# Toward a Typology of Technology-Using Teachers in the "New Digital Divide": A Latent Class Analysis of the NCES Fast Response Survey System Teachers' Use of Educational Technology in U.S. Public Schools, 2009 (FRSS 95)

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**Abstract**
Background: Recently, policy makers and school leaders have heavily invested in the promise that educational technology could catalyze systemic school change. Yet, some critics note that the conversation surrounding technology in schools is a red herring that has not produced clear, definitive, and equitable results across different school settings. Prior research has mainly focused on understanding *how* and *why* teachers use technology in order to address this concern. Still, we argue that an understudied third perspective – examining *what types* of technology-using teachers exist – could provide innovative and impactful insights to shape research, policy, and practice in instructional technology.
Purpose of the Study: We investigate the extent to which there is a typology of teachers who use technology, as well as to what extent school and teacher level variables predict membership in the different subgroups in the typology, by analyzing a nationally generalizable sample (2,764 teachers) from the Teachers' Use of Educational Technology in U.S. Public Schools, 2009 Fast Response Survey System dataset, collected by the National Center for Education Statistics.
Research Design: We used a three-step latent class analysis (LCA) with nationally generalizable data that identifies significantly different types of technology-using teachers, as well as what covariates predict membership in the identified subgroups.
Findings: We find that there are four statistically significant subgroups of technology-using teachers: *Dexterous* (24.4%), *Evaders* (22.2%), *Assessors* (28.4%), and *Presenters* (24.8%). We also find that several covariates, such as student socioeconomic status, school type, enrollment, years of teacher experience, and total number of school computers, predicted teachers' membership in these four subgroups of technology-using teachers.
Conclusions: Our findings reiterate the notion that technology-using teachers are not a monolithic group that are randomly distributed across school settings, as low-income schools are more likely to have teachers who use technology in less meaningful ways. As a quantitative phenomenology, this study provides one of the first empirically-based, nationally generalizable depictions of technology use in schools that could inform school leaders and policy makers as they evaluate new digital tools, design professional learning for teachers, and tackle inequalities in technology access, teacher knowledge, and technology-mediated learning experiences and outcomes for students.

**Keywords**
Educational Technology — Teachers — Social Justice— Digital Divide — Technology Leadership— Latent Class Analysis — Mixture Modeling— Survey Research — NCES

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## EXECUTIVE SUMMARY

Recently, many policy makers and school leaders have looked to technology integration as a potential catalyst for lasting, systemic improvement. Banking on this promise, school districts spend millions of dollars each year acquiring new digital tools and increasing technology budgets, while researchers continually work to investigate the impact of technology on teaching and learning in order to justify this investment. However, some critics argue that teacher technology use in schools has yet to produce clear and definitive outcomes. Additionally, issues of inequality have created significant challenges in technology-related implementation efforts, as historically marginalized schools still suffer from the consequences of a "digital divide" – an unjust system of inequitable access to digital tools and instructional resources. As policy makers and school leaders shape future technology-related efforts across diverse school contexts, it is imperative that future research look to examine teacher technology use from different perspectives in order to truly clarify the relationship between teachers and technology.

Research on teacher technology use is extensive and describes teacher digital tool usage from three perspectives: how teachers use technology, why teachers use technology, and what types of teachers use technology. How teachers use technology has evolved over time, and prior research finds that teachers generally use technology in seven ways: (1) class preparation; (2) professional email; (3) delivering instruction; (4) developing accommodations; (5) teacher-directed uses during class time; (6) teacher-directed uses to create products; and, (7) grading. Likewise, as more technology entered learning spaces with a diverse set of needs and challenges, research shifted to understand why certain teachers use technology more than others. While there are over 123 external and internal factors moderating why teachers choose to integrate digital tools, larger questions emerged in understanding to what extent there are similar groups of technology-using teachers that share certain user characteristics. As a result, a third perspective – which types of teachers use technology – has become a growing subset of research in the area of teacher technology use. In general, qualitative studies have argued for four different types of teachers within a single school setting. However, there are no studies that investigate the veracity of these qualitative findings with nationally generalizable data.

To study these issues, we conducted a secondary analysis of the public use data from the Fast Response Survey System – Teachers' Use of Educational Technology in U.S. Public Schools, 2009 (FRSS 95). The survey was collected in 2009 and was administered through the National Center for Education Statistics. The dataset included survey questions asking teachers to describe their technology use habits in their classrooms, as well as information on computer and Internet access, student uses of technology, and technology professional development. For the study, we examined a subset of 2,764 teachers who indicated that they use technology in their classrooms. We used latent class analysis (LCA) to identify significantly different subgroups of technology-using teachers, along with what individual and school level covariates predict teacher membership in these subgroups.

We find that there are four significantly different types of technology-using teachers, Dexterous (24.4%), Evaders (22.2%), Assessors (28.4%), and Presenters (24.8%). Dexterous teachers are flexible and wide ranging users that integrate technology for different modes and purposes. Dexterous teachers report that they are comfortable with any type of technology and are ready to learn more through professional development. In sharp contrast, Evaders are resistant to use technology in every way, including sending emails to students and taking daily attendance. Presenters are teachers who prefer using technology to aid with lectures, while also guiding students to use presentation software to produce written texts and presentations. Finally, Assessors are most comfortable with using technology as drill and practice software, directing students to use technology to practice basic skills in content areas like mathematics and reading. Our results also show that teachers in low-income schools are more likely to be Assessors and less likely to be Presenters than Dexterous. Likewise, we also find that for every one computer in a school, teachers are less likely to be Evaders, Assessors, or Presenters than Dexterous.

Our findings reiterate the notion that technology-using teachers are not a monolithic group and are not randomly distributed across school settings, as low-income schools are more likely to have teachers who use technology in less meaningful ways. As a quantitative phenomenology, this study provides one of the first empirically-based, nationally generalizable depictions of technology use in schools that could inform school leaders and policy makers as they evaluate new digital tools, design professional learning for teachers, and tackle inequalities in technology access, teacher knowledge, and technology-mediated learning experiences and outcomes for students.

## INTRODUCTION

The purpose of this study is to examine the extent to which there is a typology of technology-using teachers using a nationally generalizable dataset, the Fast Response Survey System Teachers' Use of Educational Technology in U.S. Public Schools, 2009 (FRSS 95) from the National Center for Education Statistics (NCES). Many educators and policy makers believe that technology is the key to richer, highly personalized and collaborative learning experiences for all students (Collins & Halverson, 2009; U.S. Department of Education, 2016). This excitement in the transformative potential of instructional technology has impacted the inner workings of American schooling in three key ways. First, national reports show that teacher technology use has increased steadily over the past five years (Bill and Melinda Gates Foundation, 2015; Purcell, Heaps, Buchanan, & Friedrich, 2013). Second, school technology budgets continue to increase, reaching a cumulative, national all time high of over one billion dollars in 2014

(Winters & McNally, 2014). And third, over the last decade, there has been a promising and significant body of research that investigates the extent of technology integration efforts and its impact on teacher pedagogy and larger school change efforts (Becker, 2000; Lemke, Coughlin, & Reifsneider, 2009; Lesgold, 2003; Wenglinsky, 1998), particularly in historically underserved communities (Warschauer, 2000). Indeed, teachers, school leaders, policy makers, and researchers are looking to utilize the power of technology as a catalyst to improve schooling for the next generation.

However, several researchers have noted that the conversation surrounding technology in schools is a red herring in school reform that has yet to produce clear and definitive results. Larry Cuban (2015a) writes, "The evidence thus far that increased access and use of these technological tools has, indeed, solved any of the problems is distressingly missing." In fact, in one of the first experimental design studies by Mathematica and SRI International on the effectiveness of reading and mathematics software across 132 U.S. schools, Dynarski et al. (2007) found that there were no observed effects of the educational software on student test scores in the treatment group.

Additionally, social justice issues of the "new digital divide" have also created significant challenges in technology adoption in schools. A significant body of research (Becker, 2007; Harris, 2015; Warschauer, Knobel, & Stone, 2004) asserts that teachers' technology use is inherently moderated by an unjust system of inequitable access to digital tools and instructional resources for historically underserved communities. Although schools are continually pushed to adopt new technologies year after year, a "cyclic amnesia" of the relationship between teachers and technology continues to fester (Zhao, Zhang, Lei, & Qiu, 2016). Therefore, as research in the field of educational technology continues to grow, examining teacher technology use from a different lens could enhance institutional efforts to support wide-scale technology adoption efforts.

Research on teacher technology use is extensive, and recent peer-reviewed and practitioner-focused literature describes teacher technology use from three perspectives: how teachers use technology, why teachers use technology, and which types of teachers use technology. First, a significant body of research (Becker, Wong, & Ravitz, 1998; Koehler & Mishra, 2009; McKnight et al., 2016; Mishra & Koehler, 2006; O'Dwyer, Russell, & Bebell, 2004, 2005; Rowand, 2000; Russell, Bebell, O'Dwyer, & O'Connor, 2003) argues for a more multifaceted conception of how teachers use technology, rather then measuring it through a single construct. In the second perspective of examining why certain teachers use technology more than others, Heitink et al. (2016) find that teachers tend to adopt technology to simply engage students and to support learning goals and activities, while Hew and Brush (2007) identify 123 external and internal additional moderating factors. However, in terms of the third perspective, there are very few examples in the literature that investigate which types of teachers use technology. For example, Cuban (2015b) spotlights one diagram where a teacher used a pencil as a metaphor to describe several different types of teacher technology users. In this diagram, the pencil tip was termed the technology "leaders," while the "erasers" were out to "undo the work of the leaders" (Cuban, 2015b). In the peer-reviewed literature, there are also two qualitative studies (Donnelly, McGarr, & O'Reilly, 2011; Mama & Hennessy, 2013) that describe at least four subgroups of technology-using teachers in schools in Cyprus and in Ireland. Nonetheless, there are no studies to date that test the veracity of these hypotheses around teacher technology types with empirical, nationally representative data.

Thus, the motivation of this study is to extend the research on teacher technology use and to investigate the extent to which there is a typology of teachers who use technology in their classrooms using a nationally generalizable dataset, the NCES Fast Response Survey System Teachers' Use of Educational Technology in U.S. Public Schools, 2009. By using recent innovations in person-centered statistics and typology subgroup analysis, namely Latent Class Analysis (LCA), we find that there are four significantly different subgroups of technology-using teachers: Dexterous (24.4%), Evaders (22.2%), Assessors (28.4%), and Presenters (24.8%). We also find that contextual variables, such as student socioeconomic status, school type, enrollment, years of teaching experience, and total number of computers, significantly predict the odds of a teacher belonging to the Evaders, Assessors, and Presenters groups. We argue that the implications of a nationally generalizable typology of teacher technology types could be a critical piece of the reform puzzle as school districts design evidence-based interventions that address the needs of teachers and school leaders on the ground level of implementation (Culp, Honey, & Mandinach, 2003), while also reiterating the prevailing reality that teachers in low income communities still struggle to access the adequate resources to adopt and meaningfully use new technologies in instruction (Harris, 2015; Valadez & Duran, 2007; Warschauer, 2003). Our goal is that this person-centered conception of teacher technology use can provide a clearer picture of the challenges facing teachers and school leaders as they seek to leverage the power of information and communication technologies (ICTs) to create better learning experiences for all students.

## LITERATURE REVIEW

Instructional technology literature contains a significant and growing body of teacher technology use research. This literature can be divided into three key perspectives: *how* teachers use technology, *why* teachers use technology, and *which types* of teachers use technology.

First, it is difficult to concretely describe *how* teachers use technology because our understanding of this question has evolved over time. Early survey research in the late 1990s described that teachers were only using technology to prepare for instruction (Market Data Retrieval, 1999). However, subsequent research findings showed that teachers' use of digital tools was much more multidimensional than once thought. These researchers criticized early surveys for confounding the indicators of teacher technology use into a single generic construct (Bebell, Russell, & O'Dwyer, 2004; Rowand, 2000). Instead of describing how teachers use technology as a single action, through several studies that use confirmatory factor analysis with large scale surveys (Russell, O'Dwyer, Bebell, & Miranda, 2004), research finds that the construct of how teachers use technology is characterized by seven positively correlated indicators: (1) teachers' use of technology for class preparation; (2) teachers' professional email use; (3) teachers' use of technology for delivering instruction; (4) teachers' use of technology for accommodation; (5) teacher-directed student use of technology during class time; (6) teacher-directed student use of technology to create products; and, (7) teachers' use of technology for grading (Russell, Bebell, et al., 2003; Russell et al., 2004). Likewise, in their study on teachers' use of educational technology in seven states, McKnight et al. (2016) found that teachers use technology for communication, direct instruction of content, accommodations, collaboration, research, and assessment. This multifaceted understanding of how teachers use technology over time was, and continues to be, a critical part of how researchers capture a more complex snapshot of how teachers use digital tools across different school settings and attempt to build a grounded theory of teacher technology use (Bebell et al., 2004; Koehler & Mishra, 2009; Mishra & Koehler, 2006).

Although we understand that teachers use technology in a variety of ways, there is still a significant problem in understanding how teachers use technology within this new multidimensional construct (Bebell et al., 2004; Russell, Bebell, et al., 2003). This problem persists for three main reasons. First, despite evidence that shows that teachers have varied technology use habits (Rowand, 2000; Russell et al., 2004), policy makers and school leaders continue to perpetuate a broad and superficial definition of how teachers use technology in the professional learning and evaluation of teachers, focusing on if a teacher can use digital tools rather than how he or she is using them (Bebell et al., 2004; Cuban, 2001, 2015a; Lawless & Pellegrino, 2007; Russell, Bebell, et al., 2003). Second, our current measures of teacher technology use do not factor a wide array of individual and contextual factors that may influence how a teacher integrates technology in instruction (Lesgold, 2003; Wenglinsky, 2005). Third, issues of equity and access have complicated how we understand how teachers use technology in diverse school environments. Warschauer (2000) notes:

> In analyzing [the] integration of technology into instruction, Cuban (1993) proclaimed that "computers meets classroom: Classroom wins" (p. 185) [. . . ] the computer "beats" the classroom, it doesn't necessarily beat the system. [Technology in schools] can all leave intact or even reinforce patterns by which schools channel students into different social systems. (p. 18)

In other words, as more technology enters learning spaces with a diverse set of needs and challenges, issues of social justice influence how teachers envision technology integration (McLeod, Bathon, & Richardson, 2011; Natriello, 2001; Valadez & Duran, 2007). Consequently, new research inquiries emerged to investigate the individual and school-level barriers on why certain teachers use technology in order to address these prevailing challenges.

Ertmer (1999) describes two types of barriers that influence *why* certain teachers use technology more than others, referred to as first-order barriers and second-order barriers. First-order barriers are defined as "obstacles that are extrinsic to teachers [such as] the types of resources (e.g., equipment, time, training, support) that are either missing or inadequately provided in teachers' implementation environments" (Ertmer, 1999, p. 50). When first-order barriers exist, there are fewer opportunities for teachers to integrate technology in instruction (Cuban, Kirkpatrick, & Peck, 2001; Ertmer, 1999; Hew & Brush, 2007; Mumtaz, 2000). While policy talk tends to focus on first-order barriers, second-order barriers present a more difficult challenge, where action is "rooted in teachers' underlying beliefs about teaching and learning and may not be immediately apparent to others or even to the teachers themselves" (Ertmer, 1999, p. 51). A significant body of research (Cho & Littenberg-Tobias, 2016; Ertmer, 2005; Ertmer & Ottenbreit-Leftwich, 2010; Ertmer et al., 2012; Hsu, 2016; Levin & Wadmany, 2006; Palak & Walls, 2009) has found that teacher beliefs, attitudes, and enacted values with technology and instruction are closely associated with why certain teachers choose to integrate technology in their classroom practice. Although we understand many of the barriers, there are still lingering questions about how this knowledge translates into practice.

There is still no clear picture of the relationship between first- and second- order barriers and how this relationship influences different types of teachers who use technology (Ertmer, 1999; Hew & Brush, 2007). Ertmer (1999) asks two critical questions about these barriers and their relationship with teachers:

> Do teachers at higher levels of use encounter relatively fewer first- and second-order barriers? In what ways are barriers that are encountered by teachers at higher levels of technology use similar or dissimilar to those encountered by teachers at lower levels of use? (p. 52)

Ertmer (1999) opens up the possibility that teachers with similar technology usage patterns could have different experiences with certain second- and first-order barriers. Likewise, as these barriers exist within the sociocultural context of a school (Sherman & Howard, 2012; Windschitl & Sahl, 2002), comparing these subgroups of technology-using teachers could provide additional insight into how action, intent, and context are interrelated when teachers use technology in their classrooms. As such, another perspective emerges to further explain teacher technology use – whether or not different types of technology-using teachers exist.

The third perspective, *which types* of teachers use technology, is a growing subset of research in the area of teacher technology use. The Rogers (1962) innovation adopter categories were arguably the first technology user typology to describe user technology habits. Rogers (1962) theorizes that users who adopt technology can be divided into five user segments: innovators, early adopters, early majority, late majority, and laggards. While the first three are characterized by quick adoption of new tools, the last two are more reluctant to learn new technologies and integrate them in their practice (Rogers, 1962). The Rogers (1962) adopter categories spawned several other typologies of technology-using teachers in the literature.

There are two small-scale qualitative studies that classify different types of teachers who use technology. After interviewing thirteen (n=13) Irish science educators about their use of a computer program, Donnelly et al. (2011) theorize four subgroups of teachers who integrate technology into their instructional practices: contented traditionalist, the selective adopter, the inadvertent user, and the creative adapter. While creative adapters and selective adopters are intrinsically empowered and motivated to integrate technology into their pedagogical practice and open to new types of teaching tools and methods, the contented traditionalist and inadvertent user tend to adopt technology only by force or pressure from their colleagues.

Likewise, Mama and Hennessy (2013) also conduct a multi-case study on the technology use habits and beliefs of eleven (n=11) teachers in Cyprus and argue for four distinct subgroups of teachers. Teachers are generically labeled (Groups A – D) and are identified by attitudinal characteristics. For example, Group A, the high user group, consists of teachers who are both integrational and diversifying, meaning their use of ICTs align with lesson objectives and their beliefs centers on technology as a tool for differentiation. In contrast, Group D, the low users, describes a teacher who is more inimical and subversive (Mama & Hennessy, 2013).

Collectively, this research on typologies of technology-using teachers (Donnelly et al., 2011; Mama & Hennessy, 2013) highlights three common themes. First, these studies highlight the need for more person-centered approaches in describing technology-using teachers. Arguably, the qualitative findings from these studies provide the first robust, person-centered descriptions of the technology-using teacher. Second, in all three typologies, frequency of use (low, middle, and high use) appears to be an organizing characteristic in designating subgroups of technology-using teachers. Third, the findings from both of these studies describe at least four, mutually exclusive subgroups of technology-using teacher types.

Although these studies provide some of the first descriptions of which types of teachers use technology, there are still prevailing concerns pertaining to the validity, the generalizability, and sociocultural implications of the findings. As mentioned earlier, there is a clear consensus in the literature that teacher technology use should be measured in a more multidimensional fashion (Bebell et al., 2004). However, each of the two aforementioned studies only investigate teacher technology users from the perspective of one of the seven significant correlates of teacher technology use (Bebell et al., 2004). In addition, although large-scale data on teacher technology use is scarce, the small sample size, the absence of statistically significant groupings, and the lack of actual membership proportions per subgroup raise additional questions about the generalizability of the findings to all technology-using teachers. Finally, research suggests that there is a "digital divide" between high- and low-income schools in access to digital tools, content, and teacher resources for technology-focused curriculum and instruction (Natriello, 2001; Valadez & Duran, 2007; Wenglinsky, 1998). Mama and Hennessy (2013) and Donnelly et al. (2011) fail to describe differences in access because the researchers examine teacher technology use within one school setting. Understanding how teacher types may differ across school settings should be the next frontier for teacher technology user typology studies. Thus, the motivation of our study is to address these issues described above by using latent class analysis (LCA), a mixture modeling approach that statistically tests the extent to which there are subgroups of similar individuals within a nationally representative dataset of teachers across schools in the United States.

## FRAMEWORK OF THE STUDY

Identifying subgroups of teachers in schools with national data has become an emerging trend in educational research. Typology subgroup studies typically use methods such as cluster analysis (Antonenko, Toy, & Niederhauser, 2012) to develop profiles of students and teachers. Although cluster analysis produces meaningful groupings, the method does not embed a hypothesis test in the analysis, leaving measures of best fit up to the interpretation of the researcher (Vermunt & Magidson, 2002). This study utilizes latent class analysis (LCA) to statistically determine the extent to which there are homogenous groups of individuals within a heterogeneous dataset (Asparouhov & Muthén, 2008; Henry& Muthén, 2010; Jung & Wickrama, 2008).

There is a wealth of other education research that uses latent class analysis to explore typologies of different teachers, leaders, and schools. For example, Boyce and Bowers (2016) identified two significantly different types of principals who exit their schools. The first group, Satisfied principals, reported higher satisfaction with their job performance, salary, attitude, and self-perception of their leadership than the second group, the Disaffected. In another example, Brasseur-Hock et al. (2011) found that there are four significantly different levels of students and their reading comprehension levels. Finally, in validating the Comprehensive Assessment of

**Table 1.** Summary of Existing Typologies of Technology-Using Teachers

| Author and Year Literature Type | Sample Size | Research Analytical Method | Summary of Findings |
|---|---|---|---|
| Mama and Hennessy (2013) Peer-reviewed article | 11 teachers (*N*=11) in elementary school in Cyprus | Qualitative; multi-case study | Four (4) subgroups: *Group A* (*n*=2): Moderate to high usage, constructivist-oriented, encourages autonomous learning, use related to lesson objectives *Group B* (*n*=3): Low to moderate usage, engagement-oriented purpose, encourages student motivation, use related to student technical knowledge *Group C* (*n*=5): High usage, administrative-oriented purpose, encourages research skills and information gathering, use related to improving teacher efficiency *Group D* (*n*=1): Moderate to low usage, necessity-oriented purpose, distracts students, lack of use related to fear and threat to authority |
| Donnelly, McGarr, and O'Reilly (2011) Peer-reviewed article | 13 science teachers (*N*=13) and other education stakeholders in Ireland | Qualitative; semi-structured interviews | Four (4) subgroups: *Contented traditionalist*: Focus on assessment, fatalistic, low technological pedagogical content knowledge *Selective adopter*: Focus on assessment, teacher-centered but willing to change, high technological pedagogical content knowledge but only when preparing for assessment *Inadvertent user*: Use from external pressure, student-centered but unaware of classroom implications, lack of ownership, low technological pedagogical content knowledge *Creative adapter*: Strong student-centered approach, adaptable pedagogy, strong sense of purpose and empowerment, high and varied technological pedagogical content knowledge |

Leadership for Learning (CALL) survey in a two-level LCA, Bowers, Blitz, Modeste, Salisbury, and Halverson (2017) argued for three significantly different groups of teachers in three types of schools that enact leadership for learning behaviors, using the ordinal grouping of low, moderate, and high leadership for learning teachers and schools.

Yet, despite interest in this type of analysis in education research and the wealth of literature on teacher technology use in schools, little is known about the extent to which there are different groups of teachers who share similar technology usage habits. While the majority of research in the domain of educational technology focuses on how and why teachers use technology to describe and to generalize teacher technology integration efforts, the goal of this study is to explore if there are underlying subgroups of similar teacher technology users within nationally generalizable data, while also exploring various teacher level covariates that could predict membership in the subgroups. Thus, the research questions for this study are:

1. Using a nationally representative dataset, to what extent are there different types of teachers who use technology?
2. To what extent are other contextual factors, such as urbanicity, percentage of free / reduced lunch, total number of classroom computers, school type, years of teaching experience, and enrollment, associated with membership in these subgroups of technology-using teachers?

## METHODS

### Data

This study is a secondary analysis of the public use data from the Fast Response Survey System – Teachers' Use of Educational Technology in U.S. Public Schools, 2009 (FRSS95). This survey was originally collected in 2009 by the National Center for Education Statistics and had a representative sample size of 3,159 teachers from public schools across the United States. Weights were provided through a complex probabilistic weighting strategy so that findings can be generalizable to all 2.39 million public school teachers in the US in 2009 (National Center for Education Statistics, 2009). The data on teachers' use of educational technology includes information on the use of computers and Internet access, teacher responses on students' use of educational technology, teacher professional development, and availability of technology resources (Gray, Thomas, Lewis, & Tice, 2010).

The FRSS 95 provides a unique opportunity to explore teacher technology types with national data. As such, we selected this data for four reasons. First, although the dataset contains variables directly related to educational technology, research that uses the FRSS 95 dataset to describe teachers' use of educational technology is virtually nonexistent. Second, it directly relates to factors that influence teacher technology use in schools (Gray et al., 2010), a clear application to the research questions at hand. Third, with the statistical weights applied, FRSS 95 is nationally generalizable (National Center for Education Statistics, 2009), and findings from this study could contribute to current research, practice, and policy in the field of educational technology. Fourth, the FRSS 95 is the most recent, nationwide data available on teacher technology surveying teachers in 2009, at the time of analysis. The sample for this study relies on a subset of the full FRSS 95 dataset. Given the related literature and research questions for the study, we selected teachers based on their frequency of technology use. Teachers who responded "rarely," "sometimes," or "often" (i.e., some degree of technology usage) for question (Q2A), "how frequently do you or your students use computers during instructional time in your classroom," were used in the final analysis. All other responses ("never" or "not applicable") were excluded. Of 3,159 teachers in the full sample, we examined a subset of n = 2,764 teachers who indicated that they use technology in their classrooms.

We also applied the final sampling weights (TFWT) from FRSS 95 to the data so that the results of the LCA could be generalized to a national population of technology-using teachers in the United States in 2009.

## Variables Included in the Analysis

We drew on the literature and theory on teacher technology use to guide our inclusion of variables for our analysis. Our indicator variables focused on the measures of the teacher technology use construct as outlined in the Bebell et al. (2004) study. Our covariates were selected based on teacher and school factors that previous literature identified as being associated with teacher technology use.

### Teacher use of technology for instruction

The 2009 FRSS 95 included fifteen questions related to how teachers use technology in their preparation for direct instruction. We decided not to include all fifteen questions in the study, omitting questions that asked about specialized software (e.g., photo editing software), word processing programs and Internet browsers, or resources that are typically censored in public schools (e.g. social media). These questions were omitted based on prior research that suggests that certain technologies have been institutionalized by teachers as they prepare for instruction and do not add a significant contribution to understanding how teachers use technology in schools (Adams, 2006; Kuiper & de Pater-Sneep, 2014; Russell, Goldburg, & O'Conner, 2003). Furthermore, maintaining a parsimonious model closely related to the relevant literature is helpful to maintaining the appropriate level of statistical power (Boyce & Bowers, 2016; Dziak, Lanza, & Tan, 2014). Thus, the following uses were included in the statistical model: making presentations, administering computer-based tests, and using drill, practice, and tutorial software programs. Teachers were asked to rate their frequency of use on a four-point scale. For this study, responses were dichotomized into high to moderate (1 = "often / sometimes") and low to none (0 = "rarely / never") usage of technology for direct instruction. Specifics on the survey questions used, response coding schema, and the descriptive statistics for these and other variables can be found in Appendix 1-A.

### Preparation to use technology

The 2009 FRSS 95 included six questions that asked teachers about their preparation to use educational technology in their school, three of which were used for this study. Activities, such as professional learning activities (Brinkerhoff, 2006), training from technology staff (Ausband, 2006), and independent learning (Yan & Piper, 2003), were included in the model based on relevant literature. Using a four-point scale, teachers were asked about the extent to which these activities have prepared them to use technology. Responses were dichotomized into not at all (0 = "not at all") and to some extent (1 = "minor / moderate / major extent").

### Disposition toward professional learning

The 2009 FRSS 95 included one question that asked teachers if their professional learning in technology met their needs and goals. We included this variable in response to the Vannatta and Fordham (2004) findings that a teacher's willingness to change and their effort to participate in professional learning predicts classroom technology use. Measured on a four-point scale, questions measured how teachers responded negatively or positively toward whether technology professional development met their goals. Responses were dichotomized into either positive (1 = "somewhat agree / strongly agree") or negative (0 = "somewhat disagree to strongly disagree").

### Use of technology for productivity

The 2009 FRSS 95 included twelve questions that asked teachers how often they use technology for certain productivity tasks. Questions about email to students and parents, as well as student record management, were included based on Bebell et al. (2004) study that listed these two specific scales (i.e., email and grading) to be associated with the teacher technology use construct. Teachers were asked to rate their frequency of usage on a four-point scale. For the analysis, responses were dichotomized into high to moderate (1 = "often / sometimes") and low to none (0 = "rarely / never").

**Teacher-directed student use of technology for discrete and hands-on skills**

The 2009 FRSS 95 included thirteen questions that asked teacher-directed student use of technology, seven of which were used in the analysis. Many questions were omitted because the majority of the respondents answered "not applicable" to the question. The questions for this indicator have been divided into technology to learn discrete skills and to perform hands-on tasks based on extensive research on how certain classroom activities benefit from the integration of technology and lead to increased student transfer and understanding of content (Bransford, Brown, & Cocking, 2000). Activities involving discrete skills include preparing written text, learning and practicing basic skills, conducting research, and solving problems with data and calculations. Teacher-directed student uses of technology for hands-on skills include developing multimedia (Neo & Neo, 2009), making art and other creative mediums (e.g., music, movies, and webcasts) (Greenhow, Robelia, & Hughes, 2009), and conducting experiments (Newman et al., 2012). Similar to using technology for productivity, responses were dichotomized into high to moderate (1 = "often / sometimes") and low to none (0 = "rarely / never").

Across the variables missingness ranged from 0% to 25%. Following the recommendations for missing data in samples of this type of analysis (Strayhorn, 2009), we relied on missing data imputation using Full Information Maximum Likelihood (FIML) as recommended (Asparouhov & Muthén, 2013; Enders, 2010; Vermunt & Magidson, 2007)

**Covariates**

Hew and Brush (2007) have identified 123 extrinsic and intrinsic teacher and school related factors that influence how teachers integrate technology into the classroom. Due to the rapid data collection strategy employed by the Fast Response Survey System program (National Center for Education Statistics, 2009), most of these factors are not included in the survey questionnaire. Still, we included some teacher level demographic factors, such as years of teaching experience, as well as school level demographics factors, such as urbanicity, percentage of students on free and reduced lunch, school type, enrollment, and number of total computers, in the model. There were no missing data from the covariates. Descriptive statistics, variable recodes, and survey questions used for the covariates can be found in Appendix 1-B.

## Analytic Model

We used latent class analysis (LCA) for this study to determine if there were significantly different types of teachers who use technology in schools. In general, LCA is a subset of mixture modeling which is useful in determining the extent to which there is one or more than one subgroup of responders within a dataset (Jung & Wickrama, 2008; Masyn, 2013; Múthen, 2002, 2004; Muthén & Asparouhov, 2002; Samuelsen & Raczynski, 2013; Vermunt & Magidson, 2004). LCA was selected as the analytic technique because LCA evaluates how groups of individuals differ or relate to one another, or simply put, the method is person-centric (Boyce & Bowers, 2016; Jung & Wickrama, 2008). In contrast to previous studies on teachers' technology use that focus on how different technology use indicators relate to one another (Bebell et al., 2004; Ertmer, Ottenbreit-Leftwich, & York, 2006), the research questions here are centered on the teachers, and as such, LCA was the most suitable analytic model. As standard in these types of analyses, Figure 1 is the structural equation model that we tested for the study.

Labeled as "Latent Classes C," the different subgroups of technology-using teachers are determined based on the seven indicator variables described above: use of technology for instruction, preparation to use technology, disposition toward professional learning, use of technology for productivity, teacher-directed use of technology for productivity, and teacher-directed student use of technology for hands-on tasks. We then added six covariates (identified on the left side of figure as urbanicity, percentage of free / reduced lunch, total number of classroom computers, school type, years of teaching experience, and enrollment) as control variables.

All statistical procedures were performed in Mplus, version 7.4 (Muthén & Muthén, 2012). The Mplus code used for the analysis is included in Appendix 1-C. Following the latent class analysis literature, this study uses a three-step LCA structural equation modeling framework (Asparouhov & Muthén, 2013; Kim et al., in press; Lanza, Tan, & Bray, 2013; Vermunt, 2010). First, as suggested in the literature (Jung & Wickrama, 2008; Nylund, Asparouhov, & Muthén, 2007; Nylund-Gibson, Grimm, Quirk, & Furlong, 2014), we performed an initial LCA using the indicator variables to determine the number of statistically different types of technology-using teachers through hypothesis testing. This initial step only includes the indicator variables to ensure that no other variable would confound how the groups are identified. Each respondent is then assigned to the most likely class.

In this step, LCA uses an iterative process with a different number of classes in each model in order to determine model fit. However, there is no one method in the literature that is considered the best way to correctly indicate the proper number of classes in the model (Bakk & Vermunt, 2016; Dziak et al., 2014; Jung & Wickrama, 2008; Lo, Mendell, & Rubin, 2001; Muthén & Asparouhov, 2002; Tofighi & Enders, 2008; Vermunt & Magidson, 2004). There are two conventions described in the literature. In the first method, some research suggests using the Bayesian information criteria, a statistic that compares the BIC of the current model, k, with the BIC from the k-1 class model (Magidson & Vermunt, 2004; Muthén & Asparouhov, 2002; Nylund et al., 2007). In

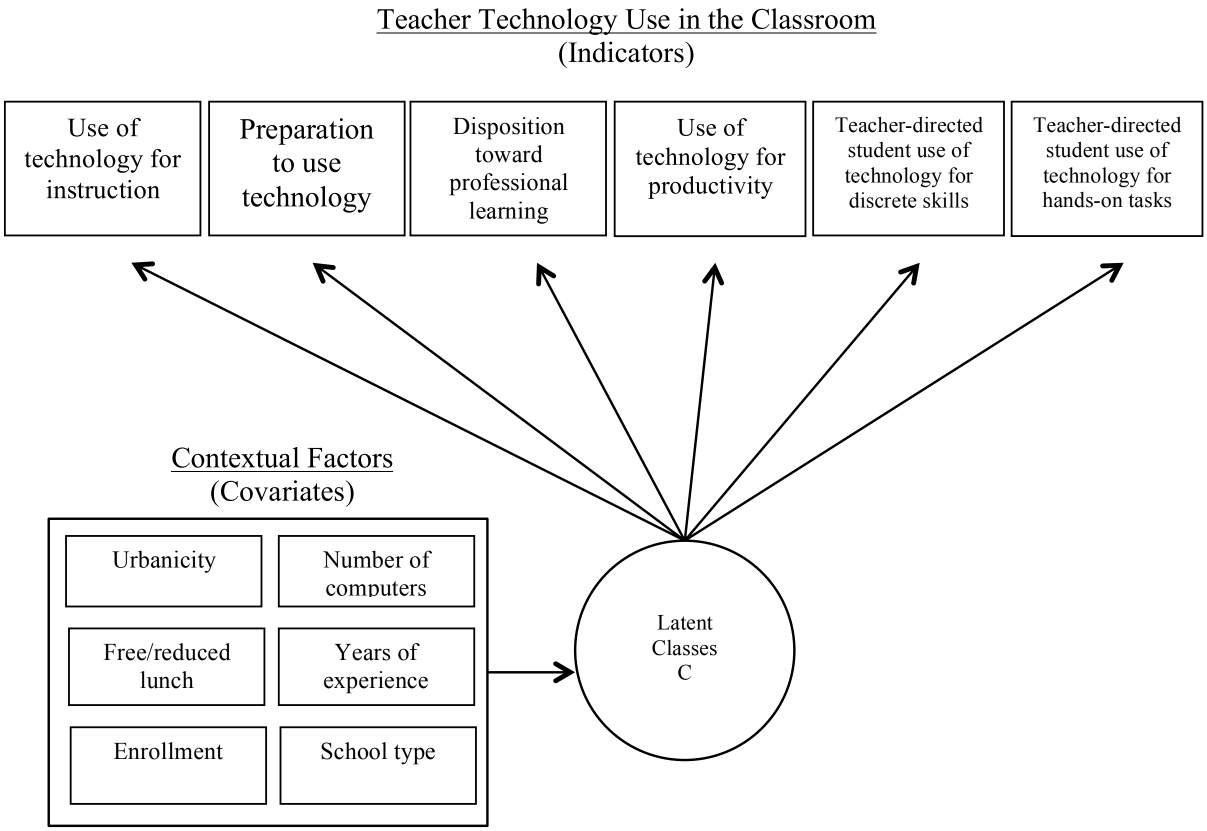


**Figure 1.** Structural and Conceptual Equation Model for 1-Level Latent Class Analysis (LCA) of Teachers Who Use Technology

other words, when performing the analysis, a model with a specific number of classes is estimated one at a time, progressively increasing in number of classes until the specified model has a larger BIC value than the previous (Jung & Wickrama, 2008; Nylund et al., 2007). When this occurs, the previously selected model is the best fit. In contrast, the Lo-Mendell-Rubin (LMR) adjusted likelihood test can be used to determine model fit as well, using a hypothesis test to determine whether the current model, k, is a better, statistically significant model fit than the previously estimated k-1 class model (Lo, 2005; Lo et al., 2001). Again, a model would be specified with varying number of classes one at a time until the p-value of the test is not significant. When this occurs, the previously selected model is the best fit. We considered the BIC and LMR statistics, as well as an a priori number of different subgroups ($n = 4$) based on previous literature, when we selected the proper number of groups in the data.

Next, using the auxiliary command (R3STEP) with the six covariates (Kim et al., in press), we performed another LCA with a post-hoc multinomial logistic regression to estimate the odds of an individual belonging to a group based on the covariates. The last step of the three-step sequence, a chi-square testing procedure to produce distal outcomes, was omitted due to a lack of appropriate follow-up data to test in the FRSS dataset.

## RESULTS

We now describe four different types of technology-using teachers, along with the covariates that predict membership in these groups. To find the best model fit, we performed the LCA on a two-class model, running subsequent models that increased in the total number of specified classes until both the BIC and LMR statistics indicated the best model fit (Jung & Wickrama, 2008; Masyn, 2013; Múthen, 2002). A seven-class model was the preliminary result of the initial analysis. Based on the literature on using the LMR test (Lo et al., 2001), the five-class model had the first non-significant p-value ($p = 0.732$), demonstrating that the previous model, four-class model, was the best model fit for the data using this statistic. The four-class LCA model fit the data well with fit statistics of AIC = 42204.407, BIC = 42625.014, -Log likelihood = 21031.203, LMR $p < 0.001$, and entropy = 0.674. Also, Table 2 shows the classification probabilities for latent class membership. The classification probabilities figure shows the probability of an individual belonging to a particular group to be placed in that group when fitting the model. In examining the probabilities in the diagonal, as well as in the off-diagonal cells, the probabilities show that the model fit the data well for all four groups.

In addition, we also considered the BIC to determine the best model fit (Jung & Wickrama, 2008; Múthen, 2002). With this analysis, the first positive change in the BIC fit statistic occurred between the six-class model (BIC = 42513.032) and the seven-class model (BIC = 42521.286), indicating that the six-class model is the best model fit according to the BIC. However, we chose the more conservative four class model as the best fit with a significant LMR as the LMR fit statistic has been identified in the literature as the more conservative of the measures, erring on the side of a more parsimonious model fit to avoid issues of model over-interpretation (Tofighi & Enders, 2008). As such, although up to six classes could fit the data, we argue for and interpret the four-class model. Table 3 presents the estimated model fit statistics for the each of the iterations of the seven-class model.

We identified four significantly different groups of teachers who use technology in their classrooms. We named these four subgroups Dexterous, Presenters, Assessors, and Evaders. For purposes of comparison, Figure 2 details an indicator plot for the proportions of the indicator variables per subgroup. The LCA model identified two groups in the typical high use – low use hierarchy. The high users, or Dexterous teachers, made up approximately 24.4% of the sampled teachers. This group had a high proportion of flexible teachers who indicated using technology in a variety of functions, including for themselves to prepare for classroom activities and for directing students to use technology with hands-on and discrete tasks, such as preparing written texts, conducting research, developing multimedia presentations, and conducting experiments. Dexterous teachers also had the highest satisfaction with technology professional learning with 92.1% of these teachers indicating that the professional learning experiences with technology met their goals.

In contrast, 22.2% of teachers were in the Evaders group. This group of teachers indicated that they neither directed students to use technology to complete discrete tasks or hands-on tasks, nor did they use technology to administer tests (17.9%) or use skill and practice software (19.5%) with students. In fact, Evaders also indicated the lowest technology use for productivity, like student record management (64.5%), email with parents (41.8%), and email with students (8.4%). Although teachers in all four groups had high levels of engagement in learning about technology through professional development, 69.2% of Evaders, the lowest proportion of the four groups, reported that these experiences met their professional goals.

Interestingly, the LCA model also identified the two highest proportions of teachers in groups that use technology for specific pedagogies and teaching styles. Approximately 24.8% of the sample, the majority of teachers in the Presenters group reported using technology for their own classroom presentations (82.6%) and for instructing their students to use technology for their presentations (70.5%). In looking at student use with this subgroup, the Presenters group also has the second highest proportion of teachers (second to the Dexterous group) to have students use technology to prepare written texts (92.0% for Dexterous, 82.0% for Presenters) and to conduct research (95.0% for Dexterous and 89.4% for Presenters). Yet, in the second lowest proportion after the Evaders group, Presenters also indicate that they rarely use technology to prepare drill and practice instruction for students (27.4%), to lead students in solving problems and analyzing data (26.5%), to create visual or digital media (36.3%), or to conduct experiments (14.4%).

The largest proportion of technology-using teachers is the Assessors, who make up 28.4% of the sample. Individuals in this group indicated that they direct their students to use technology when practicing basic skills (94.0%) and when preparing for instruction with drill and practice software (77.3%). Again, the Assessors group share the inclination to use technology to practice basic skills like the Dexterous group; however, with the second lowest usage pattern from the Evaders, Assessors indicate that they infrequently use technology to have their students create presentations (8.6%), use creative media (9.9%), and less than half of respondents have students produce written texts (47.8%).

We present the covariates that were examined to estimate the odds of a teacher belonging to a particular group in Table 4. Dexterous teachers were used as the reference category to assist with interpretation, and relative effect sizes are reported based on significant differences. Results show that when a school has more than 50 percent of students eligible for free and reduced lunch, teachers are 1.36 times more likely to be in the Assessor group than the Dexterous group ($p$ = 0.056) and more than two times less likely to be a Presenter than Dexterous ($p$ <0.001). In comparing small (less than 300 students) to medium (300 – 999 students) schools, teachers in small schools are 1.48 times more likely to be an Evader than a Dexterous technology-using teacher ($p$ = 0.086). Likewise, compared to secondary teachers, teachers in elementary schools are 1.65 times more likely to be in the Evaders group than the Dexterous group (p = 0.006) and more than three times more likely to be an Assessor than Dexterous ($p$ <0.001). Elementary school teachers are also 2.22 times less likely to be a Presenter than a Dexterous teacher who uses technology ($p$ <0.001). Years of teaching experience also predicted the odds of teachers belonging to a technology user group, indicating that for every one unit increase in teaching experience, technology-using teachers are 1.02 times less likely to be an Evader than Dexterous ($p$ = 0.027) and 1.28 less likely to be a Presenter than Dexterous ($p$ = 0.002). Finally, in looking at first-order barriers for technology (Ertmer, 1999), for every one unit increase in total number of computers in a classroom, teachers are 1.29 times less likely to be in the Evaders subgroup ($p$ <0.001), 1.07 times less likely to be in the Assessors subgroup (p <0.001), and 1.05 times less likely to be in the Presenters subgroup than be Dexterous ($p$ <0.001).

**Table 2.** Classification Probabilities for the Most Likely Class Membership (Column) by Latent Class (Row)

| Latent Class | Most Likely Class Membership | | | |
|---|---|---|---|---|
| | Class 1 (Evaders) | Class 2 (Dexterous) | Class 3 (Assessors) | Class 4 (Presenters) |
| Class 1 | **0.831** | 0.001 | 0.113 | 0.056 |
| Class 2 | 0.001 | **0.879** | 0.044 | 0.077 |
| Class 3 | 0.088 | 0.052 | **0.794** | 0.070 |
| Class 4 | 0.050 | 0.082 | 0.076 | **0.789** |

**Table 3.** LCA Results and Fit Statistics for Teachers Who Use Technology

| Model | AIC | BIC | -Log likelihood | LMR Test for k-1 classes | $p$ | Entropy |
|---|---|---|---|---|---|---|
| Two classes | 43232.732 | 43442.087 | 21582.366 | 3177.214 | <0.001 | 0.729 |
| Three classes | 42676.497 | 42990.492 | 21285.249 | 590.098 | <0.001 | 0.707 |
| **Four classes** | **42204.407** | **42625.041** | **21031.203** | **504.553** | **<0.001** | **0.674** |
| Five classes | 42006.373 | 42533.648 | 20914.187 | 232.404 | 0.732 | 0.681 |
| Six classes | 41879.118 | 42513.032 | 20832.559 | 162.119 | 0.798 | 0.699 |
| Seven classes | 41780.732 | 42521.286 | 20765.366 | 133.450 | 0.763 | 0.710 |

## DISCUSSION

This study informs the literature on teacher technology use by using a nationally generalizable dataset to examine technology-using teachers within the current multidimensional measures of teacher technology use. Using latent class analysis (LCA) to explore six domains of teacher technology use variables, we identified four significantly different groups of technology-using teachers: Dexterous, Presenters, Assessors, and Evaders. We derived the names for our four-subgroup typology of technology-using teachers based on our narrative interpretation of the survey response data. Our hope is that our labels provide a clear and concise portrayal of how teachers describe their technology usage habits in schools in 2009. Here, we briefly describe our typology again with a few concrete example characteristics of the subgroups.

Dexterous teachers are flexible and wide ranging users that integrate technology for different modes and purposes. Affectionately known as the “innovators” and the “early adopters” (Rogers, 1962), Dexterous teachers report that they are comfortable with any type of technology and ready to learn more through professional development opportunities. In sharp contrast, Evaders are resistant to use technology in every way, including sending emails to students and taking daily attendance. Presenters are teachers who prefer using technology to aid with lectures and interactive whiteboard activities, while guiding students to use presentation to produce written texts and presentations. Finally, Assessors are most comfortable with using technology as drill and practice software, directing students to use this technology to practice basic skills in content areas such as mathematics or literacy.

The findings from the study add to the teacher technology use literature in three ways. First, this study is the first to use national data to examine the assumption that there are different types of technology-using teachers. Second, our findings break out of the traditional ordinal scale of low, medium, and high frequency of technology use as presented in past research findings (Donnelly et al., 2011; Mama & Hennessy, 2013). Rather, the results describe the differences between these teachers in their pedagogical uses of technology, their beliefs and dispositions toward technology, their personal use of technology for productivity, and how they direct students to use technology in various tasks, the first time this has been done within the same statistical model. Third, with the weights applied, conducting an LCA on nationally representative data allow the findings to be generalizable to the entire population of over 2 million public school teachers in 2009.

Our findings are aligned to the qualitative work of Mama and Hennessy (2013). In their study, they uncover four different types of technology-using teachers, while also finding that teacher beliefs and attitudes are important indicators for the different types of technology-using teachers. However, our present study differs in two key ways. First, the scope of Mama and Hennessy (2013) only focuses on using attitudes and beliefs to create their typology of teachers who use information and communication technologies (ICTs). Our use of the full LCA model, including not only teacher dispositions toward technology, but also teacher-centered use of technology, teacher directed student uses of technology, and preparation to use technology, provided the opportunity to find four statistically significant groups of technology-using

**Table 4.** Means and Odds Ratios for Covariates with Dexterous Teachers Who Use Technology as the Reference Group

| | Dexterous (24.4%) | | Evaders (22.2%) | | | Assessors (28.4%) | | | Presenters (24.8%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Variable | Mean | Odds Ratio | Mean | Odds Ratio | $p$ | Mean | Odds Ratio | $p$ | Mean | Odds Ratio | $p$ |
| School urbanicity: | | | | | | | | | | | |
| City | 0.20 | — | 0.23 | | 0.467 | 0.23 | | 0.435 | 0.20 | | 0.421 |
| Town | 0.15 | — | 0.13 | | 0.609 | 0.14 | | 0.745 | 0.15 | | 0.280 |
| Rural | 0.31 | — | 0.30 | | 0.970 | 0.30 | | 0.560 | 0.30 | | 0.836 |
| <50% free and reduced lunch | 0.45 | — | 0.47 | | 0.610 | 0.53 | 1.36† | 0.056 | 0.29 | 0.38*** | <0.001 |
| School type: | | | | | | | | | | | |
| Elementary | 0.54 | — | 0.65 | 1.65** | 0.006 | 0.76 | 3.27*** | <0.001 | 0.40 | 0.45*** | <0.001 |
| Enrollment: | | | | | | | | | | | |
| Small (<300) | 0.11 | — | 0.15 | 1.48† | 0.086 | 0.14 | | 0.522 | 0.10 | | 0.887 |
| Large (>1000) | 0.29 | — | 0.23 | | 0.952 | 0.17 | | 0.388 | 0.35 | | 0.835 |
| Years of teaching experience | 14.36 | — | 13.18 | 0.98* | 0.027 | 14.56 | | 0.859 | 13.13 | 0.78** | 0.002 |
| Number of total computers | 6.52 | — | 2.81 | 0.77*** | <0.001 | 3.96 | 0.93*** | <0.001 | 4.55 | 0.95*** | <0.001 |

Note: †$p < .10$, *$p < .05$, **$p < .01$, ***$p < 0.001$.

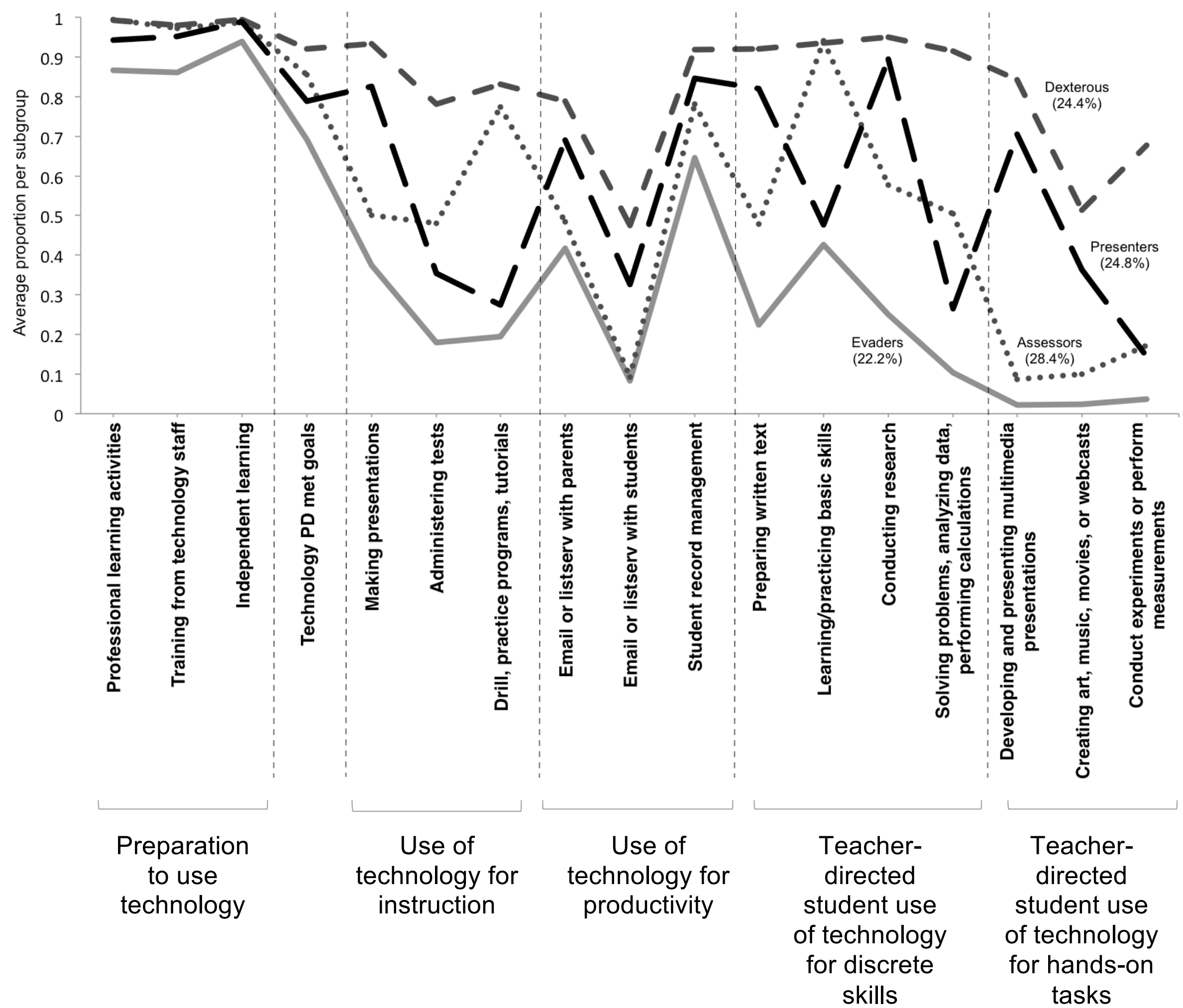


**Figure 2.** Statistical indicator plot of Latent Class Analysis results showing four subgroups of technology-using teachers. The Dexterous teachers (24.4%) are the highest and most flexible users of classroom technology, while the Evaders (22.2%) have the lowest usage across the indicators. The Assessors (28.4%) and Presenters (24.8%) are the two largest groups and use technology for specific pedagogical techniques.

teachers. This allowed us to understand differences across all four groups in more dynamic ways than just their attitudes and beliefs. The second difference between the present study and the Mama and Hennessy (2013) study is our understanding of the proportion of teachers belonging to each subgroup. Our present study shows a nationally representative ratio of technology-using teachers: Assessors (28.4%), Dexterous (24.4%), Presenters (24.8%), Evaders (22.2%). While the Mama and Hennessy (2013) study provides rich descriptions and describes the essence of the lived experience of eleven technology-using teachers within one school, the ratios of teachers in each subgroup are not generalizable on a larger scale. As such, our study extends this work on technology-using teachers to the entire population of U.S. public school teachers, identifying a concrete ratio of different types of teacher users. This again raises important considerations in using a larger sample size (n = 2,764) from a national-level dataset.

Our findings are also congruent with the four-user typology in the Donnelly et al. (2011) study. In their work, the authors describe four different subgroups of teachers divided by their assessment practices. A significant body of research (Ertmer, 2005; Ertmer & Ottenbreit-Leftwich, 2010; Ravitz, Becker, & Wong, 2000; Zhao, Pugh, Sheldon, & Byers, 2002) points out that effective technology-using teachers tend to have a more learning, student-centered approach toward learning, as opposed to an assessment or teacher-focused centered approach. Like the findings in Donnelly et al. (2011), our findings show that the largest variance among the four significantly different subgroups of teachers lies in how they use technology for themselves and for their students (see Figure 2). While Dexterous and Presenter teacher types reported higher usage of student-centered approaches toward technology (i.e., making presentations, conducting research, developing multimedia, creating art and webcasts), Evader and Assessor teacher types tended to use more teacher-centered approaches (i.e., administering tests, drill and practice programs, solving problems). While the Donnelly et al. (2011) study present rich descriptions of the technology types, again, the present study tests this hypothesis with a larger sample of teachers and provides a nationally generalizable proportion of teachers who belong to each one of the subgroups with a particular propensity for certain pedagogical approaches with technology.

This study also sheds light on the critical issue of examining teacher technology use within a social justice framework. As described earlier, the results of our study show that school socioeconomic status (see Table 4) significantly predicted a teacher's membership in two of the subgroups in national data. We found that technology-using teachers in schools with more than half of the students on free or reduced lunch were 1.36 times more likely to be an Assessor than a Dexterous teacher. Likewise, in these same schools, teachers were less likely to be a Presenter than a Dexterous teacher. In light of these seemingly contradictory findings, we revisit this notion of a "new digital divide" that perpetuates gross inequities "in [the] differential ability" (Warschauer & Matuchniak, 2010, p. 213) to effectively use technology in teaching, learning, and leading in certain types of schools (Valadez & Duran, 2007; Warschauer, 2003; Warschauer et al., 2004). While it is outside of the scope of this study to explain why teachers in low-income schools have higher odds of belonging to these two groups, our findings push the concerted effort nationwide to close the "new digital divide" through teacher professional development that focus on more hands-on, project-based applications of technology that encourage critical thinking and deeper understanding of content (Ertmer et al., 2012; Mostmans, Vleugels, & Bannier, 2012; Ravitz et al., 2000; Vannatta & Beyerbach, 2000). Through emphasizing more student-centered approaches, how teachers use new technologies could align with high-impact instructional best practices that use social justice pedagogies to affirm, validate, and celebrate all students' personal identities and life experiences (O'Hara, Pitta, Pritchard, & Webb, 2016). In all, we encourage the development of more robust, nationally representative survey instruments on teacher and school leader use of educational technology in schools as research looks to use nationally representative, quantitative data to address prevailing questions about equity, teaching, technology, and school change.

## LIMITATIONS

While we argue that the results of our study are significant, we recognize that our study is limited in five key ways. First, the data collected on teachers' use of educational technology were collected in early 2009. Given that how teachers use digital tools is constantly shifting and evolving, we recognize that the data collected in one given year might not fully represent how teachers are using technology in the classroom at any time before or after 2009. However, we used the FRSS 95 dataset because it was the most recent, nationally generalizable survey available from the National Center of Education Statistics, which provides information on teacher computer use, number of technology resources, and teachers' perspective on technology-based professional learning. We encourage the collection of additional nationally representative data in order to capture the more current trends in school technology implementation efforts. Second, the sample size of the study ($N$ = 2,764) while one of the largest used to date in considering subgroups of technology use, is relatively small due to the limited nature of the FRSS 95 sampling procedures. In looking forward, alternative national datasets with larger samples should be analyzed to continue identifying subgroups in technology-using teachers with a higher degree of statistical power to identify small to moderate effect size differences between these groups. Third, the results of the LCA yielded a strong model fit of at least four significantly different groups of technology-using teachers. However, in considering both fit statistics identified in the literature that determine the best model fit (Jung & Wickrama, 2008; Lo, 2005; Lo et al., 2001; Masyn, 2013; Múthen, 2002), as well as the entropy (0.674) of the four-class model, there could be up to six different groups that can be identified in the data. Still, we are confident in our decision in interpreting the more parsimonious, four-class model due to the more conservative estimation of the LMR test and to avoid over-interpretation of the model. Fourth, robust variable selection within national datasets could provide a more complete picture of the types of teachers who use technology. Our hope is that subsequent national surveys on teacher technology use would consider more research-based constructs when developing future instruments. Finally, although our findings are robust, we cannot address the question of why certain teachers belonged to certain groups or why certain external variables predicted membership in these subgroups. We encourage future research to address these critical questions about teacher technology users through other descriptive studies.

## IMPLICATIONS AND CONCLUSIONS

Our study reiterates the fact that technology-using teachers are not a monolithic group. We can identify four statistically distinct groups of technology-using teachers that are generalizable to a population of U.S. public school teachers in 2009. Also, we find that the subgroups are not randomly distributed across school contexts, as low-income schools are more likely to have teachers who use technology in less meaningful ways. This propels the movement to advance a social justice oriented theory for technology integration in schools that works to address digital inequity not only with what tools educators have, but what policies are developed to ensure that teachers and leaders are provided with the best professional supports and learning opportunities to learn how to use technology in ways that promote critical thinking, empower students' identities, and validate students' voice and perspectives as part of the learning process (Jenkins, Ito, & boyd, 2016; Livingstone, 2004).

As such, our study has several implications for actionable improvement in research, policy, and practice in educational technology. First, our new approach to exploring technology user typologies has a considerable amount of implications for the development of educational technology products, as well as how schools select which technologies they purchase for teachers. Our findings are aligned with past research that problematizes the widely accepted belief that technology tools are socially neutral entities that can be utilized with one approach across time, contexts, and individuals (Biraimah, 1993; Furr, Ragsdale, & Horton, 2005; Gorski, 2009). Knowing this, remaining fixated on describing technology as "just a tool" becomes difficult to justify. Zhao, Alvarez-Torres, Smith, and Tan (2004) note that when educators only envision "technology [as] just a tool, a means to an end" (p. 1), this belief can have detrimental implications for educational practice. Promoting the technology-as-tool argument in schools "gives teachers a false sense of empowerment, as well as a feeling of guilt when they do not achieve their intended goals... [technology] comes with shapes and expectations" (Zhao et al., 2004, p. 1). As technology leaders in industry develop new innovations and as school leaders make decisions to purchase and promote certain classroom technologies, it is imperative to understand that the tools themselves propagate expectations for teacher usage. Seeing that two of the four groups of technology-using teachers in our study (Presenters and Assessors) utilize technology for distinct pedagogical purposes, we implore school leaders to circumspectly select new technologies that align to the vision for teaching and learning they expect to see in classrooms, particularly in schools that have been historically marginalized. For example, does purchasing and installing stationary, interactive whiteboards actually encourage teachers to use technology in active, student-centered ways? Do one-to-one laptop programs promote teacher growth in a school of Evaders or Presenters? In looking forward, our study provides an empirically-based typology framework for additional research and evaluation studies investigating what different types of digital tools district leaders purchase and how that might influence what type of technology-using teachers exist at the individual, school, or district levels.

The typology described throughout this paper also reiterates the need for data-driven professional learning experiences for technology-using teachers that are situated to address the needs in their school contexts (Bauer & Kenton, 2005; Lawless & Pellegrino, 2007; Meier, 2005; Mouza, 2009). Prior research argues that technology professional development cannot assume homogeneity of teachers' skill levels and competencies with technology (Brinkerhoff, 2006; Hughes & Ooms, 2004; Mouza & Wong, 2009; Phillips, Desimone, & Smith, 2011; Swan et al., 2002). As districts design new personalized, professional learning opportunities for teachers to address this reality, there is a renewed call for school leaders to use data for evidence-based improvement in professional learning (Agasisti & Bowers, in press; Bowers, in press; Bowers, Shoho, & Barnett, 2014). Our hope is that the use of latent class analysis in our study could provide a useful and innovative methodological model toward using quantitative data to create evidence-based technology professional development that focuses on building the capacity and skills of the teacher starting from their current practice. We imagine that district data leaders can utilize latent class analysis as a means to help identify sustained opportunities for professional development for teachers and encourage teachers in the same subgroup, or even different groups, to participate in highly customized, evidence-based professional learning communities.

Our study also has strong implications for research and practice in school technology leadership. Given that effective technology leadership continued to be the largest predictor of positive technology-related outcomes in schools (Anderson & Dexter, 2005), the results of the present study help in two ways. First, as modern conceptions of educational leadership (Boyce, 2015; Murphy, Elliott, Goldring, & Porter, 2007; Spillane, Halverson, & Diamond, 2001) posit that leadership is not a function of one individual but rather a series of leadership roles, this typology of technology-using teachers can help school leaders identify certain characteristics of individuals that can act as teacher leaders based on their own vision for technology integration in their schools. Second, because our findings are nationally generalizable, leaders can use this typology has a starting point with teachers as he or she pushes teachers toward their growing edge in what they were taught to do and what they actually do in the classroom with technology (Pope, Hare, & Howard, 2002). Because the full LCA model accounts for multiple indicators of teacher technology use, the findings reveal critical gaps in how certain teachers use technology, allowing leaders to target specific knowledge and skills that teachers need to grow. We encourage further multilevel latent class analysis (Urick & Bowers, 2014) that nests these subgroups of teachers within schools with certain types of leaders to further explore the impact of technology leadership on the teacher technology types.

In examining teacher technology use as a multifaceted construct (Bebell et al., 2004), this study presents a clearer picture of teacher technology use and has several implications for the development of future policy interventions. In examining district-level policy for teacher technology use, Culp et al. (2003) found that policy makers tend to use three predetermined rationales to warrant the increased investment of instructional technology, such as envisioning technology as a tool for addressing challenges with teaching and learning, using technology as a change agent for instructional practice, and promoting technology as a central force in economic competitiveness (Culp et al., 2003, pp. 5-6). While these rationales are notable in light of the increased emphasis on digital age learning (U.S. Department of Education, 2016), schools continue to suffer from an implementation problem when addressing certain barriers to sustaining technology integration efforts (Ertmer, 1999; Hsu, 2016; Kopcha, 2012). It is easy to see that many of the policies concerning educational technology are implemented using an ineffective "forward mapping approach," where policies are created and then implemented by policy makers without the input of the individuals on the ground level in its planning and execution (Elmore, 1980). Forward-mapped policy implementation can result in confusion, error, and obscurity on the ground level (Elmore, 1980). Hence, our nationally generalizable typology of four significant different subgroups of technology-using teachers, along with usage indicators of each type and predictive variables, can provide policy makers with a starting point as they create more person-centered, grassroots instructional technology policy interventions that evolve based on the characteristics and needs of the lowest level of implementation, or teachers in schools. Our findings, along with this "backward mapping" approach toward policy (Elmore, 1980), could help transform district-level decision making strategies as they develop policy instruments pertaining to resource allocation, teacher evaluation, teacher professional development, and teacher and principal preparation programs that better support the growth of various types of technology-using teachers and leaders.

Finally, this study is marked as an emerging subset of research called "quantitative phenomenology" (Bowers, Blitz, Modeste, Salisbury, & Halverson, 2017) in which researchers use empirical, national level data to explore shared experiences of students, teachers, and school leaders. While we know that our study simply shows what types of technology-using teachers exist, rather than how or why these variables interact to influence teacher technology use, we maintain that this present study is the start of many important contributions to the field of educational technology as it is one of the only studies to quantitatively examine teacher technology user types with nationally representative data while also building on prior qualitative research that poignantly address the existing questions and complexities of understanding teacher technology use in schools.

## RECOMMENDED CITATION FORMAT

Graves, K.E., & Bowers, A.J. (in press). Toward a typology of technology-using teachers in the "new digital divide": A latent class analysis (LCA) of the NCES Fast Response Survey System Teachers' Use of Educational Technology in U.S. Public Schools, 2009 (FRSS 95). *Teachers College Record*.

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## ABOUT THE AUTHORS

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**Appendix 1-A: Descriptive Statistics for Indicator Variables for Teachers Who Use Technology**

| Variable Name | N | Min | Max | Mean | SD | FRSS 95 Survey Item |
|---|---|---|---|---|---|---|
| ***Use of technology for instruction*** | | | | | | |
| Making presentations | 2,764 | 0 | 1 | 0.664 | 0.472 | Q6G; 0=Never/Rarely, 1=Sometimes/Always |
| Administering tests | 2,764 | 0 | 1 | 0.455 | 0.498 | Q6H; 0=Never/Rarely, 1=Sometimes/Always |
| Drill, practice programs, tutorials | 2,764 | 0 | 1 | 0.525 | 0.499 | Q6J; 0=Never/Rarely, 1=Sometimes/Always |
| ***Preparation to use technology*** | | | | | | |
| Professional learning activities | 2,675 | 0 | 1 | 0.951 | 0.215 | Q9C; 0=Not at all, 1=To some extent |
| Training from technology staff | 2,675 | 0 | 1 | 0.943 | 0.232 | Q9D; 0=Not at all, 1=To some extent |
| Independent learning | 2,675 | 0 | 1 | 0.979 | 0.142 | Q9E; 0=Not at all, 1=To some extent |
| ***Disposition toward PD*** | | | | | | |
| Technology PD met goals | 2,446 | 0 | 1 | 0.824 | 0.381 | Q11A; 1=Agree or strongly agree |
| ***Use of technology for productivity*** | | | | | | |
| Email or listserv with parents | 2,764 | 0 | 1 | 0.599 | 0.490 | Q8A1;0=Never/Rarely, 1=Sometimes/Always |
| Email or listserv with students | 2,764 | 0 | 1 | 0.252 | 0.434 | Q8A2;0=Never/Rarely, 1=Sometimes/Always |
| Student record management | 2,764 | 0 | 1 | 0.807 | 0.395 | Q6D; 0=Never/Rarely, 1=Sometimes/Always |
| ***Teacher-directed student use of technology for discrete skills*** | | | | | | |
| Preparing written text | 2,498 | 0 | 1 | 0.633 | 0.482 | Q7A; 0=Never/Rarely, 1=Sometimes/Always |
| Learning/practicing basic skills | 2,573 | 0 | 1 | 0.699 | 0.459 | Q7C; 0=Never/Rarely, 1=Sometimes/Always |
| Conducting research | 2,545 | 0 | 1 | 0.688 | 0.464 | Q7D; 0=Never/Rarely, 1=Sometimes/Always |
| Solving problems, analyzing data, performing calculations | 2,237 | 0 | 1 | 0.466 | 0.499 | Q7H; 0=Never/Rarely, 1=Sometimes/Always |
| ***Teacher-directed student use of technology for hands-on skills*** | | | | | | |
| Developing and presenting multimedia presentations | 2,348 | 0 | 1 | 0.450 | 0.498 | Q7J; 0=Never/Rarely, 1=Sometimes/Always |
| Creating art, music, movies or webcasts | 2,159 | 0 | 1 | 0.266 | 0.442 | Q7K; 0=Never/Rarely, 1=Sometimes/Always |
| Conduct experiments or perform measurements | 2,067 | 0 | 1 | 0.266 | 0.442 | Q7I; 0=Never/Rarely, 1=Sometimes/Always |
| ***Sub-Sample n*** | **2,764** | | | | | |

**Appendix 1-B: Descriptive Statistics for Covariates for Teachers Who Use Technology**

| Variable Name | N | Min | Max | Mean | SD | FRSS 95 Survey Item |
|---|---|---|---|---|---|---|
| School urbancity: | | | | | | |
| City | 2,764 | 0 | 1 | 0.216 | 0.412 | URBAN; 1=City |
| Town | 2,764 | 0 | 1 | 0.145 | 0.350 | URBAN; 1=Town |
| Rural | 2,764 | 0 | 1 | 0.302 | 0.459 | URBAN; 1=Rural |
| School type: | | | | | | |
| Elementary | 2,764 | 0 | 1 | 0.588 | 0.492 | LEVEL; 1=Elementary school |
| Enrollment: | | | | | | |
| Small (less than 300) | 2,764 | 0 | 1 | 0.124 | 0.329 | SIZE; 1=Less than 300 |
| Large (more than 1000) | 2,764 | 0 | 1 | 0.124 | 0.329 | SIZE; 1=300 to 999 |
| More than 50% of students on free and reduced lunch | 2,764 | 0 | 1 | 0.434 | 0.496 | POVST; 1=More than 50% |
| Number of computers in classroom | 2,764 | 0 | 33 | 4.47 | 5.819 | Q1A1_TOP |
| Years of teaching experience | 2,764 | 0 | 41 | 13.83 | 9.797 | Q15_TOP |
| ***Sub-Sample n*** | **2,764** | | | | | |

# Appendix 1-C

## Mplus Code

```
TITLE: Teacher Technology Use LCA, FRSS 95 2009

DATA: FILE = "C:\Users\keg2132\Documents\InUseDataFiles\FRSS95_CLEAN.dat" ;

VARIABLE:
 NAMES = ID Q6G_R Q6H_R Q6J_R Q9C_R
  Q9D_R Q9E_R Q11A_R Q8A1_R Q8A2_R Q6D_R
  Q7A_R Q7C_R Q7D_R Q7H_R Q7J_R Q7K_R
  Q7I_R CITY TOWN RURAL POVST_R ELEM
  SEC SMALL MEDIUM YRSEXP COMPS TFWT ;
 MISSING = ALL(9999) ;
 WEIGHT = TFWT ;
 IDVARIABLE = ID ;
 USEVARIABLES = Q6G_R Q6H_R Q6J_R Q9C_R
  Q9D_R Q9E_R Q11A_R Q8A1_R Q8A2_R
  Q6D_R Q7A_R Q7C_R Q7D_R Q7H_R Q7J_R
  Q7K_R Q7I_R ;
 CATEGORICAL = Q6G_R Q6H_R Q6J_R Q9C_R
  Q9D_R Q9E_R Q11A_R Q8A1_R Q8A2_R
  Q6D_R Q7A_R Q7C_R Q7D_R Q7H_R Q7J_R
  Q7K_R Q7I_R ;
CLASSES = c(4) ;
AUXILIARY =
 (R3STEP) CITY TOWN RURAL POVST_R ELEM
  SEC SMALL MEDIUM YRSEXP COMPS ;

ANALYSIS:
 TYPE = MIXTURE;
 PROCESSORS = 8 (STARTS) ;
 MITERATION = 5000 ;
 STARTS = 25000 250 ;
 STITERATIONS = 100 ;

OUTPUT:
 SAMPSTAT STANDARDIZED TECH11 ;

PLOT:
 TYPE = plot3 ;
 SERIES = Q6G_R Q6H_R Q6J_R Q9C_R
 Q9D_R Q9E_R Q11A_R Q8A1_R Q8A2_R
 Q6D_R Q7A_R Q7C_R Q7D_R Q7H_R Q7J_R
 Q7K_R Q7I_R (*) ;

SAVEDATA:
 SAVE = CPROBABILITIES ;
 FILE = CPROBS-KEG-001.DAT ;
 FORMAT = FREE ;
 ESTIMATES = MIXEST-001.DAT ;
```