 experts who participated in Round One, 31 of these who continued in Round Two, and 27 who completed all three of the Delphi rounds. The initial group of respondents who participated in Round One included ten K-12 teachers, ten individuals responsible for technology support in their school, two school-based administrators, six district-level administrators, 11 educational researchers, and six who served in another role (i.e. Library Media Specialist, Professional Development Consultant, Department Chair, or Director). Several panelists served in multiple roles related to one-to-one computing, such as a school-based administrator who had also conducted research on technology integration. Figure 7 shows the various roles of the panelists, as identified by the demographic information they provided in Round One.

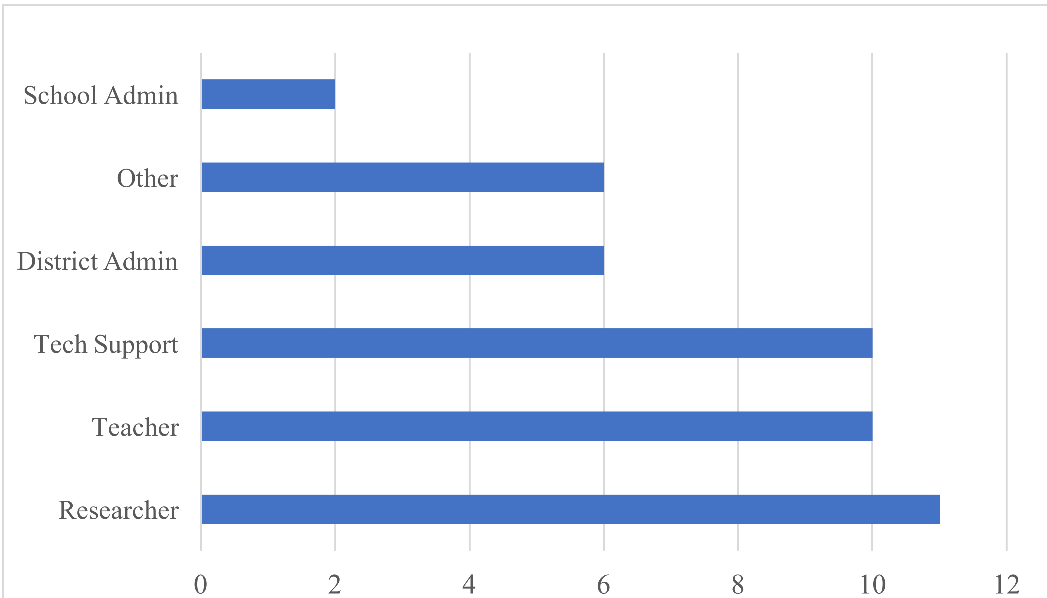


Figure 7. Professional roles of the panelists.

Overall, the panel was made up of an experienced group of professionals, with most of them indicating more than five years of experience in their current professional role. Figure 8 shows the experience of the panelists. This panel was made up of experts from twelve states across the United States. Figure 9 shows the home states of the experts in yellow. In this study, the goal was to develop a heterogeneous group of experts, representing varying sets of perspectives from a variety of schools and districts. The diversity of this sample reflects the positive results associated with that effort.

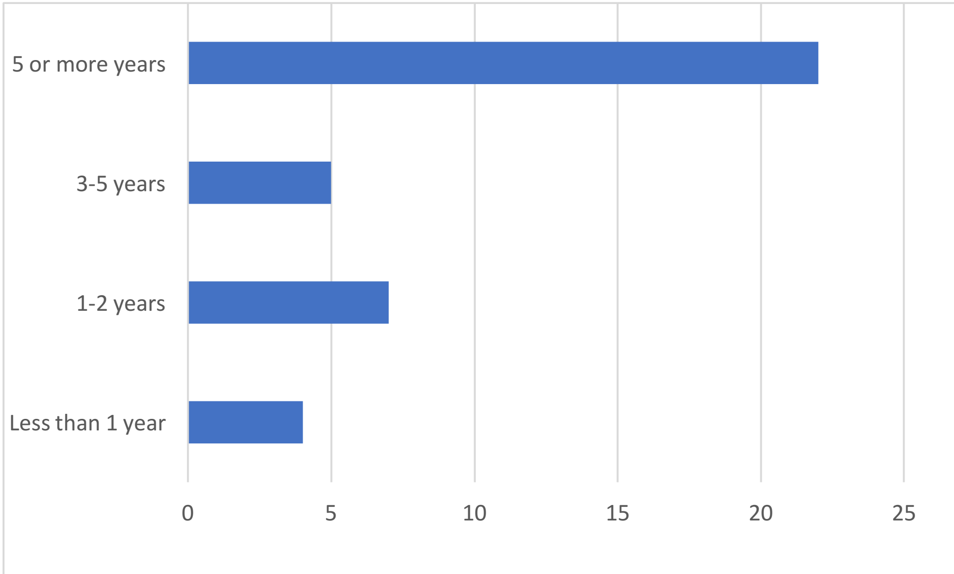


Figure 8. Years of experience of the panelists.

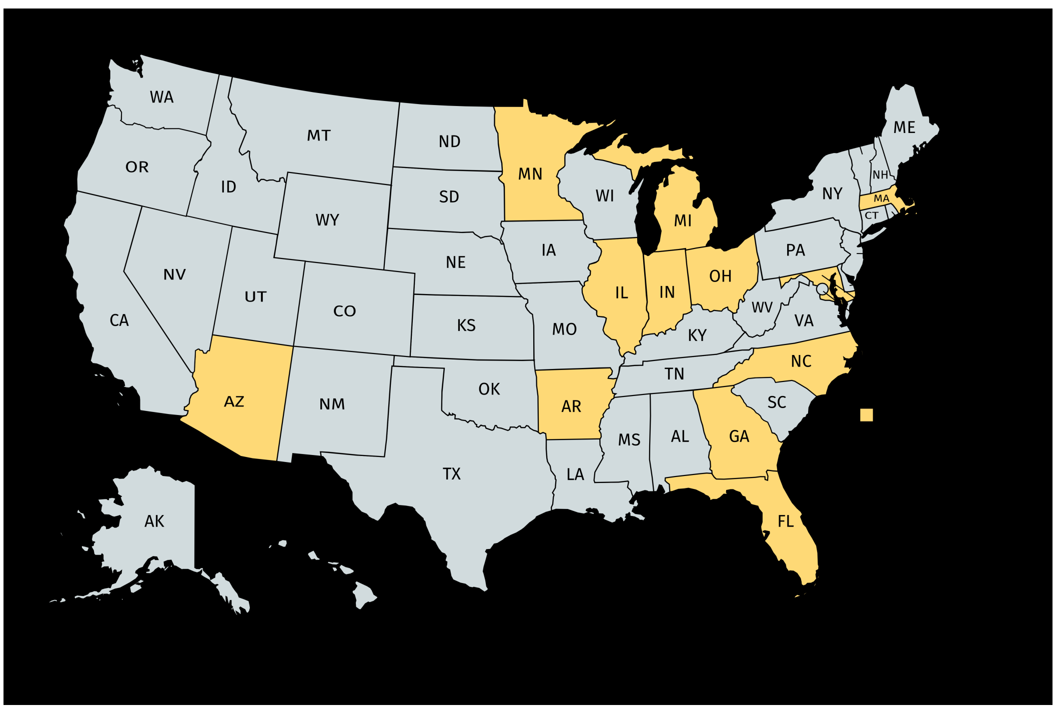


Figure 9. Home states of the panelists.

Data Collection and Analysis Timeline

This Delphi study was completed over a span of approximately eight months, not including the initial review of literature. The three rounds of data collection and accompanying analysis took place over the span of approximately six months, from January through June 2017. Figure 10 provides a timeline of the various stages of the study, beginning with the selection process and culminating with the development of the final inventory.

Round One

The initial online survey distributed in Round One included a list of 33 proposed competencies that were developed based on an in-depth review of one-to-one peer-reviewed research, government reports, white papers, and professional teaching standards. A complete version of the Round One survey is included as Appendix E. The online survey was originally distributed via email to 37 identified experts, 33 of whom responded within the two-week deadline. In this round, panelists were asked to complete the informed consent documentation, provide basic demographic information, and rate the importance of each of the 33 proposed teaching competencies using a nine-point Likert scale (where 1=Not Important/Irrelevant and 9=Essential). In addition, panelists were invited to propose additional competencies that they believe should be included.

The Rand UCLA Appropriateness Method for consensus (Fitch et al., 2001) was utilized to determine whether group consensus had been reached on each teaching competency. Panelists' responses to each item were tabulated to determine: (a) the median score, (b) the interquartile range, and (c) the mean score. Items with a median

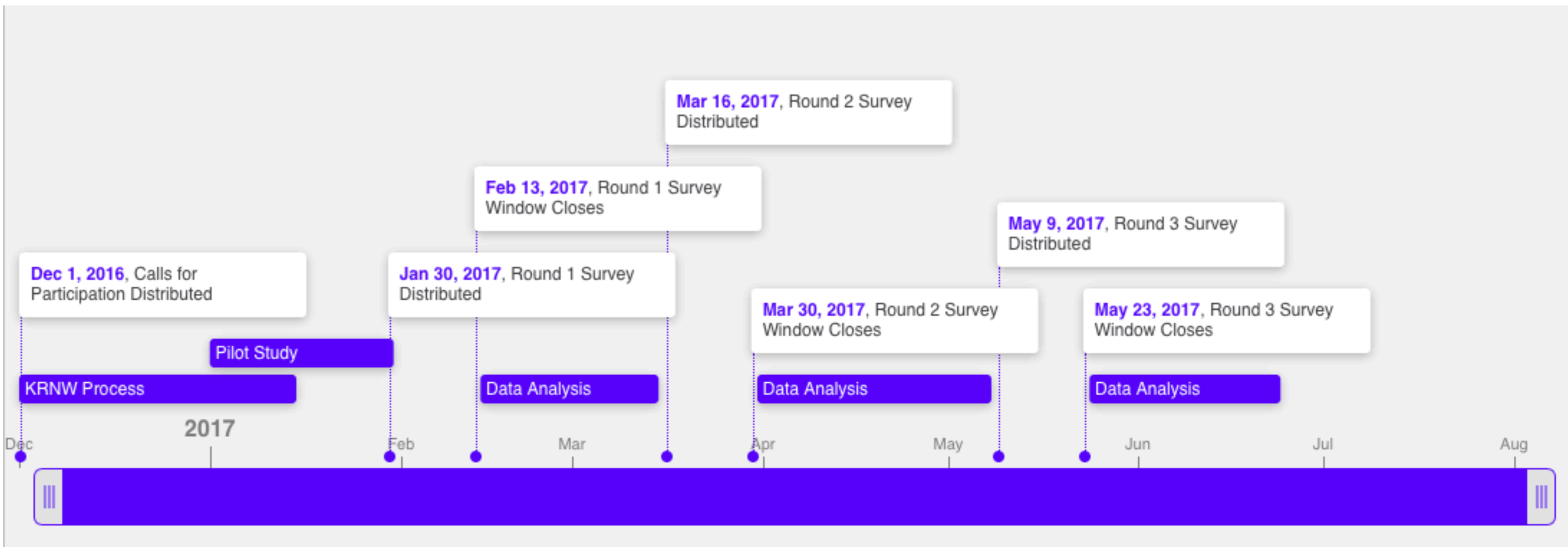


Figure 10. Timeline of study.

score of one through three were categorized as inappropriate, scores four through six were considered equivocal, and those items with a median score between seven and nine were considered appropriate competencies to include (Fitch et al., 2001). Table 2 shows the Round One consensus results; the mean, median, and standard deviation for each item; and the disaggregated frequency data organized by the categories delineated in the Rand UCLA Appropriateness Method.

Table 2

Round One Consensus Results

Proposed teaching competency	Mean	Median	Standard deviation	Disaggregated frequency data	Consensus decision
Replace or enhance traditional instructional tasks with technological approaches.	6.88	7.0	1.93	I (*n*= *3*) E (*n*=*9*) A (*n*=*21*)	Appropriate
Gather, organize, and categorize digital curricular resources when planning instruction.	7.03	7.0	1.61	I (*n*=*1)* E (*n*=*10*) A (*n*=*22*)	Appropriate
Create and maintain web content for student use, such as a class website, video tutorials, or online modules.	6.85	7.0	1.35	I (*n*=*0)* E (*n*=*13*) A (*n*=*20*)	Appropriate
Address and redirect off-task behaviors or distractions caused by device usage in the classroom (i.e. online chatting, game playing, internet searching, social media use).	7.0	7.0	1.90	I (*n*=*1)* E (*n*=*10*) A (*n*=*22*)	Appropriate
Differentiate instructional materials, activities, or technology devices to	8.36	9.0	0.99	I (*n*=*0)* E (*n*=*3*) A (*n*=*30*)	Appropriate

Proposed teaching competency	Mean	Median	Standard deviation	Disaggregated frequency data	Consensus decision
meet students' individual learning needs.					
Use technology to build a team culture among students by allowing students to work together in groups on collaborative tasks.	7.76	8.0	1.23	I (*n=0)* E (*n=7*) A (*n=26*)	Appropriate
Utilize peer expertise to complete collaborative projects during instruction.	6.91	7.0	1.16	I (*n=0)* E (*n=10*) A (*n=23*)	Appropriate
Encourage student reflection through the use of collaborative digital tools during instruction.	7.18	7.0	1.26	I (*n=0)* E (*n=10*) A (*n=23*)	Appropriate
Design instruction which allows students to use technology for independent inquiry that is based on student-selected topics or interests.	7.52	8.0	1.15	I (*n=0)* E (*n=8*) A (*n=25*)	Appropriate
Support students' ability to self-regulate during the learning process by teaching goal-setting, self-monitoring, and/or allowing students to work at their own pace.	7.61	8.0	1.41	I (*n=0)* E (*n=8*) A (*n=25*)	Appropriate
Design instruction which allows students a degree of choice in how they will respond in an activity or how they will be assessed in the learning process.	7.88	8.0	1.36	I (*n=0)* E (*n=5*) A (*n=28*)	Appropriate
Design instruction that allows students to use digital and non-digital	8.18	8.5	1.01	I (*n=0)* E (*n=2*) A (*n=31*)	Appropriate

Proposed teaching competency	Mean	Median	Standard deviation	Disaggregated frequency data	Consensus decision
tools to solve real world problems.					
Utilize games to reinforce students' thinking and learning.	5.52	5.0	1.35	I (*n=2)* E (*n=24*) A (*n=7*)	Equivocal
Encourage students to publish or act on their new knowledge by using a variety of media.	7.12	7.0	1.05	I (*n=0)* E (*n=10*) A (*n=23*)	Appropriate
Provide an academic environment that is intellectually challenging.	8.21	9.0	0.99	I (*n=0)* E (*n=2*) A (*n=31*)	Appropriate
Exercise flexibility during instruction by improvising to meet students' learning needs (i.e. extend the amount of time provided, offer additional resources, offer modeling and scaffolding).	8.36	9.0	1.06	I (*n=0)* E (*n=3*) A (*n=30*)	Appropriate
Adjust and respond to novel information or ideas that students share.	7.48	8.0	1.33	I (*n=0)* E (*n=8*) A (*n=25*)	Appropriate
Capitalize on teachable moments by supporting student inquiry.	7.73	8.0	1.10	I (*n=0)* E (*n=4*) A (*n=29*)	Appropriate
Employ a variety of formative and summative assessment techniques using digital means.	7.30	7.0	1.05	I (*n=0)* E (*n=9*) A (*n=24*)	Appropriate
Develop, teach and implement expectations and routines for device management in the classroom (i.e. how to prevent breakage, when to charge, what to do if a	7.42	8.0	1.84	I (*n=2)* E (*n=7*) A (*n=24*)	Appropriate

Proposed teaching competency	Mean	Median	Standard deviation	Disaggregated frequency data	Consensus decision
device is broken/lost, etc.).					
Anticipate potential problems that might occur during instruction and have a back-up plan in the event that technology fails.	7.73	8.0	1.51	I (*n=0*) E (*n=7*) A (*n=26*)	Appropriate
Utilize students' expertise, personal expertise, and support personnel outside of the classroom to ensure that technical issues do not interfere with teaching and learning.	7.45	7.0	1.30	I (*n=0*) E (*n=9*) A (*n=24*)	Appropriate
Engage students, parents, or colleagues who may be resistant to the use of technology by providing information about effective technology integration.	7.12	7.0	1.43	I (*n=0*) E (*n=11*) A (*n=22*)	Appropriate
Engineer the classroom environment to support student-centered learning activities (i.e. allow space for collaboration).	8.03	8.0	1.02	I (*n=0*) E (*n=3*) A (*n=30*)	Appropriate
Monitor students' use of technology in the classroom in order to determine safe and appropriate utilization of online tools.	7.67	8.0	1.67	I (*n=1*) E (*n=5*) A (*n=27*)	Appropriate
Manage environmental factors that can be inherent with student-centered approaches to instruction, such as increased noise level,	6.79	7.0	1.67	I (*n=2*) E (*n=10*) A (*n=21*)	Appropriate

Proposed teaching competency	Mean	Median	Standard deviation	Disaggregated frequency data	Consensus decision
materials, clutter, or movement.					
Pursue and accept professional development opportunities to gain technological, pedagogical, and content-based knowledge.	8.0	8.0	1.09	I (*n=0)* E (*n=3*) A (*n=30*)	Appropriate
Apply recommendations or resources shared by mentors, coaches, colleagues, or other professional development opportunities.	7.42	7.0	1.00	I (*n=0)* E (*n=5*) A (*n=28*)	Appropriate
Set goals related to personal growth in technology integration.	7.64	8.0	1.14	I (*n=0)* E (*n=6*) A (*n=27*)	Appropriate
Demonstrate proficiency in the technology platform(s) adopted by the school and/or district.	7.33	7.0	1.31	I (*n=0)* E (*n=5*) A (*n=28*)	Appropriate
Seek opportunities to provide informal support, modeling, mentoring, or coaching to fellow colleagues.	6.67	7.0	1.31	I (*n=0)* E (*n=12*) A (*n=21*)	Appropriate
Engage in reflection and inquiry with colleagues and/or administrators about effective teaching practices.	7.76	8.0	1.20	I (*n=0)* E (*n=5*) A (*n=28*)	Appropriate
Communicate the vision for new or previously adopted initiatives with both internal and external stakeholders.	7.09	7.0	1.33	I (*n=0)* E (*n=9*) A (*n=24*)	Appropriate

Note. I = inappropriate (1-3); E = equivocal (4-6); A = appropriate (7-9); disaggregated frequency data n= 33.

The Round One consensus results indicated that the panelists rated one item as equivocal (game-based learning), and the remainder of the competencies as appropriate for the inventory. These initial statistical results showed early consensus among the panel.

Experts in Round One also recommended new teaching competencies based on their past experience with one-to-one computing. To analyze this qualitative data, the researcher utilized an analysis of themes approach (Creswell, 2013) to organize the panelists' recommendations into clusters of ideas. This process, completed by tagging and color coding ideas after multiple passes through the data, yielded five themes: classroom management, student choice, technical issues, professional development, and assessment. In the first four themes, panel experts mainly commented on the wording of individual items and suggested revisions. For example, one participant shared: "I'm a little confused by the wording of #1. Is this the teacher's ability to facilitate that interaction? To design that lesson?" Another participant remarked, "In regard to teacher proficiency in the technology platform, I would divide that into proficiency with the student device (i.e. iPads) which is very important . . ." Based on this type of feedback, the researcher revised the wording within five of the original teaching competencies and corrected a grammatical error within one item.

In addition to the wording revisions, the experts also made significant contributions to the final inventory by recommending additional competencies to consider. Using the analysis of themes approach (Creswell, 2013), the researcher synthesized the panel's recommendations into ten additional new competencies, most of which are reflective of topics discussed in the literature on one-to-one computing:

1. Demonstrate proficiency with the device students are using in the classroom.
2. Provide students with choices of digital and non-digital tools in the learning process.
3. Use evidence of student learning to customize instruction and plan targeted small group or individual instruction.
4. Teach and model digital citizenship in the classroom through online communication.
5. Identify and utilize mentors, coaches, colleagues, or other available experts who can support in the development of technology integration and pedagogical skills.
6. Demonstrate basic knowledge of copyright laws and help students identify key issues in this area.
7. Solve common technology issues with students' devices in the classroom (i.e. wireless Internet, device updates, blocked content, etc.).
8. Utilize knowledge of content and pedagogy when making decisions about the use of technology in teaching.
9. Involve parents in professional development related to technology use.
10. Utilize technology to provide personalized learning opportunities for students.

Round Two

The panel reached early consensus on most items in Round One and a second round was conducted primarily to solicit ratings on the experts' recommendations. Using both the quantitative and qualitative analyses from the previous round, the researcher developed a revised survey instrument that was distributed to panelists in the subsequent round. A full version of the Round Two survey is presented in Appendix F. The 33 original experts who participated in Round One were invited to complete the second round and 31 of them responded. Experts were asked to reevaluate items which had been revised and rate the new competencies that were added. The competencies that they designated as appropriate in Round One did not receive further consideration.

One item in the first round was rated as equivocal, indicating that the panel was undecided as to the importance of this competency. The researcher provided controlled feedback to support the panel in reaching consensus. Controlled feedback was used to inform the panelists how their responses compared with others, a methodological strategy discussed by van Zolingen and Klaassen (2003). Additionally, Linstone and Turoff (1975) suggest this type of feedback as a method for achieving consensus without applying any undue pressure to participants. The researcher provided feedback through a customized box and whisker plot which showed the expert's individual response, the median group score, and the interquartile range.

Table 3 displays the consensus results from Round Two, including descriptive statistics and disaggregated frequency data. Based on the median scores, no items were identified as inappropriate, five items were rated as equivocal, and ten items were identified as appropriate for the inventory. Since panelists could provide rationales for their ratings, these qualitative responses were organized into themes using an open-coding system (Creswell, 2013), and this data provided insight as to why the experts continued to rate many of the competencies between seven and nine. For example, one expert stated, "All of these items are growing in importance . . ." and then went on to explain how our conversion to a digital world has created different requirements of teachers.

Table 3

Round Two Consensus Results

Proposed teaching competency	Mean	Median	Standard deviation	Disaggregated frequency data	Consensus decision
Utilize games to reinforce students' thinking and learning.*	5.71	6	1.07	I (*n*= *0*) E (*n*=*24*) A (*n*=*7*)	Equivocal
Select the instructional tool (digital or non-digital) that best meets the intended learning outcome.**	7.87	8	1.09	I (*n*=*0)* E (*n*=*4*) A (*n*=*27*)	Appropriate
Create and maintain web content for students using digital tools.**	5.97	6	1.64	I (*n*=*3)* E (*n*=*15*) A (*n*=*13*)	Equivocal
Allow students to collaborate with peers on projects using digital and non-digital means.**	7.97	8	0.91	I (*n*=*0)* E (*n*=*1*) A (*n*=*30*)	Appropriate
Employ a variety of formative and summative assessment techniques using digital and non-digital means.**	7.97	8	1.05	I (*n*=*0)* E (*n*=*3*) A (*n*=*28*)	Appropriate
Address concerns of students, parents, or colleagues who may be resistant to the use of technology.**	6.65	6	1.47	I (*n*=*0)* E (*n*=*16*) A (*n*=*15*)	Equivocal
Demonstrate proficiency with the device students are using in the classroom.***	6.52	6	1.90	I (*n*=*3)* E (*n*=*13*) A (*n*=*15*)	Equivocal
Provide students with choices of digital and non-	7.29	7	1.47	I (*n*=*0)* E (*n*=*10*)	Appropriate

Proposed teaching competency	Mean	Median	Standard deviation	Disaggregated frequency data	Consensus decision
digital tools in the learning process.***				A (*n=21*)	
Use evidence of student learning to customize instruction and plan targeted small group or individual instruction.***	7.81	8	1.05	I (*n=0*) E (*n=4*) A (*n=27*)	Appropriate
Teach and model digital citizenship in the classroom through online communication.***	7.42	7	1.34	I (*n=0*) E (*n=6*) A (*n=25*)	Appropriate
Identify and utilize mentors, coaches, colleagues, or other available experts who can support in the development of technology integration and pedagogical skills.***	7.19	7	1.42	I (*n=0*) E (*n=9*) A (*n=22*)	Appropriate
Demonstrate basic knowledge of copyright laws and help students identify key issues in this area.***	6.61	7	1.45	I (*n=1*) E (*n=11*) A (*n=19*)	Appropriate
Solve common technology issues with students' devices in the classroom (i.e. wireless internet connectivity problems, device updates, blocked content, etc.).***	6.42	7	1.71	I (*n=2*) E (*n=11*) A (*n=18*)	Appropriate
Utilize knowledge of content and pedagogy when making decisions about the use of technology in teaching.***	7.87	8	1.09	I (*n=0*) E (*n=3*) A (*n=28*)	Appropriate

Proposed teaching competency	Mean	Median	Standard deviation	Disaggregated frequency data	Consensus decision
Involve parents in professional development related to technology use.***	5.52	5	1.69	I (*n=3*) E (*n=21*) A (*n=7*)	Equivocal
Utilize technology to provide personalized learning opportunities for students.***	7.42	5	1.43	I (*n=1*) E (*n=7*) A (*n=23*)	Equivocal

Note. * = equivocal item; ** = revised item; *** = new item; I = inappropriate (1-3); E = equivocal (4-6); A = appropriate (7-9); disaggregated frequency data n = 31.

Both the quantitative and qualitative data from Round Two showed that the panel valued a variety of competencies that were closely related to pedagogy, such as differentiation and planning small group instruction. The panel also identified items directly related to technology integration, such as modeling digital citizenship and using technology to personalize learning for students, to be highly important in the one-to-one classroom.

Round Three

The study was concluded with a final ranking round. In order to allow for ranking of ideas within categories, the researcher divided each of the remaining appropriate competencies into categories. As discussed in chapter three, the researcher followed the Danielson Framework for Teaching (Danielson, 2007) as a guide for developing these categories. The Round Three survey instrument presented five categories, including instructional planning; instructional delivery; assessment of learning; classroom management; and professionalism and leadership.

An analysis of the resulting competencies from Rounds One and Two showed redundancy across items. It was clear that the list could be streamlined by combining some ideas and that redundancies could be eliminated while still maintaining the integrity of the experts' recommendations. To address this, the researcher compared the working list of items to one another and made slight revisions to wording that would eliminate these redundancies. Table 4 shows each revision that was made to the inventory, including the specific wording and rationale for the change. These revisions resulted in the inventory being narrowed from 36 to 29 items.

Table 4

Revisions Made to Eliminate Redundancies in the Inventory

Original item deleted	Adaptation	Rationale
Design instruction that allows students to use digital and non-digital tools.	The words "digital and non-digital tools" were added to IP1. The words "digital and non-digital means" were added to A2 and A3.	The emphasis on selecting digital or non-digital tools could be added to existing competencies.
Utilize knowledge of content and pedagogy when making decisions about the use of technology in teaching.	This wording was added to the start of IP1: "Utilize the knowledge of content and pedagogy to . . ."	This competency directly overlapped another present in the list.
Utilize technology to provide personalized learning opportunities for students.	This competency was already reflected in IP2 ("Differentiate instructional materials, activities, or technology devices to meet students' individual learning needs") and IP3 ("allow individual inquiry that is based on student-selected topics, interests, or real-world problems).	Personalized learning may be accomplished through differentiation or by allowing for student-guided inquiry based on their preferences. These ideas were already identified in the existing teaching competencies.

Original item deleted	Adaptation	Rationale
Solve common technology issues with student devices in the classroom.	This teaching competency was already reflected in IP6 (“anticipating technology problems”), in ID7 (“Demonstrate proficiency with the device”), and in CM3 (“what to do if the device is broken”).	This competency refers to the teacher’s ability to solve technical problems with the technology and it was already addressed in the existing competencies.
Encourage student reflection through the use of collaborative digital tools during instruction.	This teaching competency was already reflected in A3 (“Include student reflection opportunities as part of the assessment process using digital and non-digital means.”)	Student reflection was already discussed in another teaching competency.
Allow students to collaborate with peers on projects using digital and non-digital means.	This competency was reflected in IP3, which refers to designing instruction based on real world problems. ID4 addressed collaboration (“Use technology as a means for building collaborative skills between students.”). There was also a reference in IP3 to the independent inquiry students may conduct when completing projects.	There were several existing teaching competencies that included students working collaboratively to solve problems or to create projects based on real world issues.
Provide students with choices of digital and non-digital tools in the learning process.	This competency was added as an example within ID1 (“i.e. offer choices in digital tools”).	Offering choices of tools to students is an example of flexible instruction, so this was added to an existing teaching competency.

Note. IP = instructional planning; ID = instructional delivery; A = assessment of learning; CM = classroom.

The 31 panelists who had participated in the first two rounds were invited to complete the Round Three survey (a full copy of the instrument appears in Appendix I). Of panelists from Round Two, 27 participated. To address the five equivocal items from the previous round, panelists were provided controlled feedback, this time through an array of box and whisker plots with group and individual data. Table 5 shows the Round Three consensus results as well as the descriptive statistics and frequency data by item. Analysis of the Round Three median scores indicated that the panelists were not able to come to consensus on four out of five of these competencies. The panel was able to reach consensus on the competency which stated that teachers should “demonstrate proficiency with the device students are using.” Therefore, this competency was included as the final item in the Instructional Delivery category, but did not include ranking data.

Ranking data. Using SPSS, the panelists’ rankings in Round Three were analyzed by calculating the mean score for each competency and the range of means for each category. For most categories there were not any specific competencies that emerged as significantly more important than others in the group. Table 6 shows the mean scores of the ranked data by category, organized as the items appeared in the Round Three survey. To create the final inventory the competencies in each category were listed in ascending order based on the mean score. Appendix J shows a more in-depth examination of the information provided in Table 6 with the means and complete survey item displayed together.

Table 5

Round Three Consensus Results

Proposed teaching competency	Mean	Median	Standard deviation	Disaggregated frequency data	Consensus decision
Utilize games to reinforce students' thinking and learning.	4.92	5	1.47	I (*n*= 5) E (*n*=18) A (*n*=3)	Equivocal
Create and maintain web content for students using digital tools.	5.81	6	1.36	I (*n*=1) E (*n*=18) A (*n*=7)	Equivocal
Address concerns of students, parents, or colleagues who may be resistant to the use of technology.	6.19	6.5	1.81	I (*n*=2) E (*n*=11) A (*n*=13)	Equivocal
Demonstrate proficiency with the device students are using in the classroom.	6.88	7	1.4	I (*n*=1) E (*n*=7) A (*n*=18)	Appropriate
Involve parents in professional development related to technology use.	4.92	5	1.74	I (*n*=7) E (*n*=14) A (*n*=5)	Equivocal

Note. I = inappropriate (1-3); E = equivocal (4-6); A = appropriate (7-9); disaggregated frequency data n = 26.

Table 6

Round Three Ranking Data

	Survey item	Mean per item 1	2	3	4	5	6	7	Range
Category									
Instructional planning		1.78	3.7	3.26	3.59	3.74	4.92	-	3.14
Instructional delivery		4	3.11	4.33	2.67	4.11	2.78	-	1.66
Assessment of learning		1.93	1.59	2.48	-	-	-	-	0.55
Classroom management		4.56	5.15	1.93	3.07	2.67	3.63	-	3.22
Professionalism and leadership		3.37	3.15	3.19	4.6	5.26	3.22	5.22	2.11

In Round Three panelists had the option to provide an explanation for their rankings. Most chose to describe why they had selected the top ranked item in each category or how they approached the ranking task overall. For example, one panelist stated, "I found that I ranked the above in the order I would tackle the issue [in my position as school technology support specialist]." Several panelists shared concerns with the idea of ranking the competencies because they felt the ranking was far less important that identifying the actual competencies that should be included. One classroom teacher said, "I do not really like the wording of 'most important' and 'least important' because they are all important […]." Another panelist agreed, indicating, "I view these rankings not so much in order of importance, because they are all critical, but more as steps in the process, so my ranking refers to more of the order that things occur." These types of comments, in conjunction with the quantitative data, seem to suggest that ranking of the teaching competencies was not as critical as the competency selection that took place in earlier rounds.

During the ranking portion of the survey, six teaching competencies (related to Instructional Delivery) were inadvertently omitted from the survey that was initially distributed to panelists. To address this, the researcher re-sent these items to the panel and collected ranking data that was missing. Nine of the panelists responded. Therefore, the rankings for the Instructional Delivery category are based on the responses provided by these nine panelists, not the full panel. As will be discussed further in Chapter Five, the data collected during the first two rounds of the study is far more critical than rankings collected in Round Three. Therefore, while this omission prevented a full panel of results in this category, it did not compromise the results or content of the final inventory.

Ranking data analysis. After creating the ordered list of teaching competencies used to create the inventory, the researcher utilized Kendall's Coefficient of Concordance (or Kendall's W) to determine the degree of level of agreement for these rankings. The use of this additional statistical measure was determined to be appropriate based on literature which advocates additional forms of analyses in Delphi research. Schmidt (1997) advocates the use of the Kendall's W in ranking-type Delphi studies, as a sound method for analyzing data beyond the use of means and medians. In their three-round Delphi study, Okoli and Pawlowski (2004) used Kendall's W to assess consensus within their panel of experts. According to Okoli and Pawlowski (2004), while there are a number of options available for measuring non-parametric rankings, Kendall's W is widely recognized as the top choice. For example, Elmendorf (2012) conducted a Delphi study to develop a set of evaluation indicators for instructional technology and utilized Kendall's W in the final round to interpret final ranking data (Elmendorf, 2012;

Elmendorf & Song, 2015). Thus, Elmendorf's design provides a precedent for the use of this statistical evaluation after the conclusion of a Delphi ranking round. In this study on one-to-one teaching, Kendall's W offers an aggregated view as to the level of agreement (or disagreement) among the panelists' rankings.

The guidelines for interpreting of Kendall's W are shown in Table 7, while Table 8 shows the Kendall's W results. Using Schmidt's (1997) guidelines for interpretation, the Kendall's W results reveal a weak or very weak agreement amongst the panelists in their rankings of competencies within most categories, and a moderate to weak agreement in the area of classroom management. These results indicate a high level of disagreement among the panel as to which items they believe are the most important or least important within each of the categories.

Table 7

Interpretation of Kendall's W

W	Interpretation	Confidence in ranks
.1	Very weak agreement	None
.3	Weak agreement	Low
.5	Moderate agreement	Fair
.7	Strong agreement	High
.9	Unusually strong agreement	Very High

Taken from R.C. Schmidt, 1997, *Decision Sciences, 28*(3), 763-744.

Table 8

Kendall's Coefficient of Concordance (Kendall's W) Results

Inventory category	Kendall's W	Confidence in ranks
Instructional Planning	.295	Weak
Instructional Delivery	.153	Very Weak
Assessment of Learning	.202	Weak
Classroom Management	.411	Moderate
Professionalism and Leadership	.208	Weak

Results

The final inventory developed by this panel of experts yielded 30 teaching competencies for teachers of one-to-one classrooms. Figure 11, provided on page 115, shows the final inventory of competencies for student-centered, one-to-one educators.

Summary

The results in this study were collected over a series of three Delphi rounds involving a nationwide panel of experts in one-to-one computing. Over a period of approximately six months, this panel responded to a series of online surveys that allowed them to share their expertise. In Round One, 33 panelists rated the importance of a proposed list of 33 competencies and reached early consensus, rating all but one of these as appropriate. Panelists in Round One also recommended changes to wording in the competencies and suggested that ten new teaching competencies be added. In Round Two, 31 panelists rated the revised list of teaching competencies, this time identifying ten as appropriate for the inventory and five as equivocal. In the final round, 27 panelists re-rated the five remaining competencies but failed to reach consensus on four out of the five items. The panelists concluded by ranking teaching competencies within five categories, but the mean scores of these rankings did not show any particular competencies as being of particular high importance to the panel. Further analysis through Kendall's W indicated weak levels of agreement between panelists in these final rankings, indicating that the ranking data is far less impactful than the earlier rating data collected in Rounds One and Two. Overall, the information collected from the expert panel yielded an inventory made up of 30 teaching competencies for teachers of one-to-one classrooms, organized into instructional planning, instructional delivery, assessment of learning, classroom management, and professional and leadership skills.

Figure 11

Competencies of the Student-Centered, One-to-One Educator

Category	Teaching Competency
Instructional Planning	1. Utilize knowledge of content and pedagogy to select the instructional tool (digital or non-digital) that best meets the intended learning outcome. 2. Differentiate instructional materials, activities, or technology devices to meet students' individual learning needs. 3. Design instruction which allows students to use technology for independent inquiry that is based on student-selected topics, interests, or real-world problems. 4. Gather, organize, and categorize digital curricular resources when planning instruction. 5. Design instruction which allows students a degree of choice in how they will respond in an activity or how they will be assessed in the learning process. 6. Anticipate potential problems that might occur during instruction and have a back-up plan in the event that technology fails.
Instructional Delivery	1. Exercise flexibility during instruction by improvising to meet students' learning needs (i.e. offer choices in digital tools, extend the amount of time provided, offer additional resources, offer modeling and scaffolding). 2. Capitalize on teachable moments by supporting student inquiry. 3. Support students' ability to self-regulate during the learning process by teaching goal-setting, self-monitoring, and/or allowing students to work at their own pace. 4. Use technology as a means for building collaborative skills between students. 5. Encourage students to publish or act on their new knowledge by using a variety of media. 6. Adjust and respond to novel information or ideas that students share.
Assessment of Learning	1. Use evidence of student learning to customize instruction and plan targeted small group or individual instruction. 2. Employ a variety of formative and summative assessment techniques using digital and non-digital means. 3. Include student reflection opportunities as part of the assessment process using digital and non-digital means.

Category	Teaching Competency
Classroom Management	1. Provide an academic environment that is intellectually challenging. 2. Engineer the classroom environment to support student-centered learning activities (i.e. allow space for collaboration). 3. Develop, teach and implement expectations and routines for device management in the classroom (i.e. how to prevent breakage, when to charge, what to do if a device is broken/lost, etc.). 4. Manage classroom dynamics inherent with student-centered approaches to instruction, such as increased noise level, materials, clutter, or movement. 5. Monitor students' use of technology in the classroom in order to determine safe and appropriate utilization of online tools. 6. Address and redirect off-task behaviors or distractions caused by device usage in the classroom (i.e. online chatting, game playing, internet searching, social media use).
Professionalism and Leadership	1. Pursue and accept professional development opportunities to gain technological, pedagogical, and content-based knowledge. 2. Identify and utilize mentors, coaches, colleagues, or other available experts who can support in the development of technology integration and pedagogical skills. 3. Engage in reflection and inquiry with colleagues and/or administrators about effective teaching practices. 4. Set goals related to professional growth in technology integration. 5. Apply recommendations or resources shared by mentors, coaches, colleagues, or other professional development opportunities. 6. Communicate the vision for new or previously adopted initiatives with both internal and external stakeholders. 7. Seek opportunities to provide informal support, modeling, mentoring, or coaching to fellow colleagues.

Note. Inventory items have been listed in ascending order, according to their mean rank score.

CHAPTER V. DISCUSSION

When used effectively, one-to-one technology holds promise for transforming teaching and learning in classrooms. One-to-one learning environments have evolved over time as the improved functionality and mobility in devices and wireless Internet access now provides more students and teachers with immediate access to information (Spires et al., 2009). These classrooms are high intensity learning environments that require different teaching competencies than classrooms that are otherwise rich with technology, but do not have the one-to-one technology ratio. Given the resurgence of one-to-one learning environments in recent years, it is critical that we identify the best instructional practices that teachers can use to support students' learning. The inventory of teaching competencies designed through this research identifies those practices and provides a useful resource for schools, districts, and teacher preparation programs who prepare teachers. The purpose of this chapter is review the main features of the study and to present a discussion and interpretation of the results. This chapter consists of the following sections: Statement of the Problem, Purpose of the Study, Research Question, Research Design, Results, Examination of the Competencies, Discussion, Utilization of the Inventory, Future Research, and Summary.

Statement of the Problem

There are unique conditions that make one-to-one learning environments, where the student-to-computer ratio is equal, distinctly different from traditional technology-rich classrooms. Additionally, literature indicates that it is the combination of student-centered pedagogy with one-to-one technology that promotes the greatest instructional value (Dunleavy et al., 2007).

Given the substantial resources now being allocated to one-to-one classrooms, it is essential that we have an accurate set of teaching competencies to guide teaching, professional development, and preparation. If we do not adequately prepare teachers to develop the knowledge and skills they will need to teach effectively in these classrooms, then we have wasted these resources and denied the benefits of them to our students. Additionally, we must clearly identify what our future teachers need to be able to do in one-to-one classrooms, otherwise our next generation of teacher candidates will be unprepared for the classrooms they enter after graduation. The current ISTE (2017) standards for educators outline what teachers need to do in order to integrate a wide range of technology, but they do not address the competencies specific to one-to-one learning environments. Ultimately, if we make student-centered pedagogy a common practice in one-to-one learning environments and we distinguish the intricacies specific to these classrooms, our students have much to gain.

Purpose of the Study

The purpose of this research is to develop a resource that can be used in schools, districts, and teacher preparation programs to prepare teachers for one-to-one classrooms. To do so, we must rely on practitioners and researchers in the field who have expertise in one-to-one computing. Using the collective knowledge of these individuals, an inventory of teaching competencies identifies the skills and the dispositions teachers need to effectively facilitate instruction in student-centered, one-to-one learning environments. The implementation of these competencies is how we achieve exemplary teaching in the one-to-one classroom.

Research Question

This research was led by one guiding question: *What are the teaching competencies required of educators who facilitate instruction in student-centered, one-to-one learning environments?*

Research Design

In order to identify the teaching competencies needed for one-to-one learning environments, this study employed quantitative and qualitative research procedures as part of the Delphi method. The Delphi method is rooted in a post-positive inquiry, but with interpretivist features (Day & Bobeva, 2005), making it an ideal choice for answering this research question. This study utilizes a classic Delphi approach because it includes anonymity between participants, iterative data collection and analysis, controlled feedback by the researcher, and statistical group response.

This Delphi study draws on a sample of participants that met the sampling criteria as experts in one-to-one computing. Purposive sampling, conducted through the use of the KRNW Delphi sampling process, was used to identify the panel. The panel consisted of 33 experts in Round One, 31 in Round Two, and 27 in the third and final round. Opinions of these experts were collected through three online surveys which occurred over a period of approximately five months. Rounds One and Two consisted primarily of panelists rating items for consensus building and Round Three concluded with ranking of the final competencies.

Data analysis. Data from each survey was analyzed in order to provide controlled feedback to participants in the subsequent round and to determine whether consensus had been reached on each individual teaching competency. Analysis procedures followed the format used in the Delphi study conducted by Valentijn et al. (2015) and the Rand UCLA

Appropriateness Method was used to define consensus (Fitch et al., 2001). Qualitative data was analyzed for identification of themes and these themes were coded so that categories of ideas could be used to coordinate next steps for subsequent rounds. Finally, the researcher followed recommendations for rigorous data analysis of Delphi studies discussed by Okoli and Pawlowski (2004) and by Schmidt (1997) to calculate the Coefficient of Concordance (or Kendall's W) for ranking data in Round Three.

Results

In Round One, 33 panelists began with 33 proposed competencies that they rated, using a nine-point Likert Scale. In this initial round, the experts rated 32 items as appropriate, one item as equivocal, and no items as inappropriate. Based on the qualitative feedback from the panel, 10 new competencies were added for evaluation in Round Two. Between rounds the researcher combined some items to reduce redundancy. In Round Two, 31 panelists rated 15 competencies and analysis indicated that they evaluated 10 of these as appropriate and five as equivocal. In Round Three, 27 panelists re-rated the remaining five equivocal items but only came to consensus on one of the five (the four remaining items were discarded). In this round, the experts also ranked the remaining teaching competencies, which were organized for them by category. Analysis of the Round Three ranking data using the Coefficient of Concordance (Kendall's W) showed weak agreement between panelists. Overall, the data collected during Rounds One and Two is most critical in answering the research question, as these rounds determined consensus on the inclusion of 29 of 30 competencies. The results of this cumulative process yielded a final inventory which includes 30 teaching competencies for teaching in one-to-one learning environments, ranked in five categories: instructional planning, instructional delivery, assessment of learning, classroom management, and professionalism and leadership. These results are included in Figure 11, at the conclusion of the prior chapter.

Examination of the Competencies

The inventory developed by the Delphi panel includes a wide range of competencies and these results are grounded in the one-to-one literature. The concepts addressed in the inventory are common themes discussed in peer-reviewed research, papers, and reports on the topic. This section will present, by category, each of the competencies in the inventory. Competencies will be presented, followed by a description of how they are supported by one-to-one research. Each item will be referred to using abbreviations associated with its inventory category: IP (instructional planning), ID (instructional delivery), A (assessment of learning), CM (classroom management), and P (professionalism and leadership) and the number determined by the Round Three ranking process. For example, IP1 refers to the first competency listed within the instructional planning category.

The conceptual framework guided the initial development of all competencies proposed to the panel, and therefore, much of the inventory is reflective of the features of the ecological environment that Spires et al. (2009) discuss. As the competencies are presented, each section will also include a discussion as to how they relate to the conditions described in the new learning ecology framework. Together this presentation of the competencies is meant to provide a rich description of the content of the inventory and to bring life to these teaching competencies through real world examples.

Instructional planning. Instructional planning refers to the habits and routines of teachers as they prepare lessons, activities, and assessments based on student learning objectives. The competencies in this category are directly related to what educators need to know and be able to do prior to lesson delivery in order to facilitate high quality instruction in the one-to-one classroom. The first category is made up of six competencies for one-to-one teachers.

First, IP1 states that teachers, “Utilize knowledge of content and pedagogy to select the instructional tool (digital or non-digital) that best meets the intended learning outcome.” This was the highest ranked item, determined as the most important instructional planning competency by the Delphi panel. This competency describes the important decision the teacher makes to choose the best instructional tools to support students in mastering the learning objective. As part of this decision, the teacher may need to determine whether instruction will include students computerized devices. During the study this competency created comments and recommendations from the experts, as many shared strong opinions that the one-to-one teachers should view students’ devices as just one of the many tools available to them in addressing the learning objective. One participant explained this idea by saying, “It is important for teachers to know that the device is just an added tool in the classroom and that all lessons may not require the use of technology. Sometimes paper/pencil tasks are just as effective. The goal is to use technology to enhance instruction, not supplement.” Another panelist stated, “We view technology as a tool and not always a necessity. If students are given options for representation and action and expression, technology would be an option and not just the only plan.” Other one-to-one literature supports the comments made by these panelists. For example, Larkin and Finger (2011) discuss the one-to-one teacher’s role in planning new and more innovative approaches to previous instructional activities, rather than simply using new technology to replace traditional tasks. Lindqvist (2015), also discusses the teacher’s ability to determine when it is appropriate to incorporate students’ devices to enhance learning and select pedagogical strategies that best meet the instructional learning outcome. One Delphi panelist helped to shape the wording for this competency by refocusing these decisions on the learning objective: “Technology resources must serve the ultimate teaching and learning objectives. So, in some instances replacing or enhancing traditional approaches leverages genuine advantages and, in others, maybe less so.” Ultimately, the essence of this first competency is that teachers recognize the computerized device as a pedagogical option and plan ways they can use it in conjunction with other effective teaching methods to support students’ learning.

The second competency in this category (IP2) indicates that teachers, “Differentiate instructional materials, activities, or technology devices to meet students’ individual learning needs.” The use of one-to-one technology to support differentiation practices is discussed in other one-to-one technology research as well. Specifically, a study of one-to-one teachers and their use of the technology has shown that devices are often used to differentiate instruction for diverse groups, such as through personalizing a student’s device (Chou et al., 2012), planning for differentiated instruction with devices (Lowther et al., 2012), and preparing instructional materials in multiple formats (Bebell, 2008; Rosen & Beck-Hill, 2012). A study conducted by Corn et al. (2012) showed that teachers in one-to-one classrooms used devices to differentiate instruction for students with special needs. Thus, it is important that the one-to-one teacher capitalize on the affordances devices offer for meeting the needs of diverse groups of students.

IP3 indicates that teachers, “Design instruction which allows students to use technology for independent inquiry that is based on student-selected topics, interests, or real-world problems.” While this competency has relevancy to both instructional planning and delivery, situating it within the planning category emphasizes the importance of the teacher designing these opportunities in advance. One-to-one teachers can empower students to utilize devices to support their own learning (Li, 2010). In the observations of one-to-one classroom instruction described by Li (2010), these environments provide options where students do not have to rely on the teacher and they can be encouraged to develop self-discipline and self-regulation through inquiry.

Another important component of the planning process for one-to-one teachers includes the teacher's ability to "Gather, organize, and categorize digital curricular resources when planning instruction" (IP4). Examination of one-to-one teachers' planning practices indicate that they often conduct online research for upcoming lessons (Bebell, 2008) and some find it useful to create and maintain a digital repository of resources that they can access for future lessons (Morrison et al., 2015). In some cases, the district or school may even have a repository set up for this purpose. However, even when the district sets up a repository and offers supports, the teacher needs to have the ability to discern reputable digital resources that are appropriate for instruction. This is supported by Garthweit and Weller (2005), who discussed the importance of one-to-one teachers identifying high quality sites that could be used by students for online research or to supplement portions of the curriculum. Additionally, Broussard et al. (2014) discussed the importance of educators categorizing resources through bookmarking tools that students can access. Overall, curating digital curricular materials, such as e-textbooks and multimedia is described as a vital part of the planning process for the one-to-one teacher (Meyer, 2007).

The Delphi panelists in this study indicated (as stated in IP5), that teachers be able to "Design instruction which allows students a degree of choice in how they will respond in an activity or how they will be assessed in the learning process." Current research indicates that the one-to-one teacher can accomplish this by planning assignments and assessments that incorporate flexible options (Meyer, 2007; Storz & Hoffman, 2012). In their description of the impact of one-to-one technology on instruction, the Horizon Report discusses the importance of allowing students a degree of choice in instruction, including how they are assessed and what they will learn (Johnson, Adams Becker, Estrada, & Freeman, 2015). A Delphi panelist emphasized the importance of this competency, stating, “Student choice in the tools they use is essential to their success.” Another explained how this has been pivotal in his one-to-one classroom: “Once I moved my instructional design to include student choice, it changed everything: engagement, achievement, and attitude toward learning.”

IP6 indicates that teachers, “Anticipate potential problems that might occur during instruction and have a back-up plan in the event that technology fails.” This is indicated in the research (i.e. Lindqvist, 2015). Teachers need to have other non-technological methods to fall back on, in the event that they encounter a technical issue with the activity they had planned. Without this, teachers may rely so much on the technology that risk being unprepared and unable to adapt to other methods.

The competencies in this first category parallel the new ISTE (2017) standards for educators. While this inventory outlines the competencies specific to the one-to-one setting, the ISTE standards for educators work in tandem with these. Specifically, the newly developed 2017 ISTE standards for educators emphasize that all teachers be able to effectively design authentic and learner-driven activities and settings which require teachers to:

a. Use technology to create, adapt and personalize learning experiences that foster independent learning and accommodate learner differences and needs.
b. Design authentic learning activities that align with content area standards and use digital tools and resources to maximize active, deep learning.
c. Explore and apply instructional design principles to create innovative digital learning environments that engage and support learning. (ISTE, 2017, p. 2)

Competencies in the instructional planning section of the inventory relate directly to the new learning ecology described by Spires et al. (2009). One of the conditions of the new learning ecology is that students have "immediate and constant access to information" (Spires et al., 2009, p. 6). When planning, teachers must take this into account and make decisions about students' access to online information. Choosing when and to what extent technology can be used to access information is a primary planning consideration captured in IP1. Another planning consideration is for the teacher to consider how active a role they will play in facilitation, an identified teacher capacity within the new learning ecology framework (Spires et al., 2009). IP5 offers a particular example as to how one-to-one teachers can incorporate a degree of student choice as one way to foster a balanced role between instructional decisions made by both teacher and students.

Instructional delivery. Instructional delivery refers to the most active forms of teaching, particularly the teacher's implementation and facilitation of lessons, activities, and assessments they have prepared. This section of the inventory includes seven teaching competencies that describe what effective teachers need to do when teaching. In this category, the first six items were originally posed by the researcher in Round One of the study and these directly correlate to the teacher capacities outlined by Spires et al. (2009, 2012) in the new learning ecology. The final item, ID7, was added based on the consensus decision of the panel in Round Three.

Spires et al. (2009) discuss how continuous access to information via technology requires the one-to-one teacher to improvise, capitalize on ideas shared by students, and support the development of twenty-first century skills in their learners. In this ecological environment where a complex interplay exists between teacher, learner, and technology, the teacher facilitates instruction, rather than directing it. Spires et al. (2009) describe four teacher capacities necessary for instructional delivery (facilitation, improvisation, coaching, and consultation). In this study, the Delphi panel refined these concepts to operationalize the teacher's role in instruction. Figure 12 shows Spires et al.'s (2009) teacher capacities and their direct alignment to the inventory.

The competencies most closely aligned to Spires et al.'s (2009) description of required teacher capacities include the teacher's ability to: "Exercise flexibility during instruction by improvising to meet students' learning needs . . ." (ID1), "Capitalize on teachable moments by supporting student inquiry" (ID2), and "Adjust and respond to novel information or ideas that students share "(ID6).

The first item in this section indicates that teachers "Exercise flexibility during instruction by improvising to meet students' learning needs (i.e. offer choices in digital tools, extend the amount of time provided, offer additional resources, offer modeling and scaffolding." (ID1) The panelists in this study concurred with Spires et al.'s (2009) assertion that the one-to-one teacher needs refined improvisation abilities and that they be willing and prepared to an open exchange of ideas with students.

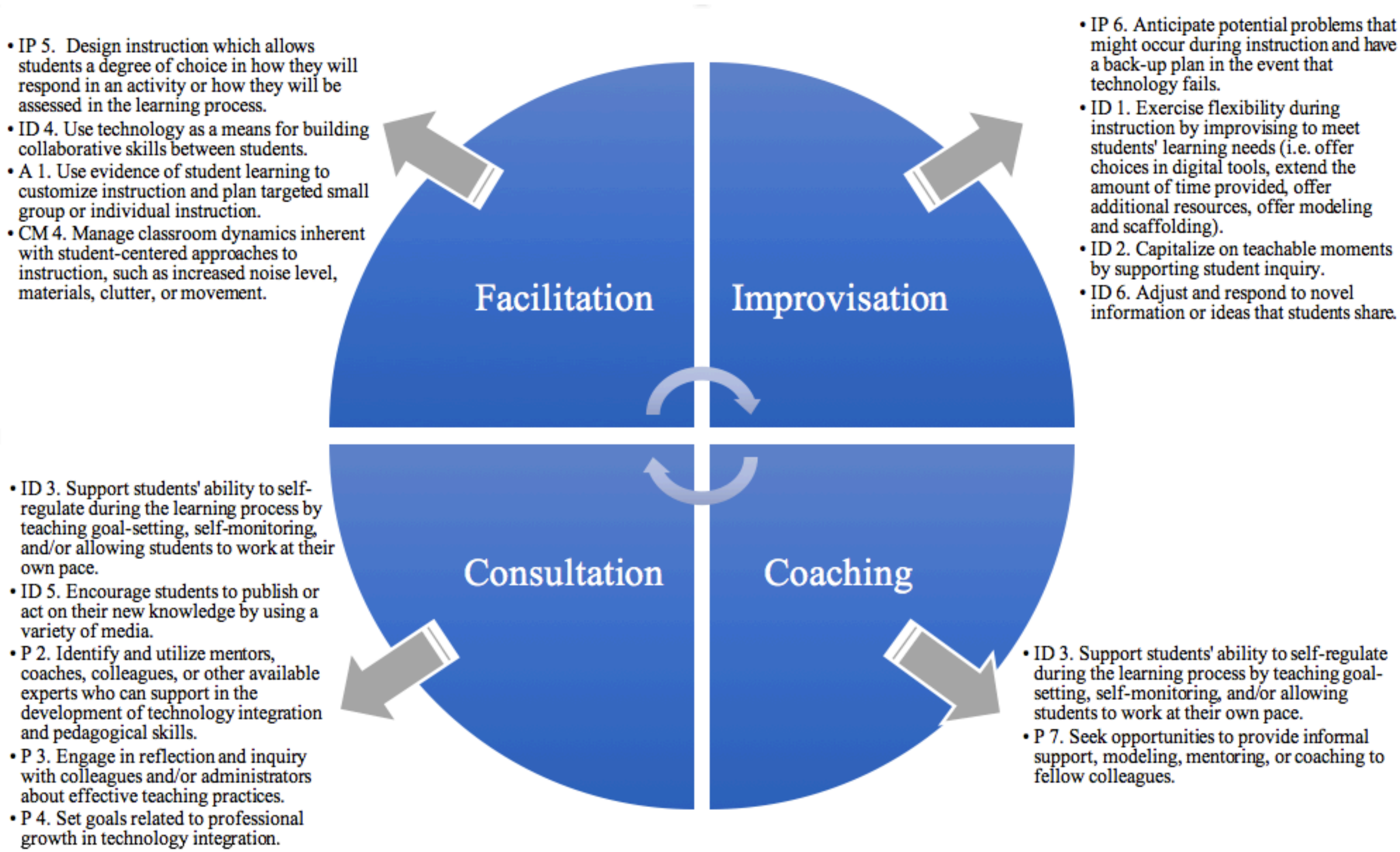


Figure 12. Alignment of inventory to the new learning ecology teacher capacities.

Another competency reflecting improvisation, indicates that the one-to-one educator be able to “Capitalize on teachable moments by supporting student inquiry” (ID2). Capitalizing on the teachable moment is critical skill in the one-to-one classroom (Christman, 2014; Garthweit & Weller, 2005; Storz & Hoffman, 2012). In high school classrooms with one-to-one technology, Christman (2014) found that students’ questions often turned into teachable moments where students could quickly go online to research answers. In a study of middle school teachers in one-to-one classrooms, Storz and Hoffman (2012) also found that students’ devices allowed moments like these to become learning opportunities for students. Skilled teachers in one-to-one learning environments need to know how to make the most of these moments in the classroom, and they must also be prepared to help students interpret what they find online.

A theme prevalent in one-to-one research that is also reflected in this inventory is students’ self-regulation and self-directedness (Li, 2010; Rosen & Beck-Hill, 2012; Spires et al., 2009). ID3 indicates that teachers must be able to “Support students’ ability to self-regulate during the learning process by teaching goal-setting, self-monitoring, and/or allowing students to work at their own pace.” Research shows that one-to-one teachers can empower students to utilize devices to support their own learning and that they can encourage self-discipline through modeling and scaffolding (Li, 2010; Rosen & Beck-Hill, 2012). Activities that allow students to engage in independent inquiry or self-paced research in the one-to-one classroom can support this (Clarke & Svanaes, 2012; Donovan et al., 2010; Lowther et al., 2012). One-to-one research emphasize the teacher’s role as a coach and facilitator of active learning, rather than an educator who primarily offers teacher-directed activities (Lowther et al., 2012; Oliver & Corn, 2008; Morrison et al., 2015, Spires et al., 2012).

Another important teaching competency for the one-to-one classroom is for teachers to "Use technology as a means for building collaborative skills between students" (ID4). Other research supports the notion that one-to-one technology can be a vehicle for increasing communication between students (Bebell & Kay, 2010; Broussard et al., 2014; Clarke & Svanaes, 2012; Johnson et al., 2015; Li, 2010; Maninger & Holden, 2009; Meyer, 2007). Some one-to-one teachers have described their opportunities to mediate discussions and interactions during technology usage in order to facilitate higher level thinking skills (Garthweit & Weller, 2005), and, in some cases, one-to-one technology usage has been reported as contributing to a team culture among students as a result of these collaborative activities (Downes & Bishop, 2015).

One of the key affordances of technology in any classroom is the opportunity for students to create unique and differentiated products which showcase their new knowledge. In the one-to-one classroom, students' increased access to technology provides greater opportunities for this to occur. However, offering flexibility to students is a philosophy toward teaching that needs to be embodied by the teacher. ID5 indicates that the one-to-one teacher "Encourage students to publish or act on their new knowledge by using a variety of media." The intent of these types of activities is to support students in understanding the importance of solving real problems and to encourage them to become involved in creating solutions to important dilemmas. This is the power of today's one-to-one classroom. This competency highlights the unique opportunity that one-to-one teachers have in shaping students to become active, engaged members of society. Students in one-to-one classrooms can use technology for sharing their products with an audience that extends well beyond their school or classroom (Clarke & Svanaes, 2012; Downes & Bishop, 2015). It is these types of technology uses in the one-to-one classroom that inspire children to extend what they have learned outside of the traditional classroom and make a true impact on the world (Greaves, Hayes, Wilson, Gielniak, & Peterson, 2012). While the skills and competencies to perform these tasks eventually lie within our students, it is first the one-to-one teacher who designs these opportunities for students and supports them as they develop this capacity.

The emphasis of this inventory sits squarely on the teaching competencies related to pedagogy, therefore knowledge related to basic, technology-related skills does not play a central role. However, responses by the Delphi panel indicated that they saw basic knowledge about device use as essential. ID7 indicates that teachers be able to "Demonstrate proficiency with the device students are using in the classroom." In order for technology integration to occur effectively, the teachers must be familiar with how to utilize the device that has been provided to them and to their students. Larkin and Finger (2011) argue that this is most successful when teachers have a working knowledge of the capabilities of student devices, including the basic features and functions of how to use it in the classroom.

Assessment of learning. Assessment refers to the portion of the instructional cycle when the teacher plans and implements assessment activities, either formative or summative, that are used to (a) measure students' learning, and (b) guide future instruction. The inventory includes three teaching competencies which relate specifically to the assessment of student learning in the one-to-one classroom. These include the teacher's ability to "Use evidence of student learning to customize instruction and plan targeted small group or individual instruction" (A1); "Employ a variety of formative and summative assessment techniques using digital and non-digital means" (A2); and the teacher's ability to "Include student reflection opportunities as part of the assessment process using digital and non-digital means" (A3).

One-to-one technology provides a variety of opportunities for assessing students in the classroom (Bebell, 2008; Broussard et al., 2014; Greaves et al., 2012; Lindqvist, 2015). Online tools and digital applications provide enhanced opportunities for one-to-one teachers to provide immediate and real-time feedback to their students (Lindqvist, 2015; Maninger & Holden, 2009; Rosen & Beck-Hill, 2012); and to develop mechanisms for monitoring the performance of students with special needs (Bebell, 2008; Sandholtz et al., 1990). Several Delphi panelists commented that it is important for one-to-one teachers to develop a repertoire of digital and non-digital assessment techniques. The significant finding from this category of results is that while devices can often provide diversified options for assessment, the teacher must carefully select the assessment method that is best suited for the learning outcome and the individual needs of students.

Classroom management. The knowledge and dispositions that a teacher uses to create and maintain a learning environment that is safe, orderly, and conducive to learning is known as the teacher's classroom management skills. In this study, the panelists concurred that the most important feature of effective classroom management is for the teacher to "Provide an academic environment that is intellectually challenging" (CM1). As one Delphi panelist stated, "I believe if you have a student-centered classroom that is intellectually challenging you will spend less time managing student behavior because they will be engaged." Another panelist explained it this way: "Providing clear expectations in the classroom along with having an intellectually challenging classroom environment will oftentimes cut down on the device issues in the room. Good classroom management stems from an engaging classroom with structure. That will not eliminate all issues, however any device problems then become on an individual basis, not as a whole class."

Two of the competencies refer to specific features of managing the unique features of the student-centered, one-to-one learning environment. These include CM2: "Engineer the classroom environment to support student-centered learning activities (i.e. allow space for collaboration)" and CM4: "Manage classroom dynamics inherent with student-centered approaches to instruction, such as increased noise level, materials, clutter, or movement." Delphi panelists indicated that establishing this type of learning environment requires the classroom be engineered to support collaboration between students as well as independent thinking, such as through furniture set-up or visual aids used to support critical thinking. District-level reports on one-to-one implementation, such as the one conducted by Morrison et al. (2015), describe the importance of setting up these opportunities for students in advance. Morrison et al.'s (2015) report indicated that educators new to one-to-one technology and student-centered learning had to adjust to increased movement around the room and allowing students to choose where they wanted to work. When implementing student-centered pedagogy, one-to-one teachers' competence in addressing related classroom dynamics, such as increased noise level, clutter of materials, and the increased amount of movement are also factors.

Additional items in the classroom management section of the inventory address issues related to device management and monitoring. CM3 outlines the teacher's competence to "Develop, teach, and implement expectations and routines for device management in the classroom (i.e. how to prevent breakage, when to charge, what to do if a device is broken/lost, etc.)." CM5 indicates that the one-to-one teacher "Monitor students' use of technology in the classroom in order to determine safe and appropriate utilization of online tools" and CM6 states that teachers be able to "Address and redirect off-task behaviors or distractions caused by device usage in the classroom (i.e. online chatting, game playing, internet searching, social media use)." One-to-one teachers need to be prepared to manage the *nuts and bolts* of device implementation (Donovan et al., 2010; Sandholtz et al., 1990; Spires et al., 2011; Oliver, 2010). While, on the surface, this may seem secondary to pedagogy, it is particularly relevant for teachers new to the one-to-one technology ratio, because, if not properly managed, it has the potential to interfere with instruction. This is another defining feature that sets the one-to-one learning environment apart from other classrooms.

The most successful one-to-one teachers are those who plan ahead and set expectations, such as developing systems for forgotten devices, broken, or uncharged devices (Donovan et al., 2010; Oliver, 2010). There may be situations when teachers must solve (or seek resources to solve) hardware problems (Dunleavy et al., 2007) or times when teachers will need to set boundaries for students who are either resistant to technology use or not caring for a device properly (Lindqvist, 2015; Sandholtz et al., 1990). There are findings that support the panel's consensus about the importance of monitoring students' safe use of technology (Klieger et al., 2010; Oliver, 2010; Storz & Hoffman, 2012) and evidence to indicate that teachers may need to redirect off-task behavior as a result of device usage. Donovan et al. (2010) found that this type of off-task behavior could be either device-related or non-related to the use of technology. While students may exhibit motivation toward the use of technology, students' devices can cause distractions or disruptions during a lesson (Dunleavy et al., 2007; Larkin & Finger, 2011; Lindqvist, 2015; Storz & Hoffman, 2012). In order to ensure that these issues do not negatively impact learning, teachers need to set rules and expectations for proper device usage, then be prepared to implement them consistently.

In order to be prepared to manage any of these issues in the one-to-one classroom, a teacher first needs to be able to anticipate the problems that may occur. The original ACOT research showed that teachers who were new to the one-to-one technology ratio were often unable to anticipate the potential pitfalls (Sandholtz et al., 1990). Sandholtz et al. (1990) found that these teachers progressed through three phases of classroom management: first, *survival* (where they were unable to anticipate the problems), *mastery* (where they began to anticipate issues and devised consequences to address them), and finally, *impact* (where teachers inserted proactive rather than reactive measures to manage the environment). Sandholtz et al.'s (1990) findings are significant because they point out what happens when teachers are not prepared to anticipate and plan for management-related issues. In the past, these one-to-one teachers could not fully prepare because there was no roadmap to indicate why routines for device management were needed. The results of this inventory support today's one-to-one teachers in properly managing the one-to-one learning environment by identifying, in advance, the types of rules and routines they need to establish.

Spires et al. (2009) describe features of effectively managing the one-to-one classroom environment and there are strong connections between their framework and the content of this inventory. For instance, Spires et al.'s emphasis on teachers' ability to execute sophisticated forms of facilitation is mentioned in CM 4, which refers to the teacher's ability to manage dynamics associated with student-centered learning. CM5 refers to the teacher's ability to monitor students' safe use of technology and this is one example of the "highly developed learning dispositions" that Spires et al. describe, sometimes also referred to as being a good digital citizen (2009, p. 6).

Professionalism and leadership. In this context, a teacher's professionalism and leadership capability is defined as the set of skills and dispositions that promote professional competence and mutually beneficial partnerships between themselves and their administrators, colleagues, parents, and students. While instructional delivery is important, talent cannot be defined solely by what goes on during the lesson.

The first item with this category indicates that the one-to-one teacher "Pursue and accept professional development opportunities to gain technological, pedagogical, and content-based knowledge" (P1). This may involve investing additional time to learn new tools or approaches with one-to-one technology (Bebell & Kay, 2010). The panel in this study indicated that the one-to-one teacher also "Set goals related to professional growth in technology integration" (P4), particularly necessary given the ever-growing number of digital tools. Research on effective one-to-one implementation indicates that the most successful teachers are those who take full advantage of the professional development opportunities offered to them (Corn et al., 2012), such as attending regular in-service activities (Klieger et al., 2010), and keeping up to date with the technological resources available in one's content area or grade level (Donovan et al., 2010).

According to Downes and Bishop (2015), applying knowledge gained through professional development requires teachers to analyze their practices and make adjustments in order to grow professionally. These ideas are reflected in the inventory in P3 ("Engage in reflection and inquiry with colleagues and/or administrators about effective teaching practices") and in P5 ("Apply recommendations or resources shared by mentors, coaches, colleagues, or other professional development opportunities"). There are related habits of mind that describe how one-to-one teachers develop competency in this area. For example, in a one-to-one study conducted by Hineman, Boury, and Semich (2015), teachers with high self-efficacy in technology use were the ones who excelled. These teachers felt empowered to try new forms of technology, to change their teaching style, and to take risks by using new tools in the one-to-one classroom (Hineman et al., 2015). They also regularly sought out the knowledge they needed to grow professionally and they set goals related to technology integration. This idea is represented in P4, which indicates that the teacher “Set goals related to professional growth in technology integration.”

The Delphi panelists indicated that communicating the vision for one-to-one technology initiatives to be critical for today’s one-to-one teacher. P6 indicates that the one-to-one teachers should be able to “Communicate the vision for new or previously adopted initiatives with both internal and external stakeholders.” This is reflected in corresponding research, such as Li’s (2010) examination of one-to-one teachers who were able to communicate the potential benefits of device integration to parents of their students. Opportunities for teachers to develop a sense of ownership of a school or district’s initiative and its goals is seen as a form of professional competence (Li, 2010). Spires et al. (2011) indicate that factors surrounding one-to-one technology make it necessary for educators to effectively communicate with their school leadership, and, when appropriate, seek opportunities to become part of the decision-making process associated with the technology initiatives in their school. This is especially true in the case of one-to-one initiatives, because administrators, support specialists, researchers, or consultants may not have had the opportunity to teach in a one-to-one classroom. It is therefore important that today's teachers with this experience to be able to articulate the primary areas of concern, support, or resource needs.

Portions of the new learning ecology framework, specifically coaching and consultation by one-to-one educators, overlap with concepts in the professionalism and leadership portion of the inventory. For example, P2, which refers to accepting support from mentors, is described by Spires et al. (2009) as an important condition in the new learning ecology classroom. On the converse, seeking opportunities to provide support to others (or coaching, as it is defined in the new learning ecology) is reflected in P7.

As this in-depth presentation of the competencies has shown, this inventory reflects many of the aspects of the new learning ecology that Spires et al. (2009) describe. This section has provided examples which describe some of the overlap. The concept map shown in Figure 13 provides a summary of all of the connections that exist between the results from this study and its conceptual framework. The inventory's alignment to the new learning ecology provides a foundation for the teaching competencies that have been developed in this research. Likewise, this inventory provides further support for the theoretical construct that Spires et al. have developed.

Discussion

The inventory has several defining features. The most noticeable attribute is that there are 30 total items and the volume of items identified by the Delphi panel is reflective of the literature. The research indicates that professional development for one-to-one initiatives is of great importance, but can be challenging to do well (Downes & Bishop, 2015; Klieger et al., 2010). The number of teaching competencies in this inventory helps to explain why preparing teachers for one-to-one environments can be so challenging and why fostering teachers' growth in all of these areas is a complex task.

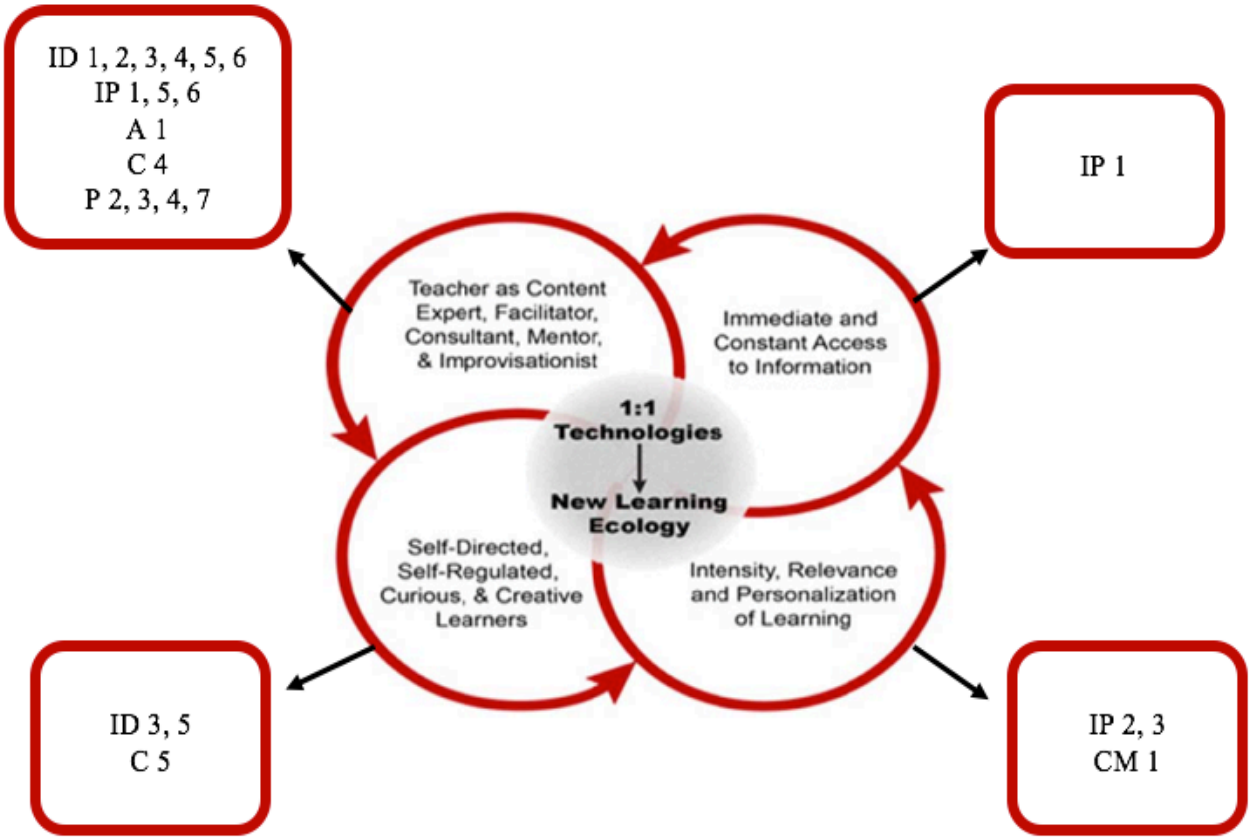


Figure 13. Concept map aligning one-to-one inventory items with the new learning ecology. Adapted from "Toward a New Learning Ecology: Teaching and Learning in 1:1 Environments," by H.A. Spires, E. Wiebe, C. A. Young, K. Hollebrands, and J. K. Lee, 2009, Friday Institute White Paper Series, No. 1 North Carolina State University.

Another key feature of these results is that some of the competencies here may be regarded by some as simply "good teaching." This seems indicative of the fact that the Delphi panelists in this study, those who have spent time in one-to-one classrooms, did not view technology integration and attributes of effective pedagogy as *separate*, because when students' devices are fully integrated into instruction, the instructional approach is seamless. The panel's thinking helps to exemplify the belief system of professionals who have seamlessly integrated one-to-one technology into the classroom setting.

This inventory describes much about the pedagogical dynamics in a student-centered, one-to-one classroom. Due to students' continuous access to technology, there are aspects that are very important for teachers to plan in advance but others that can only be realized when in the active mode of teaching. The fact that many of the competencies are demonstrated during active teaching has important implications for professional development, primarily because it challenges the notion that a one-to-one teacher can refine their teaching skills during a lecture-based, sedentary professional development opportunity. If many of the essential competencies of one-to-one teaching occur in the midst of instruction, then efforts to support and prepare one-to-one teachers should be happening through observation, modeling, coaching, and mentoring.

Utilization of the Inventory

The purpose of this research was to develop a resource that could be used to prepare teachers for one-to-one classrooms. Given that objective, the language of the inventory was intentionally developed to include user-friendly, jargon free terms that are easily interpreted by those across the educational spectrum.

K-12 schools. The potential use of this inventory by K-12 schools is multi-faceted. At the macro level, a school or district level administrator may use the inventory as a tool to guide personnel in identifying instructional indicators as they visit one-to-one classrooms. The inventory would be useful as a guide for discussing effective one-to-one integration with school administrators who are new to the approach and would provide a common language to discuss one-to-one implementation, while keeping this discussion centrally focused on pedagogy. At the school level, an administrator could utilize the inventory in some of these same ways, such as a practical list of *look-fors* during instructional rounds. While the intent was not to develop an evaluation instrument, the inventory could be used to provide qualitative feedback to the teacher based on brief periods of observation.

Those responsible for professional development within a school or program may find the inventory useful for developing a professional development plan, both for the faculty as a whole or for individual faculty members. Given slight modifications to the format, the inventory could be used as an informal needs assessment for an entire staff, a small group of faculty members, or to support teachers in setting individual goals for professional growth.

Through the use of the inventory, all of these efforts could support a district, school, or program to focus on student-centered pedagogy in the midst of one-to-one conversion. Without this focus it is possible for implementation preparation and professional development to emphasize students' devices and related technology tools rather than how they are used to improve learning and teaching.

Teacher preparation. Those in leadership roles in teacher preparation programs could use the results from this study in determining whether preservice teachers are adequately prepared to enter one-to-one learning environments. Conversely, because the inventory is not content or grade specific, it would also be useful in supporting the development of faculty members within teacher preparation programs. Those faculty responsible for technology integration coursework, whether that be in a technology course or through an embedded approach, could use the inventory as a mentoring tool as they support preservice teachers.

With the recent increased focus on clinical practice in teacher preparation programs as required by CAEP (2013), this inventory defines the actions of teaching in one-to-one environments more explicitly. It provides a framework for the skills a preservice teacher can be practicing and role playing, or situations that an instructor can simulate within coursework. It provides information that university supervisors could use to discuss performance and promote areas for improvement with interns who are placed in one-to-one learning environments. Overall, the inventory holds many promising possibilities for making the training of preservice teachers more explicit and it articulates to those involved with teacher preparation how today's one-to-one learning environments have changed the requirements for the next generation of teachers.

Future Research

The development of this inventory is an important first step in identifying the teaching competencies required for one-to-one educators, but there are additional avenues for future research that should be explored. It is not uncommon in Delphi research that the first step be to develop a framework such as an inventory or taxonomy, followed by research which validates these results for use in the field. For example, when developing a taxonomy of motor learning to be used by therapists in clinical practice, Kleynen et al. (2013) used the results from their Delphi study as a "starting point for future applied research" (p. 6). Similarly, Tigelaar et al. (2004) also referred to their Delphi study results "as a starting point for refining teacher education," not their final inquiry. Valentijn et al. (2015) actually conducted three separate Delphi studies; the first being used to identify taxonomy items; a second Delphi study to refine the items; and a final study to develop specific instruments based on this taxonomy. While Valentijn et al.'s Delphi studies were conducted on a larger scale, these designs show that a Delphi study is often used as an important first step to addressing a research question that requires additional inquiry to support field-based application.

Since so many of one-to-one teaching competencies occur in the most active phases of teaching, this inventory now needs to be vetted in one-to-one classrooms and in discussions with practitioners. Research pursuits should validate the planning and teaching practices of one-to-one teachers to determine how these competencies are utilized in the field and to determine how these competencies can be used to support the development and sustainability of effective instruction.

The content of this inventory could also be used to develop a survey designed to measure teacher preparedness for one-to-one learning environments, among both K-12 teachers and prospective educators enrolled in teacher preparation programs. Results from the survey would be useful for both practitioners in the field and for further instructional technology research. These results could be utilized to structure individual development plans for teachers as well as professional development for groups of teachers engaged in a one-to-one initiative. This type of information is needed because while research on general technology preparedness of teachers is regularly explored, past research has not focused on preparedness for one-to-one learning environments.

Additional questions could be explored by asking practitioners to utilize the inventory as a resource for planning and teaching or among technology support specialists, coaches, or mentors supporting teachers with technology integration in the one-to-one classroom. While the panel in this study has provided a useful starting point based on their insights, additional inquiry would further refine the content of the inventory to ensure practicality.

Summary

Research in one-to-one technology implementation has grown. We now know a great deal about what successful one-to-one teachers do and what causes them to struggle. However, much of the past research has focused on describing pedagogical problems, rather than solving them. This inventory clearly articulates what classroom teachers need to know and be able to do in order to implement student-centered learning in the one-to-one classroom. This inventory provides specific information about best practices to educators who are new to one-to-one technology. It helps teachers understand what to expect and it supports those who are preparing these teachers by providing a resource for planning professional development.

The benefits of Delphi methodology have contributed to the strength of these results. The procedures used for determining consensus provided an optimal way to explore this critical issue of identifying effective one-to-one pedagogy and the anonymity between panelists reduced any potential influence on their opinions in addressing this question. The methodological design of this study was based on “the premise that the collective opinions of expert panelists are of richer quality that the limited view of an individual” (Nworie, 2011, p. 25) and the diversity among this panel was designed to incorporate various perspectives.

The competencies developed in this study are not designed to replace or supersede other existing frameworks. Rather, they work in tandem with related professional standards and competencies developed for different purposes. For instance, the newly revised ISTE (2017) standards for educators have been developed to discuss general technology integration. Additionally, the Teacher Education Technology Competencies (TETCs), recently developed through Delphi methodology, explicate the knowledge and skills university faculty need to adequately prepare their preservice teachers (Slykhuis, Foulger, Graziano, & Schmidt-Crawford, 2017).

The experts in this Delphi study have made a significant contribution to the field. Including one-to-one teachers in the development of this inventory was a central focus of this research, because it is the teacher in the one-to-one classroom who is the most vital resource – not the computer. Technology itself is powerful, but it cannot ever be expected to be responsible for student learning. That power has, and always will, belong to our greatest asset: teachers.

Appendix A

Knowledge Resource Nomination Worksheet (KRNW)

<table>
<tr><th>K-12</th><th>Professional Organizations</th><th>Academic Researchers**</th></tr>
<tr>
<td>

District-wide 1:1 Initiatives

Asheboro City Schools, NC (NC State University Partnership)

Anthony Woodyard, Director of Innovation and Technology

Baltimore County, MD (STAT)

Doug Elmendorf, Principal
Ryan Greene*, Teacher
Jen Mullenax, Past Principal/Assistant Superintendent
Angela Moskunas, Teacher
Stefanie Pautz, Curriculum & Development Office/Researcher
Shelby Wood, Teacher
Mandy Slaysman, Teacher
Nicole Fiorito, Support
Elizabeth Berquist, Professional Development Specialist

Henry County Schools (McDonough, GA)

Virgil Cole*, Associate Superintendent

</td>
<td>

International Society for Technology in Education (ISTE)

ISTE Facebook page
ISTE Professional Learning Communities (Computing Teachers' Network, Innovative Learning Network, Mobile Learning Network, Teacher Education Network)

Suriati Abas, Doctoral Student & Curriculum Developer for 1:1 schools (International student)
Deidre Shetler, Technology Specialist (Phoenix, AZ)
Stephanie Alves, Instructional Technology Facilitator (Urbana, IL)
Melinda Holman, Library Media & Technology Facilitator (Little Rock, AR)
Rachel Dellman, Library Media Specialist (Towson, MD)

</td>
<td>

Boston College

Damian Bebell
Laura M. O'Dwyer

Georgia State University

Nicholas J. Sauers

Indiana University

Ai-Chu Ding
Krista Glazewski
Anne T. Ottenbreit-Leftwich
Ya-Huei Lu, Doctoral Student

Iowa State University

Yi Jin, Doctoral student
Denise Schmidt-Crawford

John Carroll University

Mark Storz
Amy Hoffman

Johns Hopkins University

Christopher Swanson

North Carolina State University

New Learning Ecology Research Group

Hiller Spires
Eric Wiebe
Carl A. Young
Karen Hollebrands

</td>
</tr>
</table>

K-12	Professional Organizations	Academic Researchers**

o Henrico County, VA
    ▪ Instructional Technology Office
o Hudson City School District
    ▪ Chris Purcell*, Teacher (New York, NY)
o Kent School District, Washington
    ▪ Technology Integration Office
o Logan School District, Utah
    ▪ Michael Nelson, One-to-one Technician
o L.A. Unified School District, California
    ▪ Instructional Technology Initiatives Support Office
o Lower Merion School District, Pennsylvania
    ▪ Jen Goldberg, Early Elementary iPad coordinator
    ▪ Brian Cole, Director of Curriculum and Instruction and Professional Learning
o Wake County Schools, NC
    ▪ Brandon Simmons*, Data, Research & Accountability Specialist, K-12/Researcher
o Westhampton Beach School District, NY
	▪ Kris Wiemer, Manager of Instructional Technology (Deerfield, MA)
	    ▪ Fred Haas, Teacher (Hopkinton, MA)
	    ▪ Helen Quinn, Technology Coach (State College, PA)
	    ▪ David Wallace, One-to-One Administrator (Milford Center, OH)
	    ▪ Jewel Anderson, Department Chair, Instructional Technology & Library Services (Peachtree Corners, GA)
	• One-to-One Institute/Project RED
	  o Leslie Wilson, CEO, One-to-One Institute
	  o Michael Gielniak, Director of Programs and Development, One-to-One Institute
	• Society for Information Technology and Teacher Education (SITE)
	  o Mobile Learning SIG; David Slykhuis
	• Maryland Assistive Technology Network (MATN)
	  o Facebook page
		▪ John K. Lee
		  o Kevin Oliver
		  o Jenifer Corn
		• Towson University
		  o Marie Heath
		• University of Minnesota
		  o Lana Peterson
		  o Cassandra Scharber

K-12	Professional Organizations	Academic Researchers**
▪ Tom Short, Instructional Technology Office • Independent 1:1 Schools o Amy McGinn*, Former Teacher, Lausanne Collegiate (Memphis, TN) o Emily Ziegler*, Teacher, St. Paul's School (Baltimore, MD) o Veronica Phillips*, Director of Academic Technology, Calvert Hall High School (Baltimore, MD) o Jon Mundorf*, Teacher, CAST UDL Fellow, 1:1 Teacher and Professional Developer (Gainesville, FL) o Christina Flake*, Teacher, PK Yong Developmental Research School (Gainesville, FL) o Nick Williams*, Director of Instructional Technology, Bartholomew Consolidated School Corporation (Columbus, IN) o Tami Hebert*, UDL Facilitator, Bartholomew Consolidated School Corporation (Columbus, IN)	• Maryland Society for Educational Technology (MSET) o Facebook page (public group) o Facebook (members only) • Maryland Association of Library Media Specialists o Christine Hurley, Library Media Specialist & Technology Coordinator (Williamsport, MD) o Heather Tuya, Library Media Specialist & Technology Coordinator (Hancock, MD)	

*These experts were identified based on referrals from other potential participants.
**The rank of each individual faculty members was not collected, but unless otherwise indicated, all are full-time faculty members conducting one-to-one research within the institution listed.

Appendix B

Initial Item Matrix

Literature type	Author, year	Instructional planning	Instructional delivery	Classroom management	Technology-related skills
Peer-Reviewed Research	Bebell & Kay, 2010	"Behind the scenes use of technology": (a) to gather curricular materials for lesson planning, (b) use school-wide communication system, (c) scheduling, (d) record-keeping and grades, (e) creating materials. (also referred to as "non-instructional practices") Invest additional time in order to learn new tools and approaches to teaching with new technology	Allow students to access digital resources and tools Allow students to collaborate and interact in a variety of ways using technology		

Literature type	Author, year	Instructional planning	Instructional delivery	Classroom management	Technology-related skills
Peer-Reviewed Research	Bebell & O'Dwyer, 2010	N/A	N/A	N/A	N/A
Peer-Reviewed Research	Broussard, Hebert, Welch, & vanMetre, 2014	Using tech to organize or categorize materials (Moodle, Blackboard, bookmarking sites, etc.)	Implementing activities that allow students to interact with one another and teacher (synchronous or asynchronous) Allow students to use the internet to extend their learning (i.e. extension activities, remedial activities, for reinforcement) Use technology as the primary mode for content delivery Use technology to support higher-order thinking skills		

Literature type	Author, year	Instructional planning	Instructional delivery	Classroom management	Technology-related skills
			Incorporate technology as a means of assessing what students have learned		
Peer-Reviewed Research	Chou, Block, & Jesness, 2012	Use technology to differentiate instruction for diverse groups of learners Personalize a student's device to meet his or her specific needs			Knowledge of how specific apps can be incorporated for assignments/learning
Peer-Reviewed Research	Christman, 2014		Use teachable moments to have students quickly research answers to their questions online Allow students to use multimedia to make presentations		

Literature type	Author, year	Instructional planning	Instructional delivery	Classroom management	Technology-related skills
Peer-Reviewed Research	Corn, Tagsold, & Argueta 2012		Use technology to differentiate for students with special needs		Pursue professional development that helps them to gain technological skills
Peer-Reviewed Research	Donovan, Hartley, & Strudler 2007	N/A	N/A	N/A	N/A
Peer-Reviewed Research	Donovan, Green, & Hartley, 2010		Allow students to collaborate using technology Utilize electronic communication between students and teacher Use technology for required purposes (i.e. attendance, grades) Use technology for lecture/presentation purpose Allow students to work at their own pace	Address off-task behavior (device-related) Address off-task behavior (non device-related) Have a back-up plan for forgotten or broken devices Develop routines for device management (i.e. when to charge, etc.)	Be able to fix broken devices Access technology supports, personnel or resources to fix broken devices Device management: how to download apps/software Use cloud-based system, school LMS, other functionalities to create paperless processes Keep up to date on technological resources

Literature type	Author, year	Instructional planning	Instructional delivery	Classroom management	Technology-related skills
Peer-Reviewed Research	Donovan, Green, & Hansen, 2011	N/A	N/A	N/A	N/A
Peer-Reviewed Research	Downes & Bishop, 2015	Use technology to plan relevant and engaging curriculum	Use technology to implement project-based learning Allow students to use technology as a means of sharing their work Use technology to build a team culture among students (i.e. teambuilding activities)		Engage in reflection and inquiry regarding their use of technology in teaching
Peer-Reviewed Research	Dunleavy, Dextert, & Heinecket, 2007		Use technology for: online research, productivity tools, drill and practice, electronic communication, or in online environments to facilitate communication	Address distractions caused by device usage	Solve (or seek resources to solve) hardware problems

Literature type	Author, year	Instructional planning	Instructional delivery	Classroom management	Technology-related skills
Peer-Reviewed Research	Dwyer, Ringstaff, & Sandholtz, 1990		ACOT's 4 stages of evolution for teachers Entry – not relevant Adoption – not relevant Adaptation – increased opportunities for writing through word processing Appropriation – teacher masters use of technology; role reversal between teacher and student; individually-paced instruction; use of problem-based learning		
Peer-Reviewed Research	Garthweit & Weller, 2005	Identify high quality sites that can be used for online research Supplement resources in the curriculum (provide	Mediate discussions and interactions during technology usage in order to facilitate higher level thinking skills	Monitor students' use of devices closely in order to recommend additional resources/supports	Support colleagues in troubleshooting issues with technology Model technology integration to support

Literature type	Author, year	Instructional planning	Instructional delivery	Classroom management	Technology-related skills
		extension to the learning) Create their own website that students may use to access information	Respond to teachable moments presented by the dynamic information students access online (think on your feet in order to react spontaneously and help students make sense of the information that have found) Utilize games that reinforce learning		and mentor colleagues
Peer-Reviewed Research	Gulek & Demitras, 2005	N/A	N/A	N/A	N/A
Peer-Reviewed Research	Heath, 2016	Create co-planning opportunities with colleagues	Be open to constructive feedback from colleagues when implementing new strategies or activities		
Peer-Reviewed Research	Hineman, Boury, & Semich, 2015				High sense of self-efficacy in the area of technology use. For

Literature type	Author, year	Instructional planning	Instructional delivery	Classroom management	Technology-related skills
					example, these teachers feel empowered to try new forms of technology, to change their teaching style, and to take risks using technology. They will also seek out knowledge and skills in order to be successful in doing so. Set goals related to one's own technology knowledge and use Accept support in developing skills and knowledge
Peer-Reviewed Research	Inserra & Short, 2012	N/A	N/A	N/A	N/A

Literature type	Author, year	Instructional planning	Instructional delivery	Classroom management	Technology-related skills
Peer-Reviewed Research	Keengwe, Schnellert, & Mills, 2012	N/A	N/A	N/A	N/A
Peer-Reviewed Research	Klieger, Ben-Hur, & Bar-Yossef, 2010			Monitor students' safe use of the internet	Participate regularly in in-service opportunities re: technology integration Integrate/apply guidance provided in PD
Peer-Reviewed Research	Larkin & Finger, 2011	Plan new ways and more innovative ways to approach old instructional activities (i.e. think SAMR); don't just use device to replace traditional task	Use devices to foster creativity and higher-level thinking skills Integrate devices in multiple instructional activities, beyond simple word processing Utilize devices to create home-school links; among	Respond to disruptions caused by the use of devices	Knowledge of the capabilities of student devices (basics of how to use)

Literature type	Author, year	Instructional planning	Instructional delivery	Classroom management	Technology-related skills
			students to continue learning at home		
Peer-Reviewed Research	LeDoux, 2012	N/A	N/A	N/A	N/A
Peer-Reviewed Research	Lei & Zhao, 2008				Utilize devices for parent-teacher communication
Peer-Reviewed Research	Li, 2010		Empower students to utilize devices to support their own learning (they don't have to rely on the teacher); encourage self-discipline and other forms of self-regulated learning Implement project-based learning Use devices for student to student communication and collaboration		Communicate the potential benefits of device integration with parents (or share overall vision for new initiatives) Access technological expertise/resources available to them Respond positively to the social pressures for adoption of devices Insert one's self into a supportive network where teachers support one another

Literature type	Author, year	Instructional planning	Instructional delivery	Classroom management	Technology-related skills
					Be receptive to change Develop a sense of ownership over technology initiatives
Peer-Reviewed Research	Li & Pow, 2011	N/A	N/A	N/A	N/A
Peer-Reviewed Research	Liu & Milrad, 2010	N/A	N/A	N/A	N/A
Peer-Reviewed Research	Lindqvist, 2015	Determine when it is appropriate to incorporate devices to enhance learning Select pedagogical strategies that best meet the instructional learning outcome	Use devices to start lessons and introduce new content or tasks Use devices to administer, score, and provide feedback on assessments Provide students digital choices for presenting material	Manage distractions caused by the devices (or students who are using device for other purposes than were assigned) Manage students who are resistant to using the device Respond to parents who are resistant to	Troubleshoot technical issues that occur with the devices Utilize devices in coordination with other forms of technology (i.e. IWBs, 3-D printer, networked system, etc.)

Literature type	Author, year	Instructional planning	Instructional delivery	Classroom management	Technology-related skills
			Use devices as a means of student accessibility (not SWD, just accessing information online) Add professional touch or polish to work (teacher or student)	their children using the device Manage students who are not caring for the devices properly	
Peer-Reviewed Research	Lowther, Inan, Ross, & Strahl, 2012	Teacher plans and implements activities that involve a high level of student engagement and interest Teacher provides a combination of specific verbal and written feedback to students Plan for differentiated instruction through the use of devices	Students participate in experiential or hands-on learning Implement activities that allow students to engage in independent inquiry or self-paced research Project-based learning Employs higher level questioning		

Literature type	Author, year	Instructional planning	Instructional delivery	Classroom management	Technology-related skills
			Teacher serves a coach or facilitator of active learning Cooperative and collaborative learning activities with and without technology Individual teaching or tutoring by teacher or trained adult Use of computer for drill and practice		
Peer-Reviewed Research	Maninger & Holden, 2009	Utilize technology in curricular planning	Use technology to provide immediate feedback to students Enhance the collaboration between students (share files, present work, communicate)		Be involved in the decision-making process that shapes the school's instructional initiatives

Literature type	Author, year	Instructional planning	Instructional delivery	Classroom management	Technology-related skills
			Integrate students with disabilities through the use of technology to support instructional accommodations		
Peer-Reviewed Research	Meyer, 2007	Plan assignments and assessments that incorporate student choice and flexible options Curate digital curricular materials, such as e-textbooks, video/multimedia	Provide opportunities for online instruction Use communication tools for a variety of purposes (teacher-student, teacher-parent, student-student)		
Peer-Reviewed Research	Oliver & Corn, 2008		Project-based learning Teachers act as coaches		
Peer-Reviewed Research	Oliver, 2010	"Design and develop digital-age learning experiences and assessments"	"Model digital age work and learning" "Facilitate and inspire student	"Promote and model digital citizenship and responsibility"	"Engage in professional growth and leadership"

Literature type	Author, year	Instructional planning	Instructional delivery	Classroom management	Technology-related skills
			learning and creativity" Increase communication options with students Allow for research and related writing activities	Develop appropriate routines for students who do not have access to their device	Request support for technology integration Provide technology support to fellow teachers
Peer-Reviewed Research	Pautz 2016	N/A	N/A	N/A	N/A
Peer-Reviewed Research	Penuel 2006	N/A	N/A	N/A	N/A
Peer-Reviewed Research	Richardson et al., 2013		PBL and collaborative learning		
Peer-Reviewed Research	Ringstaff, Sandholtz, & Dwyer, 1991	Co-plan instruction with other educators or school support personnel	Utilize peer expertise and peer teaching (allow students to serve as the "expert" in providing technical assistance to one another); also		Attend professional conferences Present at professional conferences

Literature type	Author, year	Instructional planning	Instructional delivery	Classroom management	Technology-related skills
			known as peer coaching		Regularly attend school or district-sponsored workshops Present at school or district-sponsored workshops
Peer-Reviewed Research	Rosen & Beck-Hill, 2012	Differentiate materials and instructional activities	Provide students with opportunities for independence and self-regulation Provide work that is intellectually challenging for students Offer modeling and scaffolding when appropriate Provide descriptive feedback to students during the learning process		
Peer-Reviewed Research	Sandholtz, Ringstaff, & Dwyer, 1990 (ACOT)			Anticipate and avoid possible problems that might	

Literature type	Author, year	Instructional planning	Instructional delivery	Classroom management	Technology-related skills
				arise with the use of technology (i.e. potential methods for cheating, student attitudes, changes to the physical environment, and technical problems) Address students who may be resistant to technology use or paper and pencil methods Address changes in classroom dynamics, such as increased noise level, clutter, and students moving around the room Devise rules for technology use in the classroom	

Literature type	Author, year	Instructional planning	Instructional delivery	Classroom management	Technology-related skills
				Develop techniques for monitoring student work on devices Develop mechanisms for the monitoring the performance of students with special needs	
Peer-Reviewed Research	Shapley, Sheehan, Maloney, & Caranikas-Walker, 2010	Alter instructional practices to incorporate technology-based learning experiences Set instructional goals that incorporate relevant and authentic activities for students Plan instruction that allows for active learning	Support higher level thinking skills through the use of technology Utilize content-specific technology tools during instruction Implement activities or recommendations from mentor, coaches, or other forms of professional development		Improve basic technology skills Use technology to enhance communication with students, parents, and colleagues (i.e. post information to class website) Enhance productivity using technology (i.e. data and record keeping, analyze data, etc.)

Literature type	Author, year	Instructional planning	Instructional delivery	Classroom management	Technology-related skills
		Set personal goals for development of teaching skills (i.e. pedagogy and technology-related)			
Peer-Reviewed Research	Shapley, Sheehan, Maloney, & Caranikas-Walker, 2011	N/A	N/A	N/A	N/A
Peer-Reviewed Research	Spires, Wiebe, Young, Hollebrands, & Lee, 2012	Plan activities that ask students to synthesize information Create an environment of inquiry where students can pursue topics that are of interest to them	Provide opportunities students to practice 21st century skills (i.e. innovation, creativity, problem solving, collaboration) Support students to develop and refine conjectures Allow students to prove or disprove their opinions or conclusions by searching for		

Literature type	Author, year	Instructional planning	Instructional delivery	Classroom management	Technology-related skills
			additional information Use Web 2.0 tools to generate original content and communicate with diverse audiences Teach students how to critically evaluate the information they find online Ask students to develop inventive solutions or products to address problems that they generate Improvise during instruction Serve as a coach and consultant to guide students during learning		

Literature type	Author, year	Instructional planning	Instructional delivery	Classroom management	Technology-related skills
			Facilitate student learning through a variety of methods		
Peer-Reviewed Research	Spires, Oliver, & Corn, 2011	Collaborate with colleagues to share resources and plan instruction		Develop a set of rules and routines regarding technology use in the classroom Teach and then consistently adhere to the rules and routines for technology use Help students to manage technical problems they encounter	Communicate with school leadership; seek to become a part of the decision-making process Clearly articulate to parents how technology will be used in the classroom Use the school or district's content management system to post required information Address technical problems efficiently
Peer-Reviewed Research	Stanhope & Corn, 2014	N/A	N/A	N/A	N/A
Peer-Reviewed Research	Storz & Hoffman, 2012	Allow for flexibility and creativity when designing	Use devices to conduct online research	Address interruptions or distractions caused	Utilize students' technology

Literature type	Author, year	Instructional planning	Instructional delivery	Classroom management	Technology-related skills
		assignments (project-based)	Use devices to complete independent and individualized work Use devices to address "teachable moments" (just-in-time learning) when students have questions during a lesson Offer interactive instructional activities	by devices (online chatting, game playing, internet searching) Monitor students' activities on the devices Monitor students' use of devices for personal communication	knowledge as a resource
Peer-Reviewed Research	Swallow, 2015	N/A	N/A	N/A	N/A
Peer-Reviewed Research	Tigelaar, Dolmans, Wolfhagen, & Van der Vleuten, 2004	N/A	N/A	N/A	N/A
Peer-Reviewed Research	Topper & Lancaster, 2013	N/A	N/A	N/A	N/A

Literature type	Author, year	Instructional planning	Instructional delivery	Classroom management	Technology-related skills
Peer-Reviewed Research	Weston & Bain, 2010	N/A	N/A	N/A	N/A
Peer-Reviewed Research	Zucker, 2004	N/A	N/A	N/A	N/A
White Paper/Report	Bebell, 2008	Prepare and maintain IEPs Adapt or tailor instructional activities to meet students' needs Prepare instructional materials in variety of formats Conduct own research for lesson planning purposes Create and maintain web content	Present information using devices Use devices to help students understand a concept Model relationships using the device Assess students using device		Communicate with students, parents, colleagues and administrators using devices
White Paper/Report	Clarke & Svanaes, 2012	Recognize that the device is only one pedagogical tool	Use devices to increase		Share ideas and collaborate with colleagues

Literature type	Author, year	Instructional planning	Instructional delivery	Classroom management	Technology-related skills
		and plan to use it in conjunction with other methods Plan lessons based on available apps or websites Create digital content that can be used by students (i.e. video tutorials)	opportunities for student collaboration Allow for student-led learning opportunities (facilitate rather than instruct) Serve as facilitator for instruction Allow students to use devices to express themselves using multiple methods (film, media, art, writing) Allow students to work independently on device to complete a goal Facilitate collaborative learning		

Literature type	Author, year	Instructional planning	Instructional delivery	Classroom management	Technology-related skills
			opportunities, both in and out of school		
White Paper/Report	Project RED (Greaves et al., 2012)		Use a variety of appropriate strategies Utilize devices to assess students in order to plan further instruction Use devices to increase student engagement and interest areas Use technology to motivate students to continue learning outside of the classroom		
White Paper/Report	Spires, Wiebe, Young, Hollebrands, & Lee, 2009		Create an instructional environment that allows for the open exchange of ideas through productive inquiry		

Literature type	Author, year	Instructional planning	Instructional delivery	Classroom management	Technology-related skills
			Work collaboratively with students to find critical information and ideas Post questions to students that require them to analyze and synthesize information Teach students to evaluate information they find online Provide students with opportunities to publish and act on their new knowledge Support students to find solutions to real-world problems Coach and guide students to find		

Literature type	Author, year	Instructional planning	Instructional delivery	Classroom management	Technology-related skills
			useful resources that support their learning Be willing to improvise based on the information or ideas students share		
White Paper/Report	State of Maine (Final Report, 2001)		Teacher is committed to learning with the students		Plan and implement PD with and for peers
White Paper/Report	STAT Report Year 1, Baltimore County Public Schools, Baltimore, MD (Morrison, Ross, Morrison, Cheung, & Arthur, 2015)	Create and maintain repository of digital resources Plan collaborative learning that uses technology as a resource Design problems or questions that are specifically related to student's lives	Teacher facilitates or coaches, rather than providing direct instruction Use technology to create a blended learning experience (part F2F, part online) Use of flexible grouping	Set up classroom environment that supports student-centered learning and independent thinking (i.e. through furniture set-up, space for collaboration, visual aids to support higher level thinking, etc.) Allow students to move around the room	

Literature type	Author, year	Instructional planning	Instructional delivery	Classroom management	Technology-related skills
			Allow students multiple modes for responding Allow students to work together to solve problems Focus instruction around an area of inquiry or a basic problem/question Provide higher-order feedback (i.e. offer an explanation, provide new information, extend a student’s thinking) Employ higher level questioning that moves beyond basic recall and stimulates discussion	Allow students to choose where in the room they will work	

Literature type	Author, year	Instructional planning	Instructional delivery	Classroom management	Technology-related skills
			Allow students to solve authentic, real world problems		
White Paper/Report	Horizon Report (NMC, 2015)	Allow students some degree of independence (or choice) in how they are assessed and what they will learn Design instructional activities that meets the needs of students	Serve as an effective facilitator of instruction Engage in problem solving jointly with students Teachers learn from students and vice versa	Demonstrate patience and accountability when coaching students through project completion	
Professional Standards	ISTE Standards for Teachers (2017)	Design learning activities that incorporate a variety of digital tools and resources Use digital tools to research content that will be taught Conduct independent online research to curate digital tools and	Support and model creative thinking Allow students to explore and solve real-world problems Encourage student reflection through the use of collaborative tools Provide opportunities for	Teach students safe, ethical, and legal use of technology Model proper online etiquette and appropriate social interactions	Demonstrate proficiency (or fluency) in the technology platform(s) adopted by the school and/or district Collaborate with peers, administrators, and support staff to gain proficiency in technology systems

Literature type	Author, year	Instructional planning	Instructional delivery	Classroom management	Technology-related skills
		resources that can be incorporated into instruction	students to pursue personal areas of interest Provide individualized and customized learning experiences for students Employ a variety of formative and summative assessment techniques using digital means Address the diverse needs of students by differentiating the content, process, and/or product in instruction		Develop a working understanding of the assistive technology devices, supports, and services utilized by students with special needs who receive instruction in their classroom Exhibit leadership skills by participating in school-based decision-making related to technology and/or instructional initiatives Help colleagues to develop their professional skills related to technology and instruction

Appendix C

Institutional Review Board Approval

TOWSON UNIVERSITY

APPROVAL NUMBER 1610006983

Office of Sponsored
Programs and Research

Towson University
8000 York Road
Towson, MD 21252-0001

t. 410 704-2236
f. 410 704-4494

MEMORANDUM

TO: Andrea Parrish

FROM: Institutional Review Board for the Protection of Human Participants, Elizabeth Katz, Chair

DATE: October 9th, 2017

RE: Approval of Research Involving the Use of Human Participants, Approval Number

Thank you for submitting an Application for Approval of Research Involving the Use of Human Participants to the Institutional Review Board for the Protection of Human Participants (IRB) at Towson University. The IRB hereby approves your proposal titled:

A Delphi Study to Develop an Inventory of Competencies Needed to Facilitate Instruction in Student-Centered, One-to-One Learning Environments

Please note that this approval is granted on the condition that you provide the IRB with the following information and/or documentation:

N/A

If you should encounter any new risks, reactions, or injuries while conducting your research, please notify the IRB. Should your research extend beyond one year in duration, or should there be substantive changes in your research protocol, you will need to submit another application for approval at that time.

We wish you every success in your research project. If you have any questions, please call me at (410) 704-2236.

cc: Bill Sadera

Appendix D

Informed Consent Form

Principal Investigator: Andrea Parrish
Phone: (410) 704-3835
Email: aparrish@towson.edu

Purpose of the Study

The purpose of this study is to develop an inventory of teaching competencies needed to facilitate instruction in student-centered, one-to-one learning environments. This will be conducted by assembling a panel of experts to identify these competencies.

Procedures

The Delphi method used in this study is characterized by several rounds of surveys. While the number of rounds can only be determined based on the results, participants in this study can expect to complete between two and five brief online surveys which ask to rate the importance level of teaching competencies in one-to-one classrooms. Each survey will be provided via email from the principal investigator and participants will be given a two-week window in which to submit their results electronically. At the start of each new round, participants will be informed of the previous round's results and offered opportunities to refine their responses.

Risks/Discomfort

There are no known risks associated with participation in the study. However, should the participants wish to discontinue participation, they may do so at any time.

Benefits

It is hoped that the resulting inventory can be useful in addressing gaps that exist in the research on one-to-one technology and student-centered pedagogy, inform the design of teacher preparation programs, and support professional development efforts of schools who undertake one-to-one technology initiatives.

Alternatives to Participation

Participation in this study is voluntary. You are free to withdraw or discontinue participation at any time. Refusal to participate in this study will hold no negative consequences.

Cost Compensation

Participation in this study will involve no costs or payments to you.

Confidentiality

All information collected during the study period will be kept strictly confidential. You will be identified through identification numbers. No publications or reports from this project will include identifying information on any participant. If you agree to join this study, please sign your name below.

_____ I have read and understood the information on this form.

_____ I have had the information on this form explained to me.

___________________________________ ____________
Subject's Signature Date

___________________________________ ____________
Witness to Consent Procedures Date

___________________________________ ____________
Principal Investigator Date

If you have any questions regarding this study, please contact Andrea Parrish at (410) 704-3835 or the Institutional Review Board Chairperson, Dr. Elizabeth Katz, Office of University Research Services, 8000 York Road, Towson University, Towson, MD 21252; (410) 704-2236.

Appendix E

Round One Survey

TOWSON UNIVERSITY

0% Complete

A Delphi Study to Develop an Inventory of Competencies Needed to Facilitate Instruction in Student-Centered, One-to-One Learning Environments

The purpose of this survey is to utilize the experience of subject matter experts to identify competencies that teachers need in order to facilitate instruction in student-centered, one-to-one learning environments. There are three sections in this survey: background, competency ratings, and additional comments.

The survey will take approximately 20 minutes to complete. Thank you for your participation. Please review the information below and sign to indicate your consent to participate.

Click HERE to view an introductory video with instructions from the researcher.

NEXT

TOWSON UNIVERSITY

10% Complete

Informed Consent Form

Question 1

Principal Investigator: Andrea Parrish
Phone: (410) 704-3835
Email: aparrish@towson.edu

Purpose of the Study

The purpose of this study is to develop an inventory of teaching competencies needed to facilitate instruction in student-centered, one-to-one learning environments. This will be conducted by assembling a panel of experts to identify these competencies.

Procedures

The Delphi method used in this study is characterized by several rounds of surveys. While the number of rounds can only be determined based on the results, participants in this study can expect to complete between two and five brief online surveys which ask to rate the importance level of teaching competencies in one-to-one classrooms. Each survey will be provided via email from the principal investigator and participants will be given a two-week window in which to submit their results electronically. At the start of each new round, participants will be informed of the previous round's results and offered opportunities to refine their responses.

Risks/Discomfort

There are no known risks associated with participation in the study. However, should the participants wish to discontinue participation, they may do so at any time.

Benefits

It is hoped that the resulting inventory can be useful in addressing gaps that exist in the research on one-to-one technology and student-centered pedagogy, inform the design of teacher preparation programs, and support professional development efforts of schools who undertake one-to-one technology initiatives.

Alternatives to Participation

Participation in this study is voluntary. You are free to withdraw or discontinue participation at any time. Refusal to participate in this study will hold no negative consequences.

Cost Compensation

Participation in this study will involve no costs or payments to you.

Confidentiality

All information collected during the study period will be kept strictly confidential. You will be identified through identification numbers. No publications or reports from this project will include identifying information on any participant.

If you agree to join this study, check each box below then type your full name below.

☐ I have read and understood the information on this form.
☐ I have had the information on this form explained to me.

Question 2

Your signature indicates that you are at least 18 years of age; you have read this consent form; any questions have been answered to your satisfaction and you voluntarily agree to participate in this research study. If you agree to participate, please type your name below.

If you have any questions regarding this study, please contact Andrea Parrish at (410) 704-3835 or the Institutional Review Board Chairperson, Dr. Elizabeth Katz, Office of University Research Services, 8000 York Road, Towson University, Towson, MD 21252; (410) 704-2236.

BACK NEXT

TOWSON UNIVERSITY

20% Complete

Section I: Background Information

The purpose of this section is to gather information about you and your experience with one-to-one technology. Please answer each question by choosing the best answer that describes you or by providing a brief written response.

Question 3

Your Name:

Question 4

Describe your current professional role: (Check all that apply)

- ☐ Teacher
- ☐ Technology support role (i.e. technology specialist, mentor, coach)
- ☐ School-based administrator
- ☐ District-level administrator
- ☐ Educational researcher
- ☐ Other (please specify)

Question 5

How many years have you been working in this role?

- ◯ Less than 1 year
- ◯ 1-2 years
- ◯ 3-5 years

◯5 or more years

Question 6

How many years of experience do you have with one-to-one technology?

◯Less than 1 year
◯1-2 years
◯3-5 years
◯5 or more years

BACK NEXT

TOWSON UNIVERSITY

30% Complete

Section II: Competency Ratings

This section allows you to rate a list of proposed teaching competencies. Your ratings indicate what you think teachers should know and be able to do in a student-centered, one-to-one classroom. Please rate each teaching competency on a rating scale of 1-9, where 1 is "Not Important/Irrelevant" and 9 is "Essential." Please use the comment box at the bottom of each screen to share additional comments you may have.

For your reference, a full listing of these competencies is available HERE.

Questions 7 - 12

Please rate the level of importance for the following proposed teaching competencies:

(1) Not Important/Irrelevant
(2) Very Low Importance
(3) Low Importance
(4) Slightly Important
(5) Of Average Importance
(6) Moderately Important
(7) Very Important
(8) Extremely Important
(9) Essential

	1	2	3	4	5	6	7	8	9
Replace or enhance traditional instructional tasks with technological approaches.	○	○	○	○	○	○	○	○	○
Gather, organize, and categorize digital curricular resources when planning instruction.	○	○	○	○	○	○	○	○	○
Create and maintain web content for	○	○	○	○	○	○	○	○	○

student use, such as a class website, video tutorials, or online modules.

Address and redirect off-task behaviors or distractions caused by device usage in the classroom (i.e. online chatting, game playing, internet searching, social media use).	○	○	○	○	○	○	○	○	○
Differentiate instructional materials, activities, or technology devices to meet students' individual learning needs.	○	○	○	○	○	○	○	○	○
Use technology to build a team culture among students by allowing students to work together in groups on collaborative tasks.	○	○	○	○	○	○	○	○	○

Question 13

Do you have any comments about the items you have rated above?

BACK NEXT

TOWSON UNIVERSITY

40% Complete

Questions 14 - 18

Please rate the level of importance for the following proposed teaching competencies:

(1) Not Important/Irrelevant
(2) Very Low Importance
(3) Low Importance
(4) Slightly Important
(5) Of Average Importance
(6) Moderately Important
(7) Very Important
(8) Extremely Important
(9) Essential

	1	2	3	4	5	6	7	8	9
Utilize peer expertise to complete collaborative projects during instruction.	○	○	○	○	○	○	○	○	○
Encourage student reflection through the use of collaborative digital tools during instruction.	○	○	○	○	○	○	○	○	○
Design instruction which allows students to use technology for independent inquiry that is based on student-selected topics or interests.	○	○	○	○	○	○	○	○	○
Support students' ability to self-regulate during the learning process by teaching goal-setting, self-monitoring, and/or allowing students to work at their own pace.	○	○	○	○	○	○	○	○	○
Design instruction which allows students a degree of choice in how they will respond in an activity or how they will be assessed in the learning process.	○	○	○	○	○	○	○	○	○

Question 19

Do you have any comments about the items you have rated above?

BACK NEXT

TOWSON UNIVERSITY

50% Complete

Questions 20 - 25

Please rate the level of importance for the following proposed teaching competencies:

(1) Not Important/Irrelevant
(2) Very Low Importance
(3) Low Importance
(4) Slightly Important
(5) Of Average Importance
(6) Moderately Important
(7) Very Important
(8) Extremely Important
(9) Essential

	1	2	3	4	5	6	7	8	9
Design instruction that allows students to use digital and non-digital tools to solve real world problems.	○	○	○	○	○	○	○	○	○
Utilize games to reinforce students' thinking and learning.	○	○	○	○	○	○	○	○	○
Encourage students to publish or act on their new knowledge by using a variety of media.	○	○	○	○	○	○	○	○	○
Provide an academic environment that is intellectually challenging.	○	○	○	○	○	○	○	○	○
Exercise flexibility during instruction by improvising to meet students' learning needs (i.e. extend the amount of time provided, offer additional resources, offer modeling and scaffolding).	○	○	○	○	○	○	○	○	○
Adjust and respond to novel information or ideas that students share.	○	○	○	○	○	○	○	○	○

Question 26

Do you have any comments about the items you have rated above?

BACK NEXT

TOWSON UNIVERSITY

60% Complete

Questions 27 - 32

Please rate the level of importance for the following proposed teaching competencies:

(1) Not Important/Irrelevant
(2) Very Low Importance
(3) Low Importance
(4) Slightly Important
(5) Of Average Importance
(6) Moderately Important
(7) Very Important
(8) Extremely Important
(9) Essential

	1	2	3	4	5	6	7	8	9
Capitalize on teachable moments by supporting student inquiry.	○	○	○	○	○	○	○	○	○
Employ a variety of formative and summative assessment techniques using digital means.	○	○	○	○	○	○	○	○	○
Develop, teach and implement expectations and routines for device management in the classroom (i.e. how to prevent breakage, when to charge, what to do if a device is broken/lost, etc.).	○	○	○	○	○	○	○	○	○
Anticipate potential problems that might occur during instruction and have a back-up plan in the event that technology fails.	○	○	○	○	○	○	○	○	○
Utilize students' expertise, personal expertise, and support personnel outside of the classroom to ensure that technical issues do not interfere with teaching and learning.	○	○	○	○	○	○	○	○	○
Engage students, parents, or colleagues who may be resistant to the use of technology by providing information about effective technology integration.	○	○	○	○	○	○	○	○	○

Question 33

Do you have any comments about the items you have rated above?

BACK

NEXT

70% Complete

Questions 34 - 39

Please rate the level of importance for the following proposed teaching competencies:

(1) Not Important/Irrelevant
(2) Very Low Importance
(3) Low Importance
(4) Slightly Important
(5) Of Average Importance
(6) Moderately Important
(7) Very Important
(8) Extremely Important
(9) Essential

	1	2	3	4	5	6	7	8	9
Engineer the classroom environment to support student-centered learning activities (i.e. allow space for collaboration).	○	○	○	○	○	○	○	○	○
Monitor students' use of technology in the classroom in order to determine safe and appropriate utilization of online tools.	○	○	○	○	○	○	○	○	○
Manage environmental factors that can be inherent with student-centered approaches to instruction, such as increased noise level, materials, clutter, or movement.	○	○	○	○	○	○	○	○	○
Pursue and accept professional development opportunities to gain technological, pedagogical, and content-based knowledge.	○	○	○	○	○	○	○	○	○
Apply recommendations or resources shared by mentors, coaches, colleagues, or other professional	○	○	○	○	○	○	○	○	○

development opportunities.

Set goals related to personal growth in technology integration. ○ ○ ○ ○ ○ ○ ○ ○ ○

Question 40

Do you have any comments about the items you have rated above?

BACK NEXT

TOWSON UNIVERSITY

80% Complete

Questions 41 - 44

Please rate the level of importance for the following proposed teaching competencies:

(1) Not Important/Irrelevant
(2) Very Low Importance
(3) Low Importance
(4) Slightly Important
(5) Of Average Importance
(6) Moderately Important
(7) Very Important
(8) Extremely Important
(9) Essential

	1	2	3	4	5	6	7	8	9
Demonstrate proficiency in the technology platform(s) adopted by the school and/or district.	○	○	○	○	○	○	○	○	○
Seek opportunities to provide informal support, modeling, mentoring, or coaching to fellow colleagues.	○	○	○	○	○	○	○	○	○
Engage in reflection and inquiry with colleagues and/or administrators about effective teaching practices.	○	○	○	○	○	○	○	○	○
Communicate the vision for new or previously adopted initiatives with both internal and external stakeholders.	○	○	○	○	○	○	○	○	○

Question 45

Do you have any comments about the items you have rated above?

BACK NEXT

TOWSON UNIVERSITY

90% Complete

Section III: Additional Comments

Please use the response areas below to offer any additional comments you may have about this research. In addition, you are always welcome to contact me at aparrish@towson.edu or (410) 704-3835 to share concerns or ask questions.

Question 46

Are there any additional competencies that you believe the existing items do not address?

Question 47

Do you have any questions, concerns, or additional comments about this research that you wish to share?

BACK

NEXT

TOWSON UNIVERSITY

100% Complete

Thank you for taking the survey.
Finish

Appendix F

Round Two Survey

TOWSON UNIVERSITY

0% Complete

Question 1

Your Name:

Click HERE to view an introductory video with instructions from the researcher.

Thank you for your participation in the first survey of this research study. Most of the proposed competencies that were listed in the first survey received high levels of agreement and will be included in the final inventory of teaching competencies for facilitating instruction in one-to-one classrooms.

To view a list of the competencies which were highly rated in the first round, click HERE.

NEXT

TOWSON UNIVERSITY

20% Complete

There was one item on the first survey that received a lower rate of agreement than most. In order to respond to the question below, you will need the resource that was provided to you in the original email invitation to the second round survey. Minimize this window and find the attachment to that email titled, "**INFO FOR ITEM 2_YOUR NAME.**" When you have reviewed this, answer Question #2 below.

Questions 2 - 2

Now that you see how you responded to this item compared to the rest of the participants, please reconsider your rating. You can increase it, decrease it, or leave it the same:

(1) Not Important/Irrelevant
(2) Very Low Importance
(3) Low Importance
(4) Slightly Important
(5) Of Average Importance
(6) Moderately Important
(7) Very Important
(8) Extremely Important
(9) Essential

	1	2	3	4	5	6	7	8	9
Utilize games to reinforce students' thinking and learning.	○	○	○	○	○	○	○	○	○

BACK NEXT

TOWSON UNIVERSITY

40% Complete

Questions 3 - 7

The following items appeared in Round 1 and have been revised or edited based on recommendations from one or more members of the group in the comments box. Please rate the level of importance for the following proposed teaching competencies:

(1) Not Important/Irrelevant
(2) Very Low Importance
(3) Low Importance
(4) Slightly Important
(5) Of Average Importance
(6) Moderately Important
(7) Very Important
(8) Extremely Important
(9) Essential

	1	2	3	4	5	6	7	8	9
Select the instructional tool (digital or non-digital) that best meets the intended learning outcome.	○	○	○	○	○	○	○	○	○
Create and maintain web content for students using digital tools.	○	○	○	○	○	○	○	○	○
Allow students to collaborate with peers on projects using digital and non-digital means.	○	○	○	○	○	○	○	○	○
Employ a variety of formative and summative assessment techniques using digital and non-digital means.	○	○	○	○	○	○	○	○	○
Address concerns of students, parents, or colleagues who may be resistant to the use of technology.	○	○	○	○	○	○	○	○	○

Question 8

OPTIONAL: You may use this space to share insight that would help the researcher to understand why you chose these ratings.

BACK

NEXT

TOWSON UNIVERSITY

60% Complete

Questions 9 - 13

The following competencies did not appear in the first survey but were generated to address the recommendations made by one or more participants in the comments box. Please rate the level of importance for the following proposed teaching competencies:

(1) Not Important/Irrelevant
(2) Very Low Importance
(3) Low Importance
(4) Slightly Important
(5) Of Average Importance
(6) Moderately Important
(7) Very Important
(8) Extremely Important
(9) Essential

	1	2	3	4	5	6	7	8	9
Demonstrate proficiency with the device students are using in the classroom.	○	○	○	○	○	○	○	○	○
Provide students with choices of digital and non-digital tools in the learning process.	○	○	○	○	○	○	○	○	○
Use evidence of student learning to customize instruction and plan targeted small group or individual instruction.	○	○	○	○	○	○	○	○	○
Teach and model digital citizenship in the classroom through online communication.	○	○	○	○	○	○	○	○	○
Identify and utilize mentors, coaches, colleagues, or other available experts who can support in the development of technology integration and pedagogical skills.	○	○	○	○	○	○	○	○	○

Question 14

OPTIONAL: You may use this space to share insight that would help the researcher to understand why you chose these ratings.

BACK NEXT

80% Complete

Questions 15 - 19

The following competencies also did not appear in the first survey but were generated to address the recommendations made by one or more participants in the comments box. Please rate the level of importance for the following proposed teaching competencies:

(1) Not Important/Irrelevant
(2) Very Low Importance
(3) Low Importance
(4) Slightly Important
(5) Of Average Importance
(6) Moderately Important
(7) Very Important
(8) Extremely Important
(9) Essential

	1	2	3	4	5	6	7	8	9
Demonstrate basic knowledge of copyright laws and help students identify key issues in this area.	○	○	○	○	○	○	○	○	○
Solve common technology issues with students' devices in the classroom (i.e. wireless internet connectivity problems, device updates, blocked content, etc.).	○	○	○	○	○	○	○	○	○
Utilize knowledge of content and pedagogy when making decisions about the use of technology in teaching.	○	○	○	○	○	○	○	○	○
Involve parents in professional development related to technology use.	○	○	○	○	○	○	○	○	○
Utilize technology to provide personalized learning opportunities for students.	○	○	○	○	○	○	○	○	○

Question 20

OPTIONAL: You may use this space to share insight that would help the researcher to understand why you chose these ratings.

BACK

NEXT

TOWSON UNIVERSITY

100% Complete

Thank you for taking the survey.

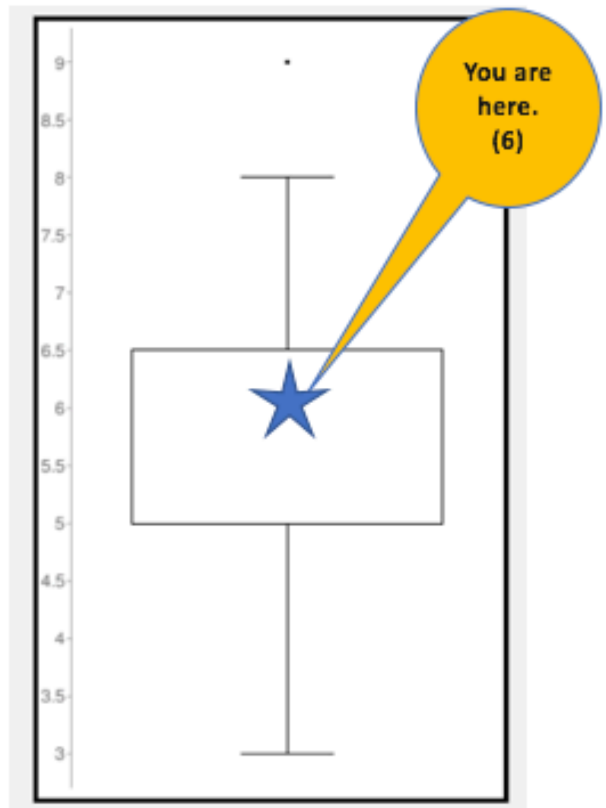
Finish

Appendix G

Controlled Feedback Format (Round Two)

While all other items on the first survey had high rates of agreement, the competency below was rated lower, suggesting that there are differences in opinion that would benefit from reconsideration. This means you have an opportunity to change your rating for this item, or keep it the same. The box shows you where the middle 50% of the responses fell. **Your rated this item as 6.0 (Moderately Important).**

Item: "Utilize games to reinforce students' thinking and learning."



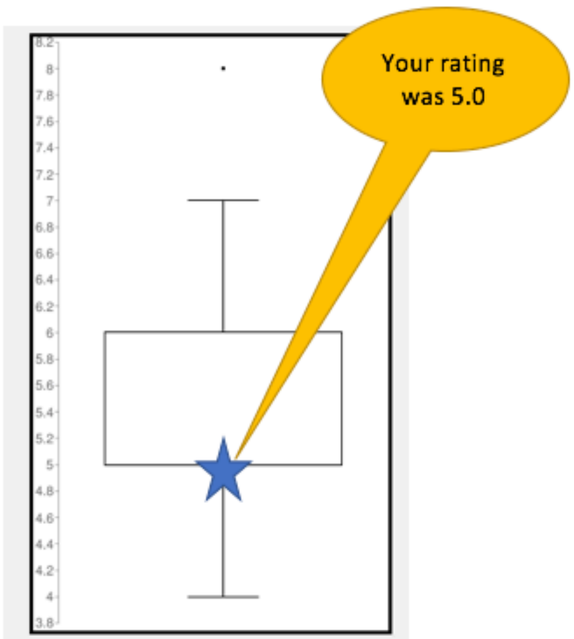
Now that you see how you responded to this item compared to the rest of the participants, please reconsider your rating. You can increase it, decrease it, or leave it the same. Please go to Item #2 in the survey to enter your answer.

Appendix H

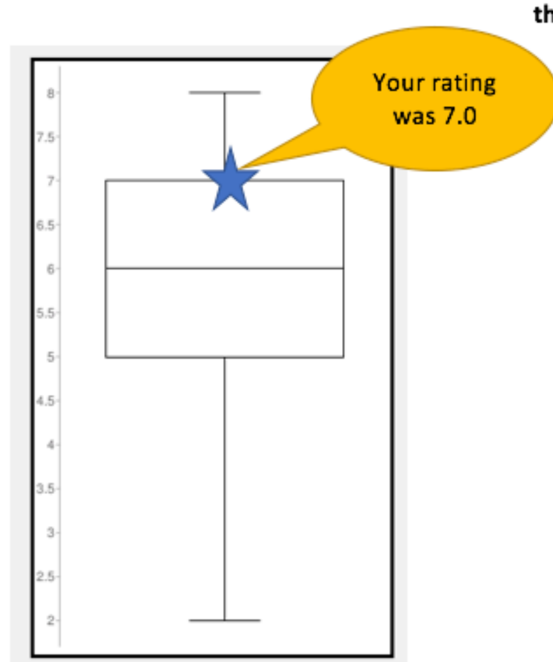
Controlled Feedback Format (Round Three)

While most items on the last survey had high rates of agreement, the ones below were rated lower, suggesting that there are differences in opinion that would benefit from reconsideration. This means you have an opportunity to change your rating for these items, or keep them the same. The boxes within each plot show where the middle 50% of the group responses fell. The star and yellow bubble indicates your response.

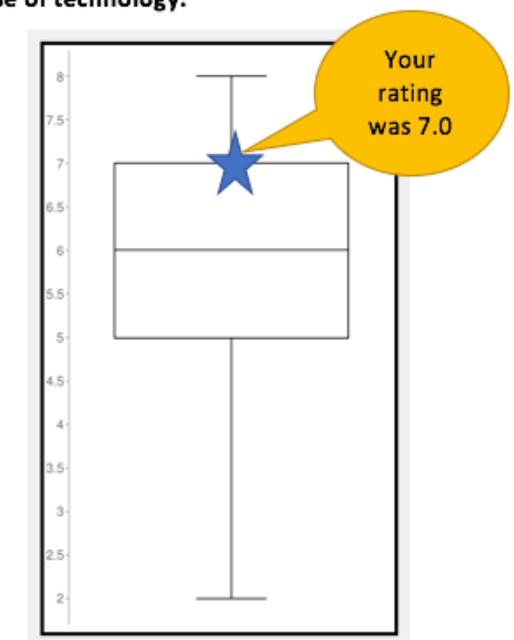
Question 28. Utilize games to reinforce students' thinking and learning.



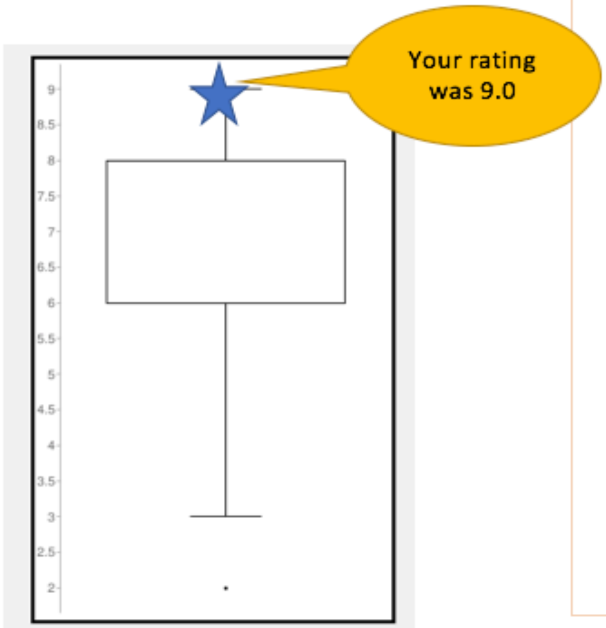
Question 29. Create and maintain web content for students using digital tools.



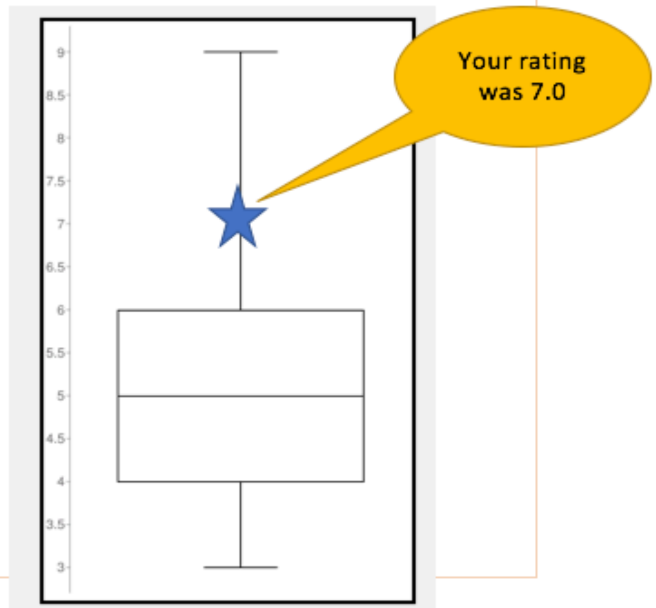
Question 30. Address concerns of students, parents, or colleagues who may be resistant to the use of technology.



Question 31. Demonstrate proficiency with the device students are using in the classroom.



Question 32. Involve parents in professional development related to technology use.



Now that you see how you responded to these items compared to the rest of the participants, please reconsider your rating for each item. You can increase it, decrease it, or leave it the same. Please go to each of these items in the survey to enter your answer.

Appendix I

Round Three Survey

TOWSON UNIVERSITY

0% Complete

SECTION 1: INTRODUCTION

Question 1

Your Name:

Thank you for your continued participation in this research study. This survey constitutes the third round in the Delphi data collection process. Click HERE to watch a brief video from the researcher. The video will provide you with additional instructions for completing this survey:

If you would like to view a list of the competencies which were highly rated in the first two rounds, click HERE.

NEXT

TOWSON UNIVERSITY

17% Complete

SECTION 2: COMPETENCY RANKINGS

The competencies that appear in the next section are ones that will be included in the final inventory. These have been categorized by theme for your review. Your task now is to rank the items within each category, based on order of importance. For example, since there are 6 items under the "Instructional Planning" category, assign each item a 1, 2, 3, 4, 5, or 6, where 1=Most Important and 6 = Least Important. Each item must receive its own unique rating, no ties please.

Questions 2 - 7

Instructional Planning

Please rank the following items in order of importance. (1 = Most Important, 6 = Least Important)

Select Answer ⇕ Utilize knowledge of content and pedagogy to select the instructional tool (digital or non-digital) that best meets the intended learning outcome.

Select Answer ⇕ Gather, organize, and categorize digital curricular resources when planning instruction.

Select Answer ⇕ Differentiate instructional materials, activities, or technology devices to meet students' individual learning needs.

Select Answer ⇕ Design instruction which allows students to use technology for independent inquiry that is based on student-selected topics, interests, or real world problems.

Select Answer ⇕ Design instruction which allows students a degree of choice in how they will respond in an activity or how they will be assessed in the learning process.

Select Answer ⇕ Anticipate potential problems that might occur during instruction and have a back-up plan in the event that technology fails.

Question 8

You may use this space to share insight that would help the researcher to understand why you chose these rankings.

BACK

NEXT

TOWSON UNIVERSITY

33% Complete

Questions 9 - 11

Assessment of Learning

Please rank the following items in order of importance. (1 = Most Important, 3 = Least Important)

Select Answer Employ a variety of formative and summative assessment techniques using digital and non-digital means.

Select Answer Use evidence of student learning to customize instruction and plan targeted small group or individual instruction.

Select Answer Include student reflection opportunities as part of the assessment process using digital and non-digital means.

Question 12

You may use this space to share insight that would help the researcher to understand why you chose these rankings.

BACK

NEXT

TOWSON UNIVERSITY

50% Complete

Questions 13 - 18

Classroom Management

Please rank the following items in order of importance. (1 = Most Important, 6 = Least Important)

Select Answer Monitor students' use of technology in the classroom in order to determine safe and appropriate utilization of online tools.

Select Answer Address and redirect off-task behaviors or distractions caused by device usage in the classroom (i.e. online chatting, game playing, internet searching, social media use).

Select Answer Provide an academic environment that is intellectually challenging.

Select Answer Develop, teach and implement expectations and routines for device management in the classroom (i.e. how to prevent breakage, when to charge, what to do if a device is broken/lost, etc.).

Select Answer Engineer the classroom environment to support student-centered learning activities (i.e. allow space for collaboration).

Select Answer Manage classroom dynamics inherent with student-centered approaches to instruction, such as increased noise level, materials, clutter, or movement.

Question 19

You may use this space to share insight that would help the researcher to understand why you chose these rankings.

BACK NEXT

TOWSON UNIVERSITY

67% Complete

Questions 20 - 26

Professionalism & Leadership

Please rank the following items in order of importance. (1 = Essential, 7 = Irrelevant/Not Important)

- Select Answer — Set goals related to professional growth in technology integration.
- Select Answer — Pursue and accept professional development opportunities to gain technological, pedagogical, and content-based knowledge.
- Select Answer — Identify and utilize mentors, coaches, colleagues, or other available experts who can support in the development of technology integration and pedagogical skills.
- Select Answer — Apply recommendations or resources shared by mentors, coaches, colleagues, or other professional development opportunities.
- Select Answer — Seek opportunities to provide informal support, modeling, mentoring, or coaching to fellow colleagues.
- Select Answer — Engage in reflection and inquiry with colleagues and/or administrators about effective teaching practices.
- Select Answer — Communicate the vision for new or previously adopted initiatives with both internal and external stakeholders.

Question 27

You may use this space to share insight that would help the researcher to understand why you chose these rankings.

BACK NEXT

TOWSON UNIVERSITY

83% Complete

SECTION 3: REVISIT PREVIOUS ITEMS

There were five items on the last survey that received a lower rate of agreement than most. Therefore, in an effort to achieve consensus on whether these items are important enough to be included in the final list, you have an opportunity to revise your rating for each of these five items.

In order to respond to these final five questions, you will need the resource that was provided to you in the original email invitation to the third round survey. Minimize this window and find the attachment to that email titled, "**INFO FOR ITEM 2_YOUR NAME RD 3.**" After you have reviewed the data in your attachment, answer Questions 28-32 below.

Now that you see how you responded to this item compared to the rest of the participants, please reconsider your rating. You can increase it, decrease it, or leave it the same for the following items:

Questions 28 - 32

Please rate the level of importance for the following proposed teaching competencies:

(1) Not Important/Irrelevant
(2) Very Low Importance
(3) Low Importance
(4) Slightly Important
(5) Of Average Importance
(6) Moderately Important
(7) Very Important
(8) Extremely Important
(9) Essential

	1	2	3	4	5	6	7	8	9
Utilize games to reinforce students' thinking and learning.	○	○	○	○	○	○	○	○	○
Create and maintain web content using digital tools.	○	○	○	○	○	○	○	○	○

Address concerns of students, parents, or colleagues who may be resistant to the use of technology.	○	○	○	○	○	○	○	○	○
Demonstrate proficiency with the device students are using in the classroom.	○	○	○	○	○	○	○	○	○
Involve parents in professional development related to technology use.	○	○	○	○	○	○	○	○	○

Question 33

You may use this space to share insight that would help the researcher to understand why you chose these ratings.

BACK NEXT

TOWSON UNIVERSITY

100% Complete

Thank you for completing the Round 3 survey!

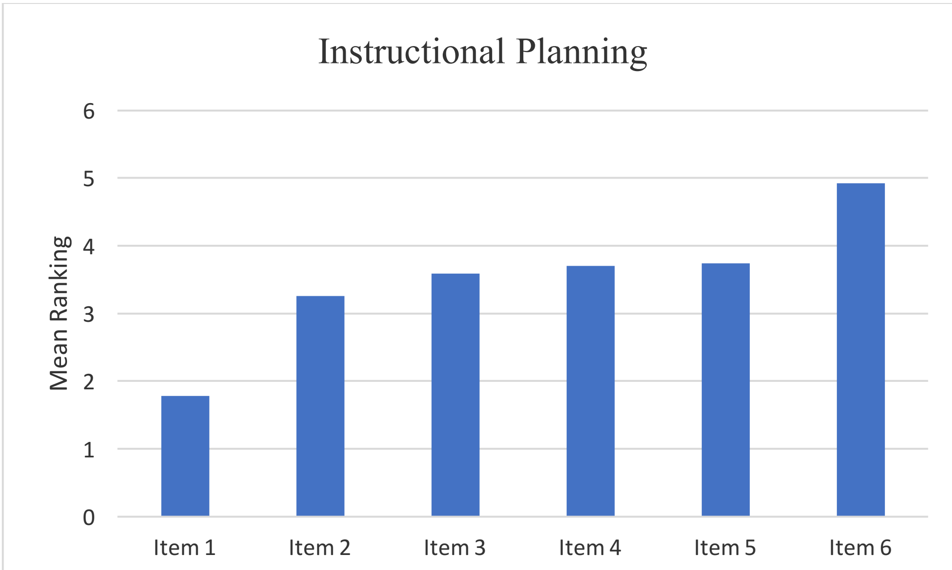
Finish

Appendix J

Round Three Ranking Data – Detailed View

Table J1

Instructional Planning Rankings



Item 1 = Utilize knowledge of content and pedagogy to select the instructional tool (digital or non-digital) that best meets the intended learning outcome.

Item 2 = Gather, organize, and categorize digital curricular resources.

Item 3 = Differentiate instructional materials, activities, or technology devices to meet students' individual learning needs.

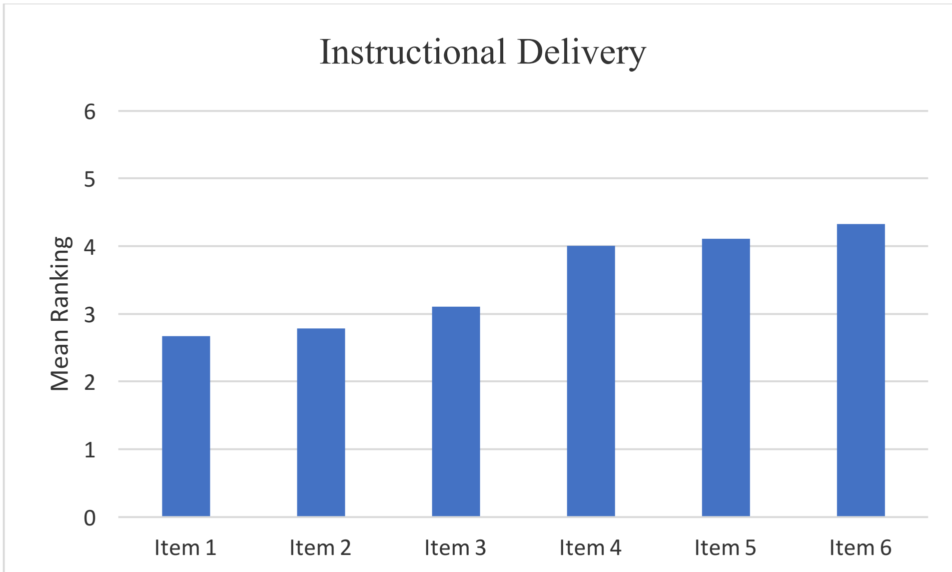
Item 4 = Design instruction which allows students to use technology for independent inquiry that is based on student-selected topics, interests, or real world problems.

Item 5 = Design instruction which allows students a degree of choice in how they will respond in an activity or how they will be assessed in the learning process.

Item 6 = Anticipate potential problems that might occur during instruction and have a back-up plan in the event that technology fails.

Table J2

Instructional Delivery Rankings



Item 1 = Use technology as a means for building collaborative skills between students.

Item 2 = Support students' ability to self-regulate during the learning process by teaching goal-setting, self-monitoring, and/or allowing students to work at their own pace.

Item 3 = Encourage students to publish or act on their new knowledge by using a variety of media.

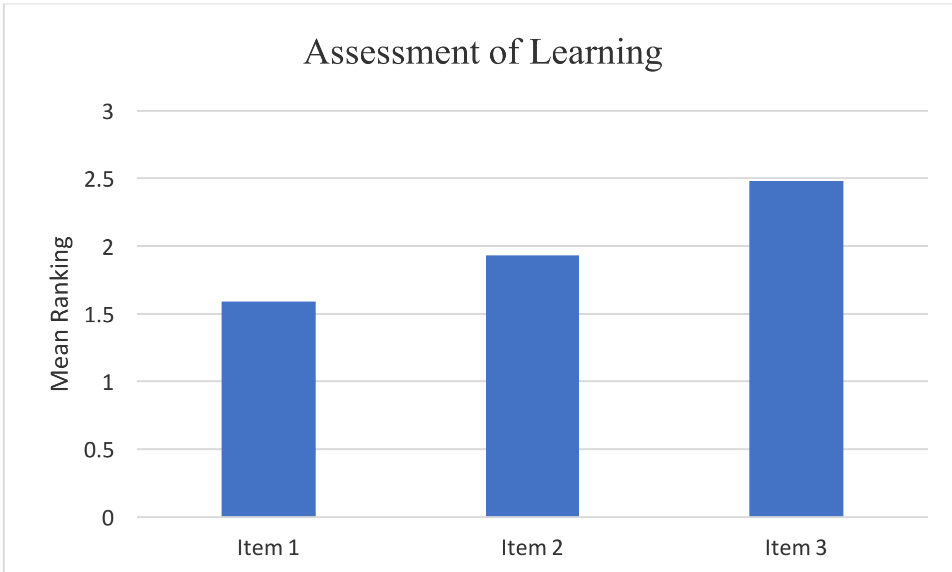
Item 4 = Exercise flexibility during instruction by improvising to meet students' learning needs (i.e. offer choices in digital tools, extend the amount of time provided, offer additional resources, offer modeling and scaffolding).

Item 5 = Adjust and respond to novel information or ideas that students share.

Item 6 = Capitalize on teachable moments by supporting student inquiry.

Table J3

Assessment of Learning Rankings



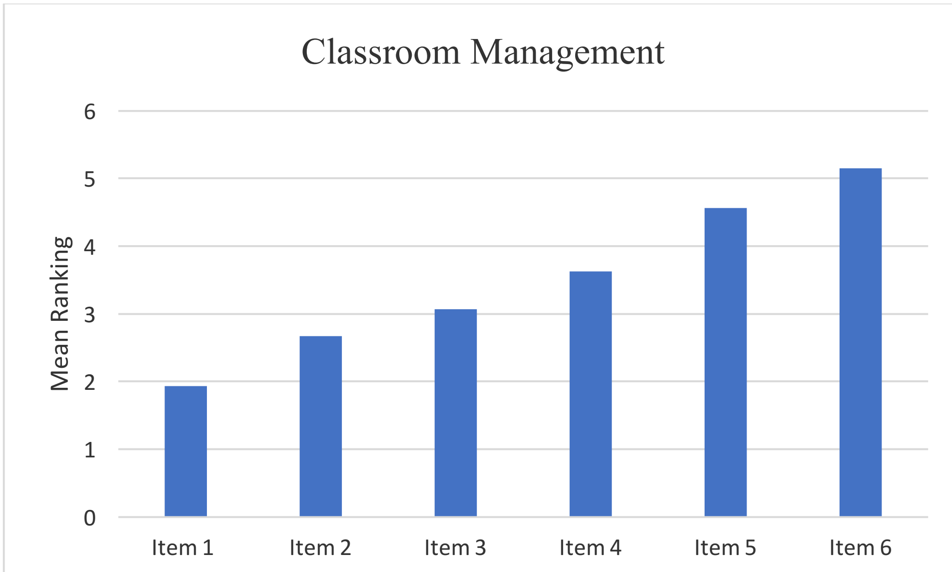
Item 1 = Employ a variety of formative and summative assessment techniques using digital and non-digital means.

Item 2 = Use evidence of student learning to customize instruction and plan targeted small group or individual instruction.

Item 3 = Include student reflection opportunities as part of the assessment process using digital and non-digital means.

Table J4

Classroom Management Rankings



Item 1 = Monitor students' use of technology in the classroom in order to determine safe and appropriate utilization of online tools.

Item 2 = Address and redirect off-task behaviors or distractions caused by device usage in the classroom (i.e. online chatting, game playing, internet searching, social media use).

Item 3 = Provide an academic environment that is intellectually challenging.

Item 4 = Develop, teach and implement expectations and routines for device management in the classroom (i.e. how to prevent breakage, when to charge, what to do if a device is broken/lost, etc.).

Item 5 = Engineer the classroom environment to support student-centered learning activities (i.e. allow space for collaboration).

Item 6 = Manage classroom dynamics inherent with student-centered approaches to instruction, such as increased noise level, materials, clutter, or movement.

Table J5

Professionalism and Leadership Rankings

Item 1 = Set goals related to professional growth in technology integration.

Item 2 = Pursue and accept professional development opportunities to gain technological, pedagogical, and content-based knowledge.

Item 3 = Identify and utilize mentors, coaches, colleagues, or other available experts who can support in the development of technology integration and pedagogical skills.

Item 4 = Apply recommendations or resources shared by mentors, coaches, colleagues, or other professional development opportunities.

Item 5 = Seek opportunities to provide informal support, modeling, mentoring, or coaching to fellow colleagues.

Item 6 = Engage in reflection and inquiry with colleagues and/or administrators about effective teaching practices.

Item 7 = Communicate the vision for new or previously adopted initiatives with both internal and external stakeholders.

References

Balasubramanian, R. & Awarwal, D. (2012). Delphi technique – a review. *International Journal of Public Health Dentistry, 3*(2), 16-25. Retrieved from http://journalgateway.com/ijphd

Barron, B. (2006). Interest and self-sustained learning as catalysts of development: A learning ecology perspective. *Human Development, 49*, 193-224. doi: 10.1159/000094368

Bebell, D. (2008). *Berkshire wireless learning initiative: Year two evaluation report.* Boston College: InTASC.

Bebell, D. & Kay, R. (2010). One to one computing: A summary of the quantitative results from the Berkshire wireless learning initiative. *Journal of Technology, Learning, and Assessment, 9*(2), 4-59. Retrieved from http://ejournals.bc.edu/ojs/index.php/jtla/index

Bebell, D. & O'Dwyer, L. M. (2010). Educational outcomes and research from 1:1 computing settings. *Journal of Technology, Learning, and Assessment, 9*(1), 4-59. Retrieved from http://ejournals.bc.edu/ojs/index.php/jtla/index

Bronfenbrenner, U. (1986). Ecological systems theory. In R. Vasta (Ed.), *Annals of Child Development*, (pp. 187-249), (Vol. 6). Greenwich, CT: JAI Press.

Broussard, J., Hebert, D., Welch, B., & VanMetre, S. (2014). Teaching today for tomorrow: A case study of one high school's 1:1 computer adoption. *The Delta Kappa Gamma Bulletin, 80*(4), 37-45. Retrieved from https://www.questia.com/library/p438442/delta-kappa-gamma-bulletin

Brown, J. S. (2000, March/April). Growing up digital: How the web changes work, education, and the ways people learn. *Change*, 10-20. Retrieved from http://www.johnseelybrown.com/Growing_up_digital.pdf

Chandler, M. A., & Tsukayama, H. (2014, May 17). Tablets proliferate in nation's classrooms, and take a swipe at the status quo. The Washington Post. Retrieved from http://www.washingtonpost.com/local/education/tablets-proliferate-in-nations- classrooms-and-take-a-swipe-at-the-status-quo/2014/05/17/faa27ba4-dbbd-11e3-8009- 71de85b9c527_story.html.

Chou, C. C., Block, L., & Jesness, R. (2012). A case study of mobile learning pilot project in K-12 schools. *Journal of Educational Technology Development and Exchange, 5*(2), 11-26. Retrieved from http://jetde.theti.org:85/ojs/index.php/jetde/index

Christman, L. M. (2014). *Ubiquitous computing: Systematic Transformation to 21st century teaching and learning*. (Doctoral dissertation). Retrieved from ProQuest. (UMI Number: 3626045).

Clarke, B., & Svanaes, S. (2012). *One-to-one tablets in secondary schools: An evaluation study.* Retrieved from http://www.tabletsforschools.co.uk/

Corn, J., Tagsold, J. T., & Argueta, R. (2012). Students with special needs and 1:1 computing: A teacher's perspective. *Journal of Research in Special Education Needs, 12*(4), 217-223. doi: 10.1111/j.1471-3802.2012.01251.x

Council for Accreditation of Educator Preparation. (2013). *CAEP Standards.* Retrieved from http://caepnet.org/~/media/Files/caep/standards/caep-standards-one-pager-061716.pdf?la=en

Creswell, J. W. (2013). *Qualitative inquiry and research design: Choosing among five approaches.* Thousand Oaks, CA: SAGE.

Cuban, L. (1993). Computers meet classroom: Classroom wins. *Teachers College Record, 95*(2), 185-210. Retrieved from http://www.tcrecord.org

Cyphert, F. & Gant, W. L. (1970). *The Delphi technique: A tool for collecting opinions in teacher education*. (ED 042691). U.S. Department of Health, Education and Welfare.

Danielson, C. (2017). *The framework.* Retrieved from https://www.danielsongroup.org/framework/

Dajani, J. S., Sincoff, M. Z., & Talley, W. K. (1979). Stability and agreement criteria for the termination of Delphi studies. *Technological Forecasting and Social Change, 13*(1), 83-90. Retrieved from http://www.journals.elsevier.com/technological-forecasting-and-social-change

Dalkey, N. C. (1967). *Delphi*. Santa Monica, CA: The RAND Corporation.

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

Day, J. & Bobeva, M. (2005). A generic toolkit for the successful management of Delphi studies. *The Electronic Journal of Business Research Methodology, 3*(2), 103-116. Retrieved from http://www.ejbrm.com/main.html

Delbecq, A. L., Van de Ven, A. H., & Gustafson, D. H. (1975). *Group techniques for program planning*. Glenview, IL: Scott Foresman. Retrieved from https://docs.google.com/a/umn.edu/viewer?a=v&pid=sites&srcid=dW1uLmVkdXxhdmFuZGV2ZW58Z3g6NDk0Y2U2ZTI5ODY1ZjNlYw

Donovan, L., Green, T., & Hartley, K. (2010). An examination of one-to-one computing in the middle school: Does increased access bring about increase student engagement? *Journal of Educational Computing Research, 42*(4), 423-441. doi: 10.2190/EC.42.4.d

Donovan, L., Hartley, K., & Strudler, N. (2007). Teacher concerns during initial implementation of a one-to-one laptop initiative at the middle school level. *Journal of Research on Technology in Education, 39*(3), 263-286. Retrieved from http://www.iste.org/lead/ed-tech-research

Downes, J. M. & Bishop, P. A. (2015). The intersection between 1:1 laptop implementation and the characteristics of effective middle level schools. *Research in Middle Level Education Online, 38*(7), 1-16. Retrieved from https://www.amle.org/ServicesEvents/ResearchinMiddleLevelEducationOnline/tabid/173/Default.aspx

Dunleavy, M., Dextert, S. & Heinecket, W. F. (2007). What added value does a 1:1 student to laptop ratio bring to technology-supported teaching and learning? *Journal of Computer Assisted Learning, 23*(5), 440-452. doi: 10.1111/j.1365-2729.2007.00227.x

Duffy, T. M. & Jonassen, D. H. (1992). Constructivism: New implications for instructional technology. In T. M. Duffy & D. H. Jonassen (Eds.), *Constructivism and the technology of instruction: A conversation* (pp. 1-16). Hillsdale, NJ: Lawrence Erlbaum.

Dwyer, D. C. (1995). *Changing the conversation about teaching, learning and technology: A report on 10 years of ACOT research.* Cupertino, CA: Apple Computer, Inc.

Dwyer, D. C., Ringstaff, C., & Sandholtz, J. H. (1990). *The evolution of teachers' instructional beliefs and practices in high-access-to-technology classroom: First-fourth year findings.* (Report No. 8). Cupertino, CA: Apple Computer, Inc.

Elmendorf, D. C. (2012). *Developing indicators for a classroom observation tool on pedagogy and technology integration: A Delphi study*. (Doctoral dissertation). Towson University, Towson, MD.

Elmendorf, D. C. & Song, L. (2015). Developing indicators for a classroom observation tool on pedagogy and technology integration: A Delphi study. *Computers in the Schools: Interdisciplinary Journal of Practice, Theory, and Applied Research, 32*(1), 1-19. doi: 10.1080/07380569.2014.967620

Farmer, E. I. (1998). A Delphi study of research priorities in tech prep. *Journal of Vocational and Technical Education, 15*(1), 1-10. Retrieved from https://www.researchgate.net/journal/1363-6820_Journal_of_Vocational_Education_and_Training

Felder, R. M. & Brent, R. (1996). Navigating the bumpy road to student-centered instruction. *College Teaching, 44*(2), 43-47. Retrieved from http://dx.doi.org/10.1080/87567555.1996.9933425

Fitch, K., Berstein, S. J., Aguilar, M. D., Burnand, B., LaCalle, J. R., Lazaro, P. . . Kahan, J. P. (2001). *The RAND/UCLA appropriateness method user's manual.* Santa Monica, CA: RAND.

Garthweit, A. & Weller, H. G. (2005). A year in the life: Two seventh grade teachers implement one-to-one computing. *Journal of Research on Technology in Education, 37*(4), 361-377. Retrieved from http://www.iste.org/lead/ed-tech-research

Gay, L. R., Mills, G. E., & Airasian, P. (2009). *Educational research: Competencies for analysis and applications.* (9th ed.). Upper Saddle River, NJ: Pearson.

Gordon, T. J. (1994). *The Delphi method*. Future Research Methodology*:* AC/UNU Millennium Project.

Greaves, T. W., Hayes, J., Wilson, L., Gielniak, M., & Peterson, E. L. (2012). *Revolutionizing education through technology: The Project RED roadmap for transformation.* Eugene, OR: ISTE.

Gulek, J. C. & Demitras, H. (2005). Learning with technology: The impact of laptop use on student achievement. *Journal of Technology, Learning, and Assessment, 3*(2), 3-38. Retrieved from http://ejournals.bc.edu/ojs/index.php/jtla/index

Gupta, U. G. & Clarke, R. E. (1996). Theory and applications of the Delphi technique: A bibliography (1975-1994). *Technological Forecasting and Social Change, 53*(2), 185-211. Retrieved from http://www.journals.elsevier.com/technological-forecasting-and-social-change

Habibi, A., Sarafrazi, A., & Izadyar, S. (2014). Delphi technique theoretical framework in qualitative research. *The International Journal of Engineering and Science, 3*(4), 8-13. Retrieved from https://www.journals.elsevier.com/international-journal-of-engineering-science

Harper, B. & Milman, N. B. (2015). One-to-one technology in K-12 classrooms: A review of the literature from 2004 through 2014. *Journal of Research on Technology in Education, 48*(2), 129-142. doi: 10.1080/15391523.2016.1146564

Heath, M. K. (2016). *Technology integration, beliefs, and pedagogical practices in the social studies: A phenomenological case study of teacher-initiated, one-to-one technology in middle school social studies.* (Doctoral dissertation). Towson University, Towson, MD.

Heath, M. K. (2017). Teacher-initiated one-to-one technology initiatives: How teacher self-efficacy and beliefs help overcome barrier thresholds to implementation. *Computers in the Schools: Interdisciplinary Journal of Practice, Theory, and Practice, 34*(1-2), 88-106. doi: 10.1080/07380569.2017.1305879

Hineman, J. M., Boury, T. T., & Semich, G. W. (2015). Technology-literate school leaders in a 1:1 iPad program and teachers' technology self-efficacy. *International Journal of Information and Communication Technology Education, 11*(2), p. 68-73. doi: http://dx.doi.org/10.4018/ijicte.2015040106

Holen, J. B., Hung, W., & Gourneau, B. (2017). Does one-to-one technology really work: An evaluation through the lens of activity theory. *Computers in the Schools: Interdisciplinary Journal of Practice, Theory, and Applied Research, 34*(1-2), 24-44. doi: 10.1080/07380569.2017.1281698

Hsu, C. & Sandford, B. A. (2007). Minimizing non-response in the Delphi process: How to respond to non-response. *Practical Assessment, Research and Evaluation, 12*(17), 1-6. Retrieved from http://pareonline.net

Imbriale, R., Schiner, N., & Elmendorf, D. (2017). Students and teachers accessing tomorrow (STAT): Baltimore County Public School's one-to-one digital conversion case in practice. *Computers in the Schools: Interdisciplinary Journal of Practice, Theory, and Applied Research, 34*(1-2), 3-8. doi: 10.1080/07380569.2017.1281705

Interactive Educational Systems Design, Inc. (2014). *2014 national survey on mobile technology for K-12 education: Educator edition.* Retrieved from http://hcpsbyod.pbworks.com/w/file/fetch/83744005/IESD_2014_Mobile_Tech_Report_Educator_Edition.pdf

International Society for Technology in Education (2017). *ISTE standards for educators.* Retrieved from https://www.iste.org/my-profile/standards-download

Israel, H. & Richter, R. R. (2011). A guide to understanding meta-analysis. *Journal of Orthopaedic & Sports Physical Therapy, 41*(7), 496-504. Retrieved from http://www.jospt.org/?code=jospt-site

Johnson, L., Adams Becker, S., Estrada, V., & Freeman, A. (2015). *NMC horizon report: 2015 K-12 edition.* Austin, TX: The New Media Consortium.

Jonassen, D. H. (2001). Objectivism versus constructivism: Do we need a new philosophical paradigm? In D. P. Ely & T. Plomp (Eds.), *Classic writings on instructional technology,* Vol. 2, (pp. 53-70). Englewood, CO: Libraries Unlimited.

Kalaian, S. A. & Kasim, R. M. (2012). Terminating sequential Delphi survey data collection. *Practical Assessment, Research, and Evaluation, 17*(5), 1-10. Retrieved from http://pareonline.net/getvn.asp?v=17&n=5

Keeney, S. Hasson, F., & McKenna, H. P. (2001). A critical review of the Delphi technique as a research methodology for nursing. *International Journal of Nursing Studies, 38*(2), 195-200. Retrieved from http://www.journals.elsevier.com/international-journal-of-nursing-studies/

Keengwe, J., Schnellert, G., & Mills, C. (2012). Laptop initiative: Impact on instructional technology integration and student learning. *Education and Information Technologies, 17*(2), 137-146. doi: 10.1007/s10639-010-9150-8

Kenton, J. (2009). Developing and maintaining a TPACK focus in the preservice, inservice, and teacher preparation classroom. In I. Gibson et al. (Eds.). *Proceedings for Society for Information Technology and Teacher Education International Conference 2009* (pp. 3782-3788). Chesapeake, VA: AACE.

Kleynen, M., Bleijlevens, M. H., Beurskens, A. J., Rasquin, S. M.., Halfens, J., Wilson, M. R. . . . Eysenbach, G. (2013). Terminology, taxonomy, and facilitation of motor learning in clinical practice protocol of a Delphi study. *Journal of Medical Internet Research, 15*(5), 1-8. doi: 10.2196/resprot.2604

Klieger, A., Ben-Hur, Y., & Bar-Yossef, N. (2010). Integrating laptop computers into classroom: Attitudes, needs, and professional development of science teachers – A case study. *Journal of Science and Educational Technology, 19*(2), 187-198. doi: 10.1007/s10956-009-9191-1

Larkin, K. & Finger, G. (2011). Informing one-to-one computing in primary schools: Student use of netbooks. *Australasian Journal of Educational Technology, 27*(3), 514-530. Retrieved from http://ajet.org.au/index.php/AJET

Lei, J. & Zhao, Y. (2008). One-to-one computing: What does it bring to schools? *Journal of Educational Computing Research, 39*(2), 91-122. doi: 10.2190/EC.39.2.a

Li, S. C. (2010). Social capital, empowerment and educational change: A scenario of permeation of one-to-one technology in school. *Journal of Computer Assisted Learning, 26*(4), 284-95. doi: 10.1111/j.1365-2729.2010.00350.x

Lindqvist, M. (2015). Gaining and sustaining TEL in a 1:1 laptop initiative: Possibilities and challenges for teachers and students. *Computers in the Schools: Interdisciplinary Journal of Practice, Theory, and Applied Research, 32*(1), 35-62. doi: 10.1080/07380569.2015.1004274

Linstone, H. A. & Turoff, M. (1975). *The Delphi method: Techniques and applications.* Boston, MA: Addison-Wesley.

Lowther, D. L., Inan, F. A., Ross, S. M., & Strahl, J. D. (2012). Do one-to-one initiatives bridge the way to 21st century knowledge and skills? *Journal of Educational Computing Research, 46*(1), 1-30. doi: http://dx.doi.org/10.2190/EC.46.1.a

Maninger, R.M. & Holden, M. E. (2009). Put the textbooks away: Preparation and support for a middle school one-to-one laptop initiative. *American Secondary Education, 38*(1), 5-33. Retrieved from https://www.ashland.edu/coe/about-college/american-secondary-education-journal

Mengual-Andres, S., Roig-Vila, R., & Blasco Mira, J. (2016). Delphi study for the design and validation of a questionnaire about digital competencies in higher education. *International Journal of Education Technology in Higher Education, 13*(12), 1-11. doi: 10.1186/s41239-016-0009-y

Meyer, R. C. (2007). *A case study of one-to-one computing: The effects on teaching and learning.* (Doctoral dissertation). Retrieved from http://www.proquest.com/products-services/pqdtglobal.html

Meyer, A., Rose, D. H., & Gordon, D. (2014). *Universal design for learning: Theory and practice.* Wakefield, MA: CAST.

Mishra, P. & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017-1054. Retrieved from http://www.tcrecord.org

Morrison, J. R., Ross, S. M., Morrison, G. R., Cheung, A. C. K., & Arthur, R. M. (2015). *Report for Baltimore County Public Schools: Students and Teachers Accessing Tomorrow – Year One Summative Evaluation Report.* Baltimore, MD: Johns Hopkins University.

Murry, J. W. & Hammons, J. O. (1995). Delphi: A versatile methodology for conducting qualitative research. *The Review of Higher Education, 18*(4), 423-436. Retrieved from https://www.press.jhu.edu/journals/review_of_higher_education/

Na, S. (2006). *A Delphi study to identify teaching competencies of teacher education faculty in 2015* (Doctoral dissertation). Retrieved from ProQuest. (UMI Number: 3225382)

New Media Consortium. (2017). *The NMC horizon project reaches 195 countries!* Retrieved from https://www.nmc.org/nmc-horizon/

Nworie, J. (2011). Using the Delphi technique in educational technology research. *Tech Trends, 55*(5), 24-30. Retrieved from http://link.springer.com/journal/11528

Okoli, C. & Pawlowski, S. D. (2004). The Delphi method as a research tool: An example, design considerations and applications. *Information and Management, 42*(1), 15-29. doi:10.1016/j.im.2003.11.002

Oliver, K. (2010). Evaluating teacher readiness for the implementation of one-to-one computing based on national educational technology standards. *Journal of Literacy and Technology, 11*(3), 40-76. Retrieved from http://www.literacyandtechnology.org

Oliver, K. & Corn, J. O. (2008). Student-reported differences in technology use and skills after the implementation of one-to-one computing. *Educational Media International, 45*(3), 215-229. doi: 10.1080/09523980802284333

Penuel, W. R. (2006). Implementation and effects of one-to-one computing initiatives: A research synthesis. *Journal of Research on Technology in Education, 38*(3), 329-348. Retrieved from http://www.iste.org/lead/ed-tech-research

Penuel, W. R., Yim, D. Y., Michalchik, V., Lewis, S., Means, B., Murphy, R. . . . Allen, J. E. (2001). *Using technology to enhance connections between home and school: A research synthesis.* (DHHS Contract # 282-00-008-Task 1). U. S. Department of Education.

Peterson, L., & Scharber, C. (2017). Lessons from a one-to-one laptop pilot. *Computers in the Schools: Interdisciplinary Journal of Practice, Theory, and Applied Research, 34*(1-2), 60-72. doi: 10.1080/07380569.2017.1296328

Project Tomorrow (2014). The new digital learning playbook: Understanding the spectrum of students' activities and aspirations. Retrieved from www.tomorrow.org/speakup/pdfs/SU13StudentsReports.pdf

Richardson, J. W., McLeod, S., Flora, K., Sauers, N. J., Kannan, S., & Sincar, M. (2013). Large-scale 1:1 computing initiatives: An open access database. *International Journal of Education and Development using Information and Communication Technology, 9*(1), 4-18. Retrieved from http://ijedict.dec.uwi.edu

Ringstaff, C., Sandholtz, J. H., & Dwyer, D. C. (1991, April). *Trading places: When teachers utilize student expertise in technology-intensive classrooms.* Paper presented at the meeting of the American Educational Research Association, Chicago, IL.

Rosen, Y. & Beck-Hill, D. (2012). Intertwining digital content and a one-to-one laptop environment in teaching and learning: Lesson from the time to know program. *Journal of Research on Technology in Education, 44*(3), 225-241. Retrieved from http://www.iste.org/lead/ed-tech-research

Rowe, G. & Wright, G. (1999). The Delphi technique as a forecasting tool: Issues and analysis. *International Journal of Forecasting, 15*(4), 353-375. Retrieved from http://www.journals.elsevier.com/international-journal-of-forecasting

Rowe, G. & Wright, G. (2011). The Delphi technique: Past, present, and future prospects – Introduction to the special issue. *Technological Forecasting and Social Change, 78*(9), 1487-1490. doi:10.1016/j.techfore.2011.09.002

Sandholtz, J. H., Ringstaff, C., & Dwyer, D. C. (1990). *Teaching in high-tech environments: Classroom management revisited, first- fourth year findings.* (Report No. 10). Cupertino, CA: Apple Computer, Inc.

Scarpa, L. C. (1998*). Identification of leadership practices and technology competencies needed by educational administrators who implement technology* (Doctoral dissertation). Retrieved from ProQuest. (UMI Number: 9834133)

Schell, K. A. (2006). A Delphi study of innovative teaching in baccalaureate nursing education. *Journal of Nursing Education, 45*(11), 439-448. Retrieved from http://www.healio.com/nursing/journals/jne

Schmidt, R. C. (1997). Managing Delphi surveys using nonparametric statistical techniques. *Decision Sciences, 28*(3), 763-774. Retrieved from http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1540-5915

Schuh, K. L. & Barab, S. A. (2008). Philosophical perspectives. In J. M. Spector, M. D. Merrill, & J. van Merrienboer (Eds.), *Handbook of research on educational communications and technology: A project of the association of educational communications and technology,* 3rd ed. (pp. 67-82). Mahwah, NJ: Lawrence Erlbaum.

Scott, D. G., Washer, B. A., & Wright, M. D. (2006). A Delphi study to identify recommended biotechnology competencies for first-year/initially certified technology education teachers. *Journal of Technology Education, 17*(2), 43-55. Retrieved from http://scholar.lib.vt.edu/ejournals/JTE/

Shapley, K. S., Sheehan, D., Maloney, C., & Caranikas-Walker, F. (2010). Evaluating the implementation fidelity of technology immersion and its relationship with student achievement. *Journal of Technology, Learning, and Assessment, 9*(4), 5-68. Retrieved from http://ejournals.bc.edu/ojs/index.php/jtla/index

Shapley, K., Sheehan, D., Maloney, C., & Caranikas-Walker, F. (2011). Effects of technology immersion on middle school students' learning opportunities and achievement. *The Journal of Educational Research, 104*(5)*,* 299-315. Retrieved from http://www.tandfonline.com/loi/vjer20#.V1d8ZVclkoU

Slkyhuis, D., Foulger, T. S., Graziano, K. J., & Schmidt-Crawford, D. A. (2017). The big reveal: Teacher educator technology competencies. In P. Resta & S. Smith (Eds.), *Proceedings of Society for Information Technology and Teacher Education International Conference 2017* (pp. 2457-2461). Chesapeake, VA: Association for the Advancement of Computing in Education.

Spires, H., Oliver, K., & Corn, J. (2011). The new learning ecology of one-to-one computing environments: Preparing teachers for shifting dynamics and relationships. *Journal of Digital Learning in Teacher Education, 28*(2), 63-72. Retrieved from http://www.tandfonline.com/loi/ujdl20

Spires, H., Wiebe, E., Young, C. A., Hollebrands, K., & Lee, J. K. (2009*). Toward a new learning ecology: Teaching and learning in one-to-one environments*. Friday Institute White Paper Series. NC State University: Raleigh, NC.

Spires, H., Wiebe, E., Young, C. A., Hollebrands, K., & Lee, J. K. (2012). Toward a new learning ecology: Professional development for teachers in one-to-one learning environments. *Contemporary Issues in Technology and Teacher Education, 12*(2), 232-254. Retrieved from http://www.citejournal.org

Storz, M. G. & Hoffman, A. R. (2012). Examining response to a one-to-one computer initiative: Student and teacher voices. *Research in Middle Level Education Online, 36*(6), 1-18. Retrieved from https://www.amle.org/ServicesEvents/ResearchinMiddleLevel EducationOnline/tabid/173/Default.aspx

Swallow, M. (2015). The year-two decline: Exploring the incremental experiences of a 1:1 technology initiative. *Journal of Research on Technology in Education, 47*(2), 122-137. doi: 10.1080/15391523.2015.999641

Tigelaar, D., Dolmans, D. Wolfhagen, I., & Van der Vleuten, C. (2004). The development and validation of a framework for teaching competencies in higher education. *Higher Education, 48*(2), 253-268. Retrieved from https://link.springer.com/journal/10734

Topper, A. & Lancaster, S. (2013). Common challenges and experiences of school districts that are implementing one-to-one computing initiatives. *Computers in the Schools: Interdisciplinary Journal of Practice, Theory, and Applied Research, 30*, 346-358. doi: 10.1080/07380569.2013.844640

United States Department of Education, Office of Educational Technology. (2014). *Future ready schools: Building technology infrastructure for learning.* Retrieved from http://tech.ed.gov/

United States Department of Education, Office of Educational Technology. (2017). *Reimagining the role of technology in education: 2017 national education technology plan update.* Retrieved from http://tech.ed.gov/

Valentijn, P. P., Vrijhoel, H., Ruwaard, D., Boesveld, I., Arends, R. Y., & Bruijnzeels, M. A. (2015). Towards an international taxonomy of integrated primary care: A Delphi consensus approach. *BMC Family Practice, 16*(64), 1-15. doi: 10.1186/s12875-015-0278-x

van Zolingen, S. J., & Klaassen, C. A. (2003). Selection processes in a Delphi study about key qualifications in senior secondary vocational education. *Technological Forecasting and Social Change, 70*(4), 317-340. doi: doi:10.1016/S0040-1625(02)00202-0

Weston, M. E. & Bain, A. (2010). The end of techno-critique: The naked truth about 1:1 laptop initiatives and educational changes. *The Journal of Technology, Learning, and Assessment, 9*(6), 4-25. Retrieved from http://ejournals.bc.edu/ojs/index.php/jtla/index

Yeh, Y., Hsu, Y., Wu, H., Hwang, F., & Lin, T. (2014). Developing and validating technological pedagogical content knowledge-practice (TPACK-practical) through the Delphi survey technique. *British Journal of Educational Technology, 45*(4), 707-722. doi:10.1111/bjet.12078

Zheng, B., Warschauer, M., Lin, C., & Chang, C. (2016). Learning in one-to-one laptop environments: A meta-analysis and research synthesis. *Review of Educational Research, 86*(4), 1052-1084. doi: 10.3102/0034654316628645

Zucker, A. (2004). Developing a research agenda for ubiquitous computing in schools. *Journal of Educational Computing Research, 30*(4), 371-386. Retrieved from http://jrnledcompresearch.com/index.php/jec

Andrea H. Parrish

Curriculum Vita

Towson University • 8000 York Road • Towson, MD • 21252
(410) 704-3835 • aparrish@towson.edu

EDUCATION

Doctor of Education in Instructional Technology, Towson University (2017)

Dissertation Title: *A Delphi Study to Identify an Inventory of Teaching Competencies Needed to Facilitate Instruction in Student-Centered, One-to-One Learning Environments*

Certificate of Advanced Study, Educational Leadership and School Improvement, Administration I Certification, Goucher College (2011)

Master of Science in Special Education, Johns Hopkins University (2006)

Bachelor of Science in Special Education, Towson University (2004)

PROFESSIONAL EXPERIENCE

TOWSON UNIVERSITY, Department of Special Education
Assistant Professor (2017-Present)
Graduate Program Director (2015-Present)
Clinical Instructor (2015-2017)
Lecturer (2011-2015)

GOUCHER COLLEGE
Adjunct Instructor, Summer Teacher's Institute (2009-2015)

BALTIMORE COUNTY PUBLIC SCHOOLS
Specialist, Office of Special Education (2008-2011)
Resource Teacher, Office of Special Education (2007-2008)
Special Educator, Harford Hills Elementary, Essex Elementary (2004-2007)

TEACHING AT TOWSON

ECSE 351: Primary Curriculum and Instruction in the Inclusive Classroom II

ECSE 352: Field Placement in the Primary Classroom II

ECSE 451: Internship in Early Childhood/Special Education

ECSE 452: Internship in Early Childhood/Special Education Seminar

SPED 413: Universal Design for Learning: Addressing Learner Variability

SPED 441: Curriculum and Methods of Instruction for Students with Disabilities, K-12

SPED 491: Internship: Students with Disabilities in the Elementary/Middle Grades

SPED 498: Internship: Special Education

SPED 527: Curriculum and Methods of Social, Emotional, and Motor Development for Students with Disabilities, K-12

SPED 605: Working with Families of Students with Disabilities

SPED 620: Educating Students with Autism Spectrum Disorder

SPED 622: Social Thinking and Connectedness for Students on the Autism Spectrum

SPED 625: Curriculum and Methods of Instruction for Students with Autism Spectrum Disorder I

SPED 628: Integrating Instructional and Assistive Technologies to Support Students with Autism Spectrum Disorder

SPED 637: Inclusion for the Classroom Teacher

SPED 641: Curriculum and Methods of Instruction of Educating Students with Disabilities, K-12

SPED 644: Universal Design for Learning and Differentiated Instruction

SPED 646: Using Technology to Differentiate Instruction

SCHOLARSHIP, PUBLICATIONS, AND RELATED ACTIVITIES

a. Articles

Richman, L., & Parrish, A. H. (2017). Foreword to the spring 2017 *School University Partnerships* special issue: Technology to support and enhance professional development schools. *School-University Partnerships, 10*(3), 5-8.

b. Scholarly Presentations

Parrish, A. H., & Harkins, S. N. (May, 2017). *English language learners in the digital age: Integrating technology to enrich instruction.* Presentation conducted at Common Ground Conference, Ocean City, MD.

Foulger, T. S., Graziano, K. J., Parrish, A. H., Sadera, W., Schmidt-Crawford, D. A., & Slkyhuis, D. (2017, March). *Employing Delphi methodology in educational technology research.* Panel presentation at the Society for Information Technology and Teacher Education Conference, Austin, TX.

Richman, L., Parrish, A. H., & Heath, M. (March, 2017). *Technology to support and enhance professional development schools: Discussion of the School University Partnerships special issue.* Presentation at the National Association for Professional Development Schools conference, Washington, D.C.

Parrish, A. H., & Sadera, W. (2017, March). *A Delphi study to develop an inventory of competencies needed to facilitate instruction in student-centered, one-to-one learning environment.* Presentation conducted at the Society for Information Technology and Teacher Education Conference, Austin, TX.

Parrish, A. H., & Sadera, W. (2016, March). *Not another workshop: Designing quality faculty development that supports technology use in teacher education.* Paper presented at the Society for Information Technology and Teacher Education Conference, Savannah, GA.

Sadera, W., & Parrish, A. H. (2016, March). *The one-to-one classroom: Are we preparing preservice teachers for technologically advanced learning environments?* Paper presented at the Society for Information Technology and Teacher Education Conference, Savannah, GA.

Parrish, A. H. (2014). *Moving beyond motivation: Using apps to enhance evidence-based practices for children with Autism Spectrum Disorder.* Invited Presentation for the Maryland Assistive Technology Network (MATN), Rockville, MD.

Parrish, A. H. (2014). *Moving beyond motivation: Using technology to enhance evidence-based practices.* Presentation at Honestly Autism Day, Towson, MD.

FELLOWSHIPS AND AWARDS

Graduate Student Fellowship
Towson University, Office of Graduate Studies, 2016-2017

Louise Lippy McHahan Memorial Scholarship
Towson University, College of Education, 2015-2016

SERVICE

a. University and Department Service Activities

College of Education Faculty Development and Research Committee
- Co-Chair, AY 2015-2016 & 2016-2017
- Member, AY 2014-2015

Department of Special Education Technology Committee
- Chair, AY 2014-2015 & 2015-2016

Halstead Academy Inquiry Team, Baltimore County Public Schools
Students and Teachers Accessing Tomorrow (STAT) Initiative
- Member, AY 2014-2015

Local Interagency Coordinating Council
- University Representative, AY 2014-2015

Very Special Arts Festival Planning Committee, Baltimore County Public Schools
- Member, AY 2006-2007 to Present

b. External or Discipline-Specific Service

Co-Editor, *School-University Partnerships* Special Issue on Technology
Richman, L., & Parrish, A. H. (Eds.). (2017). Technology to enhance and support professional development schools. [Special issue]. *School University Partnerships, 10*(3), 5-8.

Manuscript Reviews
- *International Journal of Information and Learning Technology* (2017)
- *School-University Partnerships* (2017)

PROFESSIONAL MEMBERSHIPS

American Association of College for Teacher Education (AACTE)

American Educational Research Association (AERA)

Council for Exceptional Children (CEC)

International Society for Technology in Education (ISTE)

Maryland Assistive Technology Network (MATN)

Society for Information Technology and Teacher Education (SITE)