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ORIGINAL RESEARCH

Predicting High School Teacher Use of Technology: Pedagogical Beliefs, Technological Beliefs and Attitudes, and Teacher Training

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Abstract The current study aims to explore predictors that independently contribute to high school teacher use of technology in general and for different teaching purposes (student-centered and traditional). High school teachers (N = 928) responded to a survey that consisted of measures in several categories: (1) teachers' background variables, (2) teachers' pedagogical beliefs, (3) teachers' attitudes or beliefs towards technology, (4) teachers' perceived training effectiveness. A series of multilevel models were used to explore the independent effects of these factors on teacher use of technology in general and for different teaching purposes. The results showed that teachers' technology self-efficacy was a significant predictor of teacher use of technology. More importantly, teachers' instructional approach, openness towards technology, and perceived teaching training effectiveness were more salient when predicting teacher use technology to support student-centered teaching than when predicting teacher use technology to support traditional teaching. Our findings suggest that teachers' pedagogical readiness is as important as technological readiness for teachers to integrate technology in teaching to serve more advanced teaching purposes. This study has important implications for organizing professional learning experiences for teachers.

Keywords Technology use · Teacher beliefs and attitudes · Training and support · Student-centered teaching · Secondary education

1 Introduction

Over the past several decades, technology implementation in schools has been a major reform effort (Berrett et al. 2012; Voogt and Knezek 2008). Conversations in the United States around transforming teaching and learning via the use of technology is being fueled

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at the national level by initiatives such as the Call to Action and P21's Framework for 21st Century Learning (see Office of Educational Technology 2010 for review). One objective is to use technology to prepare students to be critical thinkers, problem solvers, communicators, and innovators (P21 Partnership for 21st Century Learning 2009). However, reaching this objective depends on a range of conditions and factors associated with the teacher, student, technology itself, technology-enhanced innovation, policy/legislation, and district/school-level (Groff and Mouza 2008; Spector 2010). While all these factors are important for successful technology integration, the teacher who serves as the "innovator" appears to play a crucial role in making pedagogical transformation regarding the use of technology in their teaching (Tondeur et al. 2008). Current evidence indicates that, despite the increased availability of technology in schools (Bulman and Fairlie 2016), effective integration of technology into teaching and learning, meaning the teacher uses technology as a tool to enhance students' experiences in the classroom, continues to be a challenge (Inan and Lowther 2010; Rodríguez et al. 2012).

Teachers use technology for various purposes to support: (1) administrative or management activities, such as tracking students' grades, (2) traditional or teacher-centered instructional practices, such as lecturing or presenting, and (3) support student-centered teaching activities, such as giving students choice on how to demonstrate their learning (Palak and Walls 2009). Research on one-to-one device programs suggests that such initiatives increased teacher use of technology in the classroom, but often in ways that supported administrative activities or improved the traditional instructional processes rather than transformed instruction or facilitate student-centered learning (Baek et al. 2008; Harper and Milman 2016). Furthermore, teachers who have similar levels of technology proficiency may vary in the ways they use technology. For example, some teachers use the SMART Boards or interactive Whiteboards only to display content while others may use it to facilitate interactive, problem-based, or inquiry-based learning (Gregorcic et al. 2017; Hall 2010). In this case, why technology has been integrated into classroom teaching differently begs explanation.

Many studies on technology integration or teacher use of technology did not differentiate the purposes of using technology and used the frequency of teacher use of technology tools in the classroom as the outcome measure of technology integration (Aldunate and Nussbaum 2013; Mumtaz 2000). Only a few studies examined the predictors of teacher use of technology for student-centered practices (Fu 2013). This limits our ability to understand some important issues, such as whether the predictors of teacher use of technology for teacher-centered instructional practices are the same as the predictors of teacher use of technology to support student-centered teaching practices. To help fill this void in the existing literature, the present study explored the independent contribution of a variety of teacher factors in predicting their use of technology tools: in general, to support traditional instructional practices, and to support student-centered teaching purposes.

1.1 Predictors of Teacher Use of Technology Tools

There are several frameworks that outline the essential components of effective technology integration. For example, the Technology Acceptance Model (TAM) proposed by Davis (1989, Davis et al. 1989) argues that an individual's behavioral intention to use a system is regulated by perceived usefulness and perceived ease of use. According to TAM, teachers' beliefs and attitudes, such as the technology self-efficacy can predict their actual technology adoption. A more recent framework that deigned to understand teacher use of technology

was Technological Pedagogical Content Knowledge (TPACK, Koehler and Mishra 2009). TPACK highlighted that teachers' content knowledge and pedagogical competencies are equally important as the technology capabilities, and suggested that a thoughtful alignment of three interconnected capabilities can support teacher effective integrate technology into teaching practice (Voogt et al. 2013). Besides these teacher beliefs and knowledge, International Society for Technology Education (ISTE) revealed that the development of TPACK requires ongoing organizational support and professional development with dedicated time for teachers to (re)design and enact technology-enhanced lessons (ISTE 2009).

In alignment with these theoretical frameworks, a considerable amount of empirical research studies has been published over the past two decades to explore factors that influence teacher use of technology tools in teaching (Ertmer 1999, 2005; Ertmer and Ottenbreit-Leftwich 2010; Hew and Brush 2007; also see Buabeng-Andoh 2012, for review). Although teacher-related factors have been widely viewed from different perspectives, there are mainly four strands of research in the literature, which are: (1) teachers' background variables, (2) teachers' attitudes or beliefs towards technology, (3) teachers' pedagogical beliefs, and (4) teachers' perceived training effectiveness and organizational support. Below, we reviewed some major findings in the existing literature on these factors.

Some teacher background factors have been found to predict teacher technology use, which include gender, age, and teaching experience. For example, some research suggested that male teachers use more technology in their teaching and learning processes than their female teachers (Kay 2006; Wozney et al. 2006). Several studies have suggested that teachers with more years of teaching experience tend to incorporate technology into their teaching practices more often than their less-experienced counterparts (Giordano 2007; Hernández-Ramos 2005; Wong and Li 2008), while other research did not find this difference (Niederhauser and Stoddart 2001). Previous research has suggested that older teachers view the use of technology as a tool to foster student learning as less valuable and perceive more potential problems integrating technology in teaching practices than their younger colleagues (e.g., Afshari et al. 2009; O'Bannon and Thomas 2014; Scherer et al. 2015; Vanderlinde et al. 2014).

A considerable amount of research has been conducted to investigate the influence of teachers' beliefs towards technology on their use of technology (see Buabeng-Andoh 2012, for a review). Teachers' perceived competency beliefs of technology, or self-efficacy in using technology, has been found to relate to a more frequent use of technology in the classroom. Teachers with prior computer experience are more likely to learn new necessary skills, such as looking up information more quickly and seamlessly than those who have no prior experience (Groff and Mouza 2008). On the contrary, teachers lacking confidence in their computer skills are less likely to use technology into their teaching practices (Wozney et al. 2006). In addition to perceived competence in technology skills, teachers' positive attitude toward technology, such as passion about technology, openness towards technology, or feeling comfortable using technology, may also affect their technology integration practices (see Hew and Brush 2007, for a review).

Research has also suggested that teachers' pedagogical beliefs are an important predictor of their use of technology (Ertmer and Ottenbreit-Leftwich 2010; Ertmer et al. 2012, 2015). For example, Hermans et al. (2008) examined the influence of teachers' educational beliefs on teacher use of computer with 525 primary school teachers. They found that teachers' constructivist beliefs predicted unique variance in teacher use of computers above and beyond teachers' background variables and teachers' attitudes towards computers. As part of a large-scale national study in the Netherlands, Drent and Meelissen (2008) revealed that primary and secondary teachers' background, technology competency beliefs,

attitudes toward technology, and their pedagogical approach all explained unique variance in their use of technology to support educational objectives. Based on findings from a qualitative approach, Ertmer et al. (2012) suggested that teachers with student-centered beliefs tended to use technology through a more student-centered approach. However, research in this area is still limited comparing to research in teachers' beliefs towards technology.

Some research suggests that teacher trainings are related to teacher technology use. For example, in an empirical study that employed the Teacher Attribute Survey, Vannatta and Nancy (2004) suggested that the amount of technology trainings teachers received is a predictor of teachers' technology use. Another institutional factor that have been also suggested important is organizational supports, which means to provide teachers with time and environment to practice the ways to integrate technology in teaching and getting feedback. Based on a longitudinal case study, Levin and Wadmany (2008) suggested that opportunities to practice, reflect, and interact with other teachers are crucial in the process of facilitating classroom technology adoption. Also, Wong and Li (2008) found that the collaborating and an experimentation culture set by school leaders influenced effective technology integration. Although it is intuitive to relate trainings and supports focusing on technology with increased technical skills and use of technology, trainings or supports that focus on teachers' curriculum development or pedagogical practices may be as important as efforts to improve teachers' technology using skills (Sandholtz and Reilly 2004).

1.2 Purpose of the Study

Although most of existing literature focused on predictors of teacher use of technology in general, some recent studies suggested that teachers' pedagogical beliefs, teachers' self-efficacy around technology, and received professional development support predicted teachers' use of technology in student-centered ways (Ananiadou and Claro 2009; Chen 2010; Miranda and Russel 2012). These studies, however, did not differentiate and compare the predictors of teachers' use of technology for different purposes. Another layer of complexity in this research area relates to inclusive investigation of multiple teacher-related factors and their independent predictive effects. As noted earlier, only few studies investigated the independent contribution of teachers' pedagogical beliefs, teachers' technological beliefs and attitudes, and teacher training to teacher use of technology (see Tondeur et al. 2008 for review). Also, most studies focused on pre-service teachers and primary school teachers, thus, research on high school teachers is limited.

Considering these research gaps, the current study aims to include multiple types of teacher-related factors (pedagogical beliefs, technological beliefs, and perceived professional development) that can help us understand the independent contribution of each set of predictors in terms of using technology for different teaching purposes. A large set of survey data were collected from high school teachers from a large, urban school district implementing a one-to-one technology initiative. For this study, the following research questions are addressed: (1) *how are the teacher-related factors independently predict high school teacher using technology in general?* (2) *how are the teacher-related factors independently predict teacher use of technology to support student-centered teaching practice?* (3) *how are the teacher-related factors independently predict teacher use of technology to support traditional teaching practice?*

2 Methods

2.1 Participants and Procedure

As part of a larger longitudinal study conducted in a large, urban K-12 public school district in the Southwestern United States, a district-wide teacher survey was disseminated to high school teachers in spring 2016 with an online survey system. Researchers received teacher emails from the district and all high school teachers were sent an individual email via their school requesting their participation. The survey remained open for 2 weeks and during this time, teachers were sent three reminders about the survey but the survey participation was voluntary. In this school district, approximately 75% of students are classified as economically disadvantaged, and the majority of students are Hispanic (62%) and African American (25%) in 2016 as indicated by indices on the district's website. All high school teachers received the survey link, and participation was anonymous and voluntary. Within a two-weeks survey window, 1054 high school teachers answered on survey from 38 high schools, a 52% return rate. Of the 1054 teachers who participated, 928 respondents passed at least one of the fraud items. Fraud items are commonly used in online survey to ensure participants answer the questionnaire seriously and carefully. For example, the questionnaire stated the clear directive to "Please choose Strongly Disagree on this item." If a participant answered anything other than "Strongly Disagree," then the participant did not pass that item. Survey data of the 928 participants were included in the current study. Of the 928 participants, 26% were English teachers, 19% were math teachers, 20% were science teachers, 18% were social science teachers, and 17% were teaching other subjects. This sample included more female teachers (59%) than male teachers. Forty-two percent of the teachers had more than 10 years of teaching experience, and 28% of the teachers had less than 3 years of teaching experience. About 39% teachers were 24–34 years old; 26% were 35–44 years old; and the remaining teachers were 45-years-old or older.

2.2 Measures

The survey consisted of a variety of measures on teachers' perceptions and practice related to their technology use and classroom instruction. For the current study, the variables that we were interested in serving as predictors were teachers' pedagogical beliefs, teachers' attitudes or beliefs towards technology, teachers' perceived training effectiveness and organizational support, with teachers' demographics included as covariates. The outcome variables were teachers' use of technology for different purposes. Most survey items related to teacher use of technology were adapted from the Second Information Technology in Education Study Teacher Questionnaire (SITES 2006) and the Technology—Instructional Practices Survey for Minnesota Teachers (Minnesota Department of Education 2014), and some were developed by the researchers. Questions related to teachers' pedagogy were developed by the researchers based on multiple theoretical frameworks such as the Bloom's Revised Taxonomy Model (Anderson et al. 2001), 21st Century Skills (P21 Partnership for 21st Century Learning 2009), and ISTE Standards for Educators (2008). The researcher-developed survey items were created and refined through an iterative process between researchers specialized in educational technology and teacher education and consultants with expertise in quantitative methods and assessment. An early draft of the survey was created and piloted by the researchers in spring 2015, and 519 high school

teachers from different content areas participated in the pilot study. The researchers slightly revised the survey and then piloted the survey again with a group of 14 high school teachers before it was administered for the current study. The researchers revised the survey items one more time based on feedback from the teachers to ensure that the survey items about teachers' beliefs and actual practice were relevant. Researchers also revised the item of the teacher use of technology to have a clear focus on student-centered learning versus traditional teaching methods.

2.2.1 Teacher Background Variables

Participants reported their gender, age range, teaching experience, grade level, and content area that they most often teach.

2.2.2 Teacher Pedagogical Beliefs

Learning Goals Learning goals related to higher order thinking have been emphasized largely in 21st century education. Education should not only equip students with basic knowledge, but also skills to create, think critically, and solve problems. However, in reality, teachers may hold different value towards those learning goals related to higher order thinking. Four items were used to measure teachers' value of these learning goals. A sample item is "For each of the following statements, think about the instructional objectives and learning goals. How important is it that students engage in critical thinking or problem solving?" The means of these items were used as the score of learning goals ($\alpha = 0.67$). The 5-point response scale ranges from 1 (not important) to 5 (most important).

Instructional Approaches With or without technology, a teacher may utilize a more traditional or a more student-centered instructional approach in teaching. A student-centered approach requires teachers to give more autonomy to the students and facilitate the collaborations among students. Three items were used to measure teachers' student-centered approaches to classroom practice. A sample item is "Consider for your core content area classes. How often does your instruction consist of in-depth discussions, investigations, or problem-solving among students?" The 5-point response scale ranges from 1 (never) to 5 (very often). The means of these items were used as the score of learning goals ($\alpha = 0.69$). A higher score indicates a more student-centered instructional approach.

2.2.3 Teacher Attitudes or Beliefs Towards Technology

Self-Efficacy in Using Technology Teachers may vary in their confidence in using technology in the classroom (Tondeur et al. 2017). One multiple choice item was used to measure a teacher's self-rated technology skill. Participants selected one of the five statements describing their technology skills ranging from 1 (not being a technology user in the classroom) to 5 (being a technology leader and often teach others to use technology resources). A higher score indicates higher self-efficacy using technology.

Openness to Technology to Support Instructional Practice Regardless of teachers' self-efficacy in using technology, teachers may also vary in their mindset towards using instructional technology. Teachers who are more open to instructional technology are willing to experiment with new technology and engage in more professional learning opportunities.

Five items were used to measure a teacher's willingness or openness to use technology in his/her instructional practice. A sample item is "I actively seek out professional learning opportunities that support the use of new technologies on my own." The 5-point response scale ranges from 1 (strongly disagree) to 5 (strongly agree). The means of these items were used as the score of openness to technology ($\alpha = 0.84$).

2.2.4 Teacher Trainings

Effectiveness of General Teaching Training Four items were used to measure the perceived effectiveness of the teaching training teachers received on campus. A sample item is "My campus-provided professional development enhances my teaching practice." The 5-point response scale ranges from 1 (strongly disagree) to 5 (strongly agree). The means of these items were used as the score of teacher perceived effectiveness of general teaching training ($\alpha = 0.94$).

Effectiveness of Technology-Focused Training Two items were used to measure the perceived effectiveness of the technology-focused training teachers received on campus. A sample item is "My campus-provided professional development improves my technology using skills". The 5-point response scale ranges from 1 (strongly disagree) to 5 (strongly agree). The means of these items were used as the score of teacher's perception of the effectiveness of the technology-focused professional development ($\alpha = 0.87$).

2.2.5 Teacher Use of Technology

Use of Technology Tools in General Four items were used to measure how often teachers are using technology tools in the classroom. A sample item is "Currently, how often do you use the following technology tools in your delivery of instruction: Interactive Smartboards." The 5-point response scale ranges from 1 (every few months or less) to 5 (every class). The means of these items were used as the score of teacher use of technology tools in general ($\alpha = 0.76$).

Use of Technology to Support Student-Centered Teaching Purpose Two items were used to measure teachers' use of technology to support a student-centered teaching approach. We asked teachers: "to support your delivery of instruction in your core content area, how often do you currently use technology to: (1) guide discovery in your classes? (2) facilitate discussions and/or sharing?". The 5-point response scale ranges from 1 (every few months or less) to 5 (every class). The means of these two items were used as the score of teacher use of technology to support student-centered teaching purpose ($\alpha = 0.67$).

Use of Technology to Support Traditional Teaching Purpose Two items were used to measure teachers' use of technology to support a traditional teaching approach. We asked teachers: "to support your delivery of instruction in your core content area, how often do you currently use technology to: (1) present information in your classes? (2) deliver lectures and/or demonstrations?" The 5-point response scale ranges from 1 (every few months or less) to 5 (every class). The means of the two items were used as the score of teacher use of technology to support traditional teaching purpose ($\alpha = 0.67$).

2.3 Analyses

For the first research question, we explored whether the variables of interest are predictive of teacher use of technology tools in general after controlling for teachers' background variables. For the second research question, we explored to what extent teachers' pedagogical belief, teachers' technological belief and attitude, and teacher training predicted teacher use of technology to support traditional teaching purpose and teacher use of technology to support student-centered teaching purpose after controlling for teachers' background variables and teacher use of technology tools in general. With teacher use of technology tools in general being controlled, the analysis can identify the independent contribution of the targeted predictors to teacher use technology for different teaching purposes. Preliminary data analysis showed that the random effects between schools are significant in the null models when predicting teacher use of technology in general ($p < 0.01$) and teacher use of technology to support traditional teaching ($p = 0.02$). The intraclass correlation coefficients (ICCs) of the null models predicting teacher use of technology in general, teacher use of technology to support student-centered-teaching, and teacher use of technology to support traditional teaching were 0.09, 0.02, and 0.05, respectively. To control for the random effects between schools and to have a consistent structure of the models, a random intercept was added to all three prediction models using PROC MIXED (SAS 2004). A series of hierarchical linear models were used to investigate these two research questions. All data available for the modeling were used in this study. For each research question, we ran a model with only the teacher background variables first, and then a model added in all the personal and institutional predictors. Except for the teacher background variables, all the predictors and outcome variables were standardized using PROC STANDARD (SAS 2004) with M = 0 and SD = 1. In these models, female teachers were used as the reference group when investigating the gender difference, teachers who were 45-years-old or older were used as the reference group when investigating the age difference, teachers who taught science were used as the reference group when investigating the content difference, teachers who taught lower grade levels (9th and 10th grade) were used as the reference group when investigating the grade level difference, and teachers who had more than 10 years of teaching experience were used as the reference group when investigating the teaching experience difference.

3 Results

3.1 Descriptive Statistics and Correlations

Table 1 shows the descriptive statistics of all the predictors and outcome variables and the correlations between them. The correlation between the two pedagogical beliefs variables (Learning Goals, Instructional Approaches) was moderate ($r = 0.40$); the correlation between the two attitudes towards technology variables (Openness to Technology to Support Instructional Practice, Self-Efficacy in Using Technology) was moderate ($r = 0.27$); The correlation between the two training variables was high ($r = 0.59$). All the predictors were correlated with teacher use of technology tools in general to a small size ($rs = 0.14$–0.24), and the largest correlations appeared with the attitudes towards technology variables ($rs = 0.23,\ 0.24$). Regarding teacher use of technology to the support

Table 1 Descriptive statistics and correlations

Variable	Mean	SD	Goals	Approaches	Open	Efficacy	Training_T	Training_G	Tech_G	Tech_S
Goals	4.32	0.51								
Approaches	3.77	0.68	0.40**							
Openness	4.16	0.60	0.33**	0.31**						
Efficacy	3.81	0.80	0.09*	0.07*	0.27**					
Training_T	3.69	0.91	0.22**	0.22**	0.35**	-0.03				
Training _G	3.55	0.92	0.19**	0.18**	0.31**	-0.02	0.79**			
Tech_G	1.72	1.32	0.16**	0.17**	0.23**	0.24**	0.16**	0.14**		
Tech _S	3.19	1.03	0.24**	0.35**	0.38**	0.22**	0.34**	0.30**	0.35**	
Tech _T	3.69	0.90	0.18**	0.15**	0.26**	0.23**	0.20**	0.19**	0.31**	0.56**

Goals, Learning Goals; Approaches, Instructional Approaches; Openness, Openness to Technology to Support Instructional Practice; Comfort, Comfortable with Technology to Support Instructional Practice; Efficacy, Self-Efficacy in Using Technology; Training_T, Effectiveness of Technology-Focused Training; Training _G, Effectiveness of General Training; Tech_G, Use of technology tools in general; Tech _S, Use of technology to support student-centered teaching purpose; Tech _T, Use of technology to support traditional teaching purpose

*$p < 0.05$; **$p < 0.01$

student-centered teaching purposes, most of the predictors correlated with this outcome to a medium size ($rs = 0.22–0.38$). In contrast, the pedagogical beliefs variables ($rs = 0.15$, 0.18) and the training variables ($rs = 0.19–0.20$) had lower correlations with teacher use of technology to support traditional teaching purpose than attitudes towards technology variables ($rs = 0.23$, 0.26).

3.2 Teacher Background Predictors of Teacher Use of Technology

Table 2 shows the estimates of the background variables when predicting teacher use of technology in teaching. When predicting using technology tools in general (Model 1A), English and math teachers used technology significantly less frequently than science teachers ($p = 0.04$ and $p = 0.01$, respectively). Male teachers used technology tools more frequently than female teachers ($p = 0.04$). Also, teachers who are younger than 45-years-old used technology more frequently than older teachers. There were no significant differences in predictors regarding teachers' grade level taught or their teaching experience.

Table 2 Random intercepts hierarchical linear models predicting individual-level teacher technology use with demographics

	Model 1A Using technology tools			Model 2A Using technology tech to support student-centered teaching			Model 3A Using technology tech to support traditional teaching		
	Estimate	SE	*p*	Estimate	SE	*p*	Estimate	SE	*p*
Intercept (school)	0.07	0.04	0.05	0.01	0.02	0.28	0.03	0.02	0.07
Intercept (teacher)	−0.01	0.14	0.95	−0.14	0.13	0.31	0.00	0.13	0.99
Content (English)	**−0.25**	**0.12**	**0.04**	−0.09	0.12	0.49	**−0.31**	**0.12**	**0.01**
Content (Fine Arts)	−0.54	0.30	0.07	0.16	0.31	0.60	−0.36	0.30	0.23
Content (Foreign Language)	−0.36	0.24	0.13	0.12	0.27	0.66	0.04	0.25	0.86
Content (Health)	−0.60	0.34	0.08	0.10	0.37	0.78	−0.25	0.36	0.49
Content (History/Social Study)	−0.08	0.13	0.52	0.08	0.13	0.54	0.06	0.13	0.65
Content (Math)	**−0.34**	**0.13**	**0.01**	**−0.31**	**0.14**	**0.03**	−0.11	0.14	0.43
Grade level (11–12 grade)	−0.02	0.09	0.84	0.10	0.09	0.28	−0.02	0.09	0.84
Gender (Male)	**0.18**	**0.09**	**0.04**	0.08	0.09	0.37	0.01	0.09	0.94
Experience (1–3 years)	−0.09	0.13	0.48	0.01	0.14	0.92	**0.30**	**0.13**	**0.02**
Experience (4–6 years)	−0.01	0.14	0.97	0.10	0.15	0.51	0.12	0.14	0.40
Experience (7–9 years)	0.09	0.15	0.56	0.07	0.16	0.67	0.19	0.15	0.20
Age (24–34 years old)	**0.35**	**0.13**	**0.01**	0.12	0.14	0.37	−0.04	0.13	0.75
Age (35–44 years old)	**0.37**	**0.11**	**<0.01**	0.04	0.12	0.75	−0.04	0.12	0.74
−2 Res Log Likelihood	1533.6			1434.6			1482.3		
AIC	1537.6			1438.6			1486.3		
BIC	1540.8			1441.7			1489.5		

Experience: Teaching experience; the reference group of content is science teachers; the reference group of grade level is teachers who teach 9–10 grade; the reference group of gender is female teachers; the reference group of teaching experience is teachers with more than 10 years teaching experience; the reference group of age is teachers who are 45 years old or older

The significant estimates were bold

When predicting using technology for different teaching purposes, fewer teachers' background variables were significant. Math teachers used technology significantly less frequently to support student-centered teaching than science teachers ($p=0.03$), while English teachers used technology significantly less frequently to support traditional teaching than science teachers ($p<0.01$). In addition, teachers who had only 1–3 years of teaching experience used significantly more technology to support their traditional teaching than teachers who had more than 10 years of teaching experience ($p=0.02$), but teaching experience was not predictive to teacher use of technology to support student-centered teaching.

3.3 Teacher Beliefs and Teacher Training Predictors of Teacher Use of Technology

Table 3 shows the estimates of the predictors when the background variables were controlled as covariates. A preliminary regression analysis showed that none of the predictor has violated the multicilinearity rule (VIFs < 3). When predicting teacher use of technology tools in general (Model 1B), both attitudes towards technology variables, self-efficacy in using technology and openness to technology to support instructional practice were significant ($\beta=0.15$, $p<0.01$), and ($\beta=0.08$, $p=0.07$), respectively, indicating that teachers who have higher confidence in their technology skills and who are more open to using new technology in teaching use technology tools more frequently in their teaching practices in general.

When predicting teacher use of technology to support teaching purposes (Model 2B and Model 3B), teacher use of technology tools in general was a significant predictor in both models (βs = 0.17, 0.21.19, ps < 0.01), as well as teachers' self-efficacy in using technology (βs = 0.11, 0.13, ps = 0.01). Furthermore, Model 2B shows that teachers' instructional approach also independently predicted teacher use of technology to support student-centered teaching ($\beta=0.23$, $p<0.01$), however, teachers' instructional approach was not significant when predicting teacher use of technology to support traditional teaching. Interestingly, openness towards technology independently predicted teacher use of technology to support student centered teaching ($\beta=0.15$, $p<0.01$) but not traditional teaching. These findings indicate that teachers who frequently use a student-centered teaching approach or who are more open to experimenting with technology are more likely to use technology to support student-centered teaching. Given the exploration nature of this study, with Bonferroni corrections, teachers' self-efficacy in using technology was the only significant predictor of using technology in general and use of technology to support teacher-centered teaching, while teachers' instructional approach and openness to technology significantly predicted teacher use of technology to support student-centered teaching.

In addition, although the perceived effectiveness of training was not significant when predicting the three different measures of teacher use of technology, the estimates of the training with a technology focus were marginally significant across three models while the estimates of the teaching training in general were higher when predicting use of technology to support student-centered teaching ($\beta=0.11$, $p=0.09$) than when predicting use of technology to support traditional teaching ($\beta=0.03$, $p=0.64$).

4 Discussion

Student-centered instruction is a highly-valued way to approach learning experiences for students as it focuses on the learner. In a student-centered learning environment, teachers

Table 3 Random intercepts hierarchical linear models predicting individual-level teacher technology use with demographics, individual, and institutional predictors

	Model 1B Using technology tools			Model 2B Using technology tech to support student-centered teaching			Model 3B Using technology tech to support traditional teaching		
	Estimate	SE	*p*	Estimate	SE	*p*	Estimate	SE	*p*
Intercept (school)	0.06	0.04	0.06	0.00	0.00	–	0.02	0.02	0.12
Intercept (teacher)	−0.01	0.13	0.96	−0.21	0.12	0.08	−0.02	0.13	0.91
Tech_G				0.21	0.04	< 0.01	0.17	0.04	0.00
Content (English)	−0.22	0.12	0.07	−0.06	0.11	0.60	−0.21	0.12	0.08
Content (Fine Arts)	−0.66	0.30	0.03	0.14	0.27	0.62	−0.28	0.30	0.35
Content (Foreign Language)	−0.21	0.25	0.41	−0.05	0.25	0.84	0.07	0.25	0.77
Content (Health)	−0.48	0.33	0.15	0.13	0.32	0.69	−0.13	0.34	0.70
Content (History/Social Study)	−0.05	0.12	0.69	0.13	0.11	0.27	0.09	0.12	0.45
Content (Math)	−0.22	0.13	0.10	−0.17	0.12	0.18	0.07	0.13	0.60
Grade level (11–12 grade)	−0.04	0.09	0.64	0.12	0.08	0.13	−0.04	0.09	0.68
Gender (male)	0.14	0.09	0.11	0.08	0.08	0.34	−0.03	0.09	0.76
Experience (1–3 years)	−0.01	0.13	0.95	0.12	0.12	0.34	0.38	0.13	0.00
Experience (4–6 years)	−0.05	0.14	0.70	0.06	0.13	0.65	0.06	0.14	0.64
Experience (7–9 years)	0.14	0.15	0.35	0.16	0.13	0.24	0.18	0.14	0.23
Age (24–34 years old)	0.29	0.13	0.03	0.09	0.12	0.48	−0.11	0.13	0.41
Age (35–44 years old)	0.34	0.11	0.00	0.01	0.11	0.92	−0.10	0.11	0.35
Goals	0.03	0.05	0.53	−0.01	0.05	0.90	0.03	0.05	0.49
Approaches	0.09	0.05	0.06	**0.23**	**0.04**	**< 0.01**	0.07	0.05	0.15
Openness	**0.12**	**0.05**	**0.02**	**0.15**	**0.05**	**< 0.01**	0.07	0.05	0.18
Efficacy	**0.17**	**0.05**	**< 0.01**	**0.11**	**0.04**	**0.01**	**0.13**	**0.05**	**< 0.01**
Training _T	0.12	0.07	0.08	0.10	0.06	0.10	0.11	0.07	0.10
Training_G	0.00	0.07	0.96	0.11	0.06	0.08	0.03	0.07	0.64
−2 Res Log Likelihood	1418.5			1277.0			1397.3		
AIC	1422.5			1279.0			1401.3		
BIC	1425.7			1280.6			1404.4		

Tech_G: Use of technology tools in general; Experience: Teaching experience; Goals: Learning Goals; Approaches: Instructional Approaches; Openness: Openness to Using Technology to Support Instructional Practice; Comfort: Comfortable with Technology to Support Instructional Practice; Efficacy: Self-Efficacy in Using Technology; Training_T: Effectiveness of Technology-Focused Training; Training _G: Effectiveness of General Training; the reference group of content is Science teachers; the reference group of grade level is teachers who teach 9–10 grade; the reference group of gender is female teachers; the reference group of teaching experience is teachers with more than 10 years teaching experience; the reference group of age is teachers who are 45 years old or older

The significant estimates were bold. If we use Bonferroni corrections, $p < 0.01$ would consider as significant

may guide their students through the discovery of new knowledge, facilitate discussions, and/or give students the freedom to explore in their learning. Unfortunately, increased availability of technology in schools has not led to overall improvement in classroom teaching practices (Cuban 2001; Cuban et al. 2001; Windschitl and Sahl 2002). The technology tools only helped provide the environmental readiness, or addressed the first-order

barriers; how to address the second-order barriers, or overcome the challenges related to teacher readiness (Ertmer 1999, 2005; Kim et al. 2013) became increasingly important for this stage of technology integration in many schools and districts in the U.S. To address this challenge, one area of research indicates that teachers with more constructivist views and practices tend to not only use technology to support higher order thinking skills, but also use technology more frequently and to support more student-centered curricula (Baylor and Ritchie 2002; Ertmer et al. 2012; Overbay et al. 2010). Recent research showed that "tool access", "constructivist pedagogy", and a combination of "will" and "skill" can explain a significant amount of the variance (60–90%) in teachers' level of technology integration (Christensen and Knezek 2017; Knezek and Christensen 2016; Petko 2012). While previous studies have examined teacher beliefs and professional development factors as related to teachers' frequency of technology use, only a few have examined the predictors of teacher use technology in a student-centered way. Furthermore, according to the author's knowledge and a comprehensive literature review, no existing study has differentiated the predictors of teacher technology use for traditional teaching and student-centered teaching. Thus, results of the current study have important implications for education practitioners and researchers.

First, the findings of the current study is aligned with results from previous research on technology self-efficacy (see Hew and Brush 2007, for a review). When background variables were controlled, technology self-efficacy was still a significant predictor of teacher technology use in general and teachers use technology to support either student-centered or traditional teaching purposes. This result suggests that teachers' confidence in using technology is directly related to their actual use of technology in the classroom. As in the well-known "Little Engine that Could" story, those who "think I can, think I can" may hold an advantage over those without such beliefs. Bandura (1989) suggested that self-efficacy may influence behavioral outcomes through motivational and affective processes. The mechanisms through which teachers' technology self-efficacy influence their technology use behaviors may involve these dual processes. Motivationally, as suggested by the TAM model, technology self-efficacy might influence both teaching-related decision-making and later engagement in technology-related instructional activities. Teachers low on technology self-efficacy may correspondingly hold a low expectancy for carrying out the optimal teaching outcomes by using technology, so they may avoid using technology when they do not have to. If technology is asked to be required for their teaching, they may flag in their efforts and work passively. Affectively, technology self-efficacy may enhance teachers' coping in the face of obstacles when designing and delivering technology integrated instruction. Teachers who have stronger beliefs may be able to experience less anxiety, think more openly and persist longer when faced with difficulties than teachers who are beset by self-doubt (Bandura 1989).

Second, one important finding of the current study is, when predicting teacher technology use to support student-centered teaching, teachers' instructional approach was an important contributor. The effect of teachers' instructional approach was found to be independent from teachers' technology self-efficacy. Notably, when predicting use of technology to support student-centered teaching together, the estimate of teacher's instructional approach was more than double the size of the estimate of the technology self-efficacy, suggesting that teachers' pedagogical approaches and technology usage tendency are both important, but teachers' pedagogical approach is even more crucial to determine teachers' use of technology for more desired learning outcomes. This finding is aligned with the TPACK Model, which has been widely used to provide a foundation for practitioners and researchers to understand the multiple components of supporting teachers in their practice

and the relationship to technology (Koehler and Mishra 2009). The TPACK framework emphasizes the integrated roles of teachers' technological knowledge, pedagogical knowledge, and content knowledge and suggests that good practice requires all three components. The current study did not focus on one specific content area, and we did not measure teachers' content knowledge, but our results highlighted the importance of teachers' pedagogical readiness and technological readiness to effective teaching with technology.

Third, we found that teachers' openness towards technology was also an independent predictor of teacher use technology to support student-centered teaching when technology self-efficacy was controlled. Although teachers who were more confident in their technology ability may be more willing to experiment and practice, these two constructs are different. Another factor that could influence teachers' openness to technology is teachers' mindset. Dweck et al. (1995) suggested that people's mindsets about the malleability of ability frame the way they perceive and interpret experiences and events, which in turn influence their reactions and responses in such situations. People with a fixed mindset (also referred to as entity theory) tend to believe that ability is fixed and unchangeable, while people with a growth mindset (also referred to as incremental theory) tend to believe that through effort and appropriate strategies, learners can improve their ability. People with a growth mindset are more likely to focus on skill improvement and effective strategy use rather than documenting ability and superficial strategy use. In a new 1-to-1 program, most teachers are not skilled at using instructional technology; however, teachers who have a growth mindset may be more likely to learn how to improve their skills and take risk to try new technology and pedagogy, while teachers who have a fixed mindset would feel more comfortable using the traditional way to teach and to maintain their performance. The current study did not explicitly measure teachers' mindset, but the results on openness towards technology suggest that the teacher mindset might have an active role in determining teachers' choice of teaching approach and their performance over time. Future research can investigate how teacher mindset influences teachers' perceptions, practice, and performance regarding instructional use.

This study has important implications for practitioners organizing professional learning experiences for teachers. Research in professional learning has highlighted issues of self-confidence and coaching as important and difficult. For example, Groff and Mouza (2008) suggested that teachers lack of computer knowledge and experience is the most foreseeable challenge for teachers implementing instructional technology in the classroom. Our research confirmed that teachers' confidence in using technology is a starting point for teacher use of technology, either for traditional teaching use or for student-centered teaching purposes. More importantly, our findings suggest that developing systems of both technological and pedagogical support that accommodate teachers' technology and pedagogical skills may help teachers integrate technology into their classrooms more effectively. Only technological support is insufficient to equip teachers with the skillset to implement technology to create a student-centered learning environment. Furthermore, building a culture that embraces innovation and experimentation with new technology may be also important. Effective professional development needs to address school culture, teachers' mindset, and provide sufficient time for modeling, experimentation, and reflection, as well as follow-up support for technology integration in the classroom.

There are several limitations to this study. First, the participants were from a large, urban high school district in the Southwestern United States. The student population was predominantly Latino/a students, and the majority of teachers were Caucasian. We used a convenience sample due to resource constraints, so the sample might not be fully representative of the teachers in the district or teachers in the U.S. Since we are more interested in

the general relations between the target predictors and outcomes instead of these relations in a specific group of teachers, the large sample size of this study enhanced the potential of this study to shed lights on those relations. However, for researchers who are interested in a teacher population with a different background, the findings we drew from this study may not be generalizable.

We also acknowledge the limitations of the measurements we used in the current study. First, the measures of the teachers' learning goal, instructional approach, and use of technology to support student-centered/traditional teaching purpose had low alphas. This issue might be due to the limited items we included to measure these complex constructs. For a study that asks teachers to participate voluntarily, we intentionally designed this survey to be able to complete within 15 min. Due to this time limit, we were only able to include one item for each type of the learning goals related to high-order thinking skills, such as application, problem solving, collaboration, and communication. In this case, the items of the Learning Goals measure might capture both the differences between these learning goals and the common factor among these learning goals, which would reduce the internal consistency of the measure. The same applies to the measurement of the instructional approach and technological self-efficacy. Second, the teacher use of technology measure was self-reported. Self-reported measures may be influenced by social appraisal and personal biases. Although it is a common limitation of survey studies, other data types, such as classroom observation data, technology log data, might help to eliminate some of the biases. Also, we only used two items each to measure teacher use of technology to support student-centered teaching purposes and teacher use of technology to support traditional teaching purposes. They do not capture all types of student-centered teaching activities, and the measure would be less reliable compared to a comprehensive multiple-item scale. These limitations of those measurements might limit the generalizability and usefulness of the findings related to those measures. Future research could consider (1) how to provide some incentive to participants so a lengthier survey can be administered successfully; (2) use a more reliable scale to measure teachers' learning goals and instructional approach; (3) develop more items to measure the student-centered and traditional teaching use of technology more comprehensively and accurately; (4) supplement the survey data with additional classroom observation and technology log data to measure teacher use of technology more objectively.

Lastly, our selection of predictors of teacher use of technology was based on previous research. However, it is possible that some other teacher belief or teacher training variables can predict teacher technology use as well or better than the factors we included in the current study. Also, we did not measure the technological variables such as the accessibility and effectiveness of campus technical support because all data were collected within one school district, but it is possible that these factors also contribute to teacher use of technology.

5 Conclusions

To summarize, the current research addressed two main research gaps in the existing literature. First, by differentiating the teaching purposes of using technology, our study showed the common and distinct predictors of teacher use of technology to support student-centered teaching purposes and teacher use of technology to support traditional teaching purposes. Second, the current research included a relatively large set of different types of variable and explored the independent contribution of each factor when predicting teacher use

of technology for different teaching purposes. We found that technology self-efficacy was important in predicting teacher use of technology, and teachers' instructional approach and openness towards technology were more crucial when predicting teacher use of technology to support student-centered teaching. This study raises important implications for the field of professional learning. Pedagogical readiness is as important as technological readiness for teachers to integrate technology in teaching to serve more advanced teaching purposes. It will be important to maintain a focus on effective pedagogical practices alongside technology using skills when providing professional development opportunities to high school teachers.

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