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ARTICLE

Assessing the Role of Online Technologies in Project-based Learning

Jason Ravitz (Buck Institute for Education) and Juliane Blazevski (Hypothesi Consulting)

This study examines the relationships between teacher-reported use of online resources and preparedness, implementation challenges, and time spent implementing project-based learning (PjBL) or similar approaches in high school academic courses. Variables were measured using self-reports from those who teach in reform network high schools that emphasize related instructional reforms ($n = 166$) and those who do not ($n = 164$). In both school types, technology use was positively related to the amount of PjBL use and teacher preparedness. We used path analysis (two-group SEM) to test a model that predicted online technology use would have a negative relationship to perceived challenges and a positive relationship to more preparedness, and that these would predict time spent conducting projects. Control variables included teacher professional engagement, use of interdisciplinary instruction, and schoolwide emphasis on inquiry. Data support many of the predicted relationships, including a direct relationship between online feature use and time spent on PjBL for teachers in reform network schools. Outside the reform network schools, however, the path from online feature use to PjBL use was unclear with only indirect effects. These results suggest areas for further investigation and that we should be cautious not to overstate the role of online technologies.

Keywords: project-based learning, Internet, high school reform, survey research, SEM

Introduction

In recent decades there has been a *concurrent* growth in the availability of online technologies for teaching and learning and interest in advancing project- and problem-based learning, or simply PBL (Mitchell et al., 2005). Following guidelines for this journal and Tamim and Grant (2013), we use PjBL to distinguish conducting projects in K–12, although these can be problem-based (e.g., Maxwell, Bellissimo, & Mergendoller, 2001) from problem-based learning as developed in medical schools.

Many high school reform initiatives have emphasized both new technologies and use of PjBL as central components of reform. These include New Tech Network (Hanover, 2013; Pearlman, 2002) and High Tech High (2009) models that emphasize project-based instruction and have names that indicate the importance of technology. There has also been substantial use of PjBL and online technologies outside of specialized school reform networks. In their study of high school reforms, Mitchell, et al. (2005) listed the PjBL-related approaches as being among the most prevalent schoolwide instructional reforms (p. 40). Growth of interest is also indi-

cated by the emphasis on this approach in policy documents such as from the National Middle School Association (Yetkiner, Anderoglu, & Capraro, 2008), the National High School Center (Harris, Cohen, & Flaherty, 2008, p. 3), and by the development of web sites with research (Buck Institute for Education, 2013; Vega, 2012).

A few reform networks beyond those in our study have also emphasized use of projects, exhibitions, or authentic problems (Expeditionary Learning Outward Bound, 1999; Littky & Grabelle, 2004; McDonald, Klein, Riordan, & Broun, 2003). There have also been efforts to implement at scale across states (Williamson, 2008) and districts (Indiana University, 2010) and to improve teacher preparation for this kind of teaching (High Tech High, 2013; Marshall, Petrosino, & Martin, 2010). This advancement of PjBL-related reform all takes place within the context of a “digital decade” that saw Internet access expand from 1997 to the point where “nearly all schools can get online, and the percentage of instructional computers with high-speed access hovers around 95 percent” (Education Week Editors, 2007). Meanwhile, by most accounts, the impact of technology is only increasing (e.g., Hanover Research, 2013).

Reforming High Schools

In addition to new technologies and increased interest in PjBL, we have seen widespread high school reform initiatives, notably converting large comprehensive high schools into smaller schools to help personalize relationships and support more effective teaching and learning (Bloom, Thompson, Unterman, Herlihy, & Payne, 2010; Kahne, Sporte, de la Torre, & Easton, 2006; Ravitz, 2010). A few organizations have sought to push instructional boundaries in conjunction with more holistic school reform models (Bodilly, Purnell, Ramsey, & Keith, 1996). These include the four reform networks in our study: New Tech Network (Pearlman, 2002), High Tech High (2009), Edvisions (Newell, 2003; Van Ryzin & Newell, 2009), and Envision Schools (n.d.).

To a large extent, these reform organizations embrace PjBL as a central component of instruction and have developed uses of technology to help teachers and students. New Tech Network (n.d.) has a proprietary learning management system for managing projects called Echo, Envision Schools (n.d.) has a Project Exchange library, Edvisions uses a tool called Project Foundry for sharing assessments of student work (Project-based Learning Systems, n.d.), and High Tech High has a “digital commons” for showcasing student work (e.g., High Tech High, 2009). Schools affiliated with these reform networks benefit from having a central organization to help sustain the model’s philosophy and practices. In addition to online technologies, they have structures that support multidisciplinary teaching, provide a repertoire of practices, and a supportive culture for teaching and learning (Ravitz, 2010).

Project-based Learning

After years of research on use of problem-based learning in medical school contexts, we are seeing evidence that PjBL, as adapted for K–12 use, can be effective (Buck Institute for Education, 2013; Vega, 2012; Walker & Leary, 2009). Examples of promising findings for PjBL can be found for middle school science (Geier, et al., 2008) and middle or elementary math (Boaler, 1997; Cognition and Technology Group at Vanderbilt, 1992). There is also evidence for the effectiveness in high school economics (Finkelstein, Hanson, Huang, Hirschman, & Huang, 2010) and government (Boss, et al., 2011). Research indicates there can be advantages for teacher professional development and student learning in various disciplines (Walker & Leary, 2009), and that PjBL use is correlated to teaching of twenty-first-century skills (Hixson, Ravitz, & Whisman, 2012). These results are consistent with research suggesting this approach is most useful for knowledge that can be applied or understood at a deeper, more enduring level (Strobel & van Barneveld, 2008).

Teaching using a PjBL approach often requires students to investigate open-ended or ill-defined topics in depth so that they can create solutions, products, or performances. Using projects to motivate students can create a “need to know” (Larmer & Mergendoller, 2012) in a way that has much in common with problem-based or inquiry-based instruction although there are subtle differences (Barron & Darling-Hammond, 2008; Jonassen, 1992; Savery, 2006). In practice, “many educators will refer to the same activity interchangeably as ‘project-based’ or ‘problem-based’ learning, or simply ‘PBL’” (Mitchell et al., 2005, p. 40). As indicated previously, our use of “PjBL” highlights the K–12 context while allowing problem-based to be one type of project. Pedersen and Liu (2003) discuss the common features of student-centered, case-based, and goal-based scenarios, learning by design, and project- and problem-based learning. All of these approaches attempt to promote academic rigor while promoting “soft skills” such as critical thinking, communication, and collaboration (Trilling & Hood, 1999; Williamson, 2008). They often encourage students to be responsible and resourceful for their own learning, to solve open-ended problems, and to create and present artifacts as demonstrations of their learning.

Studies indicate that implementing PjBL effectively requires extensive planning and professional development for teachers, a supportive environment, and tools and strategies for both teachers and students (Hmelo-Silver, Duncan, & Chinn, 2007). Using a project-based approach often necessitates changes in classroom management and teaching strategies, while teachers must be ready with a vast array of resources and knowledge. For these reasons, teachers can report difficulty or feel underprepared when making the transition to this more student-centered approach (Blumenfeld et al., 1991; Bradley-Levine et al., 2010; Ertmer & Simons, 2006; Marx, Blumenfeld, Krajcik, & Soloway, 1997). Given the amount of preparation that is required and the challenges associated with conducting projects, it becomes essential to consider the best way to support teachers. Without adequate support, challenges and lack of preparedness could result in low self-efficacy and reduced implementation (English, 2013; Guskey, 1988).

Some proponents of PjBL in schools choose not to emphasize use of new technologies, in part because this could create additional hurdles for schools and teachers. For example, materials from the Buck Institute for Education emphasize significant content and twenty-first-century skills and other essential elements (Larmer & Mergendoller, 2012) in a way that leaves room for technology use but does not require it. Although web literacy and digital citizenship can be included in twenty-first-century skills (Hixson, Ravitz, & Whisman, 2012), effective PjBL does not always have to be “technol-

ogy accelerated and network-connected” (Martin, 2013). One can imagine high-tech and low-tech versions of projects that have the essential qualities of effective projects, but do not emphasize online resources: growing a garden, building a three-dimensional model, staging a debate on a scientific topic, creating a performance art piece, observing populations, or developing a land use proposal. As noted by Becker and Lovitts (2003), not requiring technology, or permitting use to vary, allows us to more carefully investigate how this use is related to teaching and learning.

Easy to Claim: A Relationship Between PjBL and Technology Use

The use of technology to support inquiry-based learning approaches goes back to Apple Classroom of Tomorrow studies (Sandholtz, Rignstaff, & Dwyer, 1997) which found computers can help reform teaching by promoting “student autonomy, more collaborative work both face to face and online, more global connections, richer learning resources than traditional textbooks, and more inquiry, interdisciplinary, and project-based learning” (Kleiman, 2001, p. 3–4). Today, there is a wealth of online resources for teachers whether they are just beginning to explore the possibilities of PjBL or are already using this approach to instruction. Both of these elements, developing knowledge and finding worthwhile implementation scaffolds, are critical to effective implementation (Boss & Krauss, 2007; Cognition and Technology Group at Vanderbilt, 1992; Ertmer & Simons, 2006; Hmelo-Silver, 2006).

Benefits of online tools include “hard scaffolds” that structure processes for teachers and students. These help teachers to focus on better interventions or “soft scaffolds” based on their improved ability to monitor student thinking (Brush & Saye, 2002). Use of different online features can also help with communicating with others outside the classroom, to access multiple viewpoints, manage group work, and help teachers give and receive feedback to each other (Koschmann, 1996; Laffey, Tupper, Musser, & Wedman, 1998; Renninger & Shumar, 2002). Online resources that support PjBL use include libraries of projects (Williamson, 2008), blogs devoted to the topic (Edutopia, n.d.), tools for assessment and feedback (Project-Based Learning Systems, n.d.), and an online community with 24,000 followers (Edmodo, n.d.). In addition, some online resources have been designed specifically to support PjBL interventions, so use of the online tools and this teaching approach are closely linked (e.g., Brush & Saye, 2002).

Hard to Explain: Causality, Equity, and Spuriousness

The above discussion suggests there is a positive relationship between use of online technologies and implementation of PjBL. However, interpreting and drawing conclusions about the impact of technology use is problematic. This is due to

issues of causality, equity, and spuriousness. Because Internet use and teaching practices have been advancing at the same time and as part of the same initiatives, it can be difficult to evaluate the contribution of the technologies by themselves (Becker & Lovitts, 2003). The appearance of a relationship between PjBL and use of online technologies could be the result of teacher and school characteristics, or simply changing times. There is often a combined emphasis on new technologies and teaching practices (e.g., Baron, 2013). In addition, proponents of technology integration may emphasize PjBL-related practices (e.g., Johnson, Smith, Smythe, & Varon, 2008) as a way to promote effective technology learning, with these being “more effective in changing student motivation and achievement than drill-and-practice applications” (International Society for Technology in Education, 2008, p. 3). The result is a mutually supportive relationship. Online technologies may influence project work, while conducting projects may influence use of these technologies.

In addition, teaching with PjBL and online technologies are both innovations in the sense pioneered by Rogers (1983). Use of new practices, like today’s PjBL, and use of new technologies, including various Internet features, will likely appeal to certain teachers and schools. Riel and Becker (2008), for example, found that teachers who use the most technologies also implement the most teaching reforms. “Teacher leaders,” defined as being the most engaged in the profession outside their classroom, are “(a) more constructivist than other teachers of the same subject and level and (b) use computers substantially more than other teachers do” (p. 398). Replicating this finding, Hixson, Ravitz, and Whisman (2012) found teacher professional engagement was related to PjBL use. In short, teacher professional engagement could cause or “explain away” the relationship we see between new technologies and practices.

Finally, there are questions about how equitable the distribution is for use of new technologies and practices within and across schools, or how widespread the relationship is. One analysis of survey studies suggests that the most innovative practices are often not implemented in the schools that are most in need of improvement and support (Camburn & Won Han, 2008). New practices and effective uses of technology often take substantial resources and commitment that may be lacking among many teachers and schools. “For technology to be used fully in K–12 schools, significant changes are required in teaching practices, curriculum, and classroom organization . . . these changes take place over years, not weeks or months, and require significant professional development and support for teachers” (p. 5). When changes are seen in schools, Creighton indicates, “technology initiatives in schools often yield in-groups and out-groups (in Hewitt, Mullen, Davis & Lashley, 2012, p. 20) resulting

in different levels of implementation. As a result, even in reform model networks with their strong support structures, we would expect variation in how much PjBL is used and to what extent technology uses are integrated.

To summarize, our reading of the literature indicates the potential value of technology scaffolds to address implementation challenges and to increase teacher preparedness for PjBL. However, it also raises concerns about claims that technologies can change teaching given the importance of school and teacher characteristics. There is a risk of overstating how much online technologies may contribute to teaching reforms.

Many attempts to integrate new technologies are not helpful, especially when incentives to adopt technologies are not provided, they are used in isolation, or do not serve an educational purpose (AASL, 2012). For decades, Cuban has described a recurring cycle of reform and failure in which technology initiatives start off with enthusiasm but end up in disappointment, ultimately with lack of evidence to support claims that technologies can transform teaching and learning (Cuban, 2011; 2013). In response to Cuban, Becker (2000) reported an increase in teaching reforms among more intensive computer-using teachers. "Constructivist change seems to have occurred more often than typically among teachers who used a large variety of software in their teaching practice" (p. 27). However, findings also indicated the importance of teacher characteristics (Riel & Becker, 2008). Our study contributes to this discussion by considering whether online technology use is still related to PjBL, even after controlling for teacher professional engagement and other key variables.

Research Questions

In order to understand how online technologies contribute to PjBL use, this study focused on the following questions:

1. What is the relationship between online technology use and teachers' sense of preparedness, implementation challenges, and time spent using PjBL in the classroom?
2. Can this relationship be accounted for by teacher characteristics (professional engagement and interdisciplinary teaching) or school characteristics (reform network or schoolwide emphasis on PjBL or inquiry)?

Method

A survey method was selected to answer the above questions. This is a useful method for gathering information from a large number of geographically distant teachers, studying variation in frequencies and measuring how relationships vary (Babbie, 1991).

Population and Sample

Our population consisted of high school teachers who used PjBL or related methods to teach math, science, social studies, or English during the 2006–2007 school year. Surveys were administered in fall 2007 using an online survey tool (SurveyMonkey, n.d.). We sampled 1568 participants from a list of 2,746 teachers across 12 different strata (see Ravitz, 2008a). The sampling frame for the first three strata consisted of 745 teachers not associated with any reform network, including recipients the Project Based Learning Handbook (Markham, Larmer, & Ravitz, 2004), bulk orders of these books, and workshops from the Buck Institute for Education (BIE).

In addition, the sampling frame included 299 teachers from the four reform model networks listed previously, as well as 524 teachers from the North Carolina New Schools Project, affiliates of High Tech High, IEARN, workshops conducted by the Center for Effective School Practices (in New Jersey and Ohio), and the San Diego Renewal High Schools initiative. These organizations provided lists of teachers and schools receiving PjBL materials or workshops in the years leading up to our study. Teachers in large strata were sampled using proportions designed to yield a sufficient number of cases in that strata (Ravitz, 2008a).

Our communications with participants borrowed heavily from Dillman (2000), including multiple contacts and methods and the use of a small gift at the outset, although we later added an economic reward (\$15) for completion. Although nonrespondents were sent invitations via "snail mail" and faxes, use of an online survey to collect data may have prevented infrequent Internet users from participating. We ultimately received responses from 406 teachers representing approximately a 35% response rate based on 1,200 estimated recipients (whose e-mails did not bounce). After removing those who gave incomplete responses, or who did not meet our criteria (confirmed use of PjBL for academics in a public high school during the previous school year), we were left with 330 teachers for our analyses. Response rates for the reform networks were over 60%, while the other strata averaged about 25% (Ravitz, 2008a).

Instrument Development

Prior to launching our study, we commissioned secondary analyses from a survey conducted by American Institutes for Research (2005). To help us select control variables, we identified practices that we thought were related to PjBL use and considered how these varied by school type and other reform measures (Ravitz, 2008a). We also selected items from Riel and Becker's work (2008) and several others. Finally, we wrote and piloted our own questions about planning and implementation of PjBL, including technology use,

preparedness, and challenges. We piloted the survey in 2006, using methods similar to “cognitive interviews” (Desimone & LeFloch, 2004), observing and interviewing teachers as they completed the survey, and revising the questions until they generated reasonable responses in each school context.

The survey instrument is available for adaptation and use in school- or district-related research studies. It can be obtained online from Ravitz (2007) or by contacting the lead author.

Measures

Project based learning was defined for participants as an approach to instruction that could include problem- or inquiry-based learning. In the original instrument, and in the tables and SEM figures that follow, we reference this approach as “PBL.” This is consistent with the actual wording of the survey items and how the original measures were constructed. The operational definition we provided indicated that, at minimum, a project-based approach:

1. features in-depth inquiry,
2. occurs over an extended period of time, like a week or more,
3. is student/self-directed to some extent, and
4. requires a formal presentation of results.

These characteristics represent minimum criteria while allowing for variation in aspects like group work or technology use. Participants were invited to substitute a preferred term for project-based, as long as their teaching met these criteria. Approximately 17% said they preferred problem-based, inquiry-based, or some other term.

In addition to being provided with the above operational definition, teachers saw a list of example project types (researching a community issue, creating a museumlike exhibit, or role-playing as stakeholders in a problem-based scenario). This helped clarify what kinds of practices were being referenced. Respondents were then instructed to identify and focus on the academic course in which they used these practices most.

Time spent using PBL (or PjBL) was the measure we used to represent the extent of these practices. This was based on teachers’ responses to the following prompt regarding their selected course: “For a typical student in this course, how much of their overall time was spent on project-based learning?” scored on a 6–point scale (1 = none or almost none, 2 = less than $\frac{1}{4}$, 3 = about $\frac{1}{4}$, 4 = about $\frac{1}{2}$, 5 = about $\frac{3}{4}$, 6 = all or almost all). During our pilot, we found this was a more effective item than number of projects used which varied widely in length.

Online feature use was a z-score based on a count of the number of online features that were used “at least a little” to support their PjBL use. This represents the number of different

technology uses each teacher reported and is consistent with Becker (2000) who found more varied use of computers was associated with teaching practices. During our pilot, we constructed a list of online technologies teachers said they used to support their use of projects. Teachers reported using various blogs, web sites, databases, feedback, and communication systems, in addition to specialized resources provided by the different school reform networks or by districts and states (e.g., Williamson, 2008). Instead of trying to list every resource or tool, we categorized the kinds of features that teachers used and how many they reported. We focused on general features that could be available across multiple products or platforms, for example, asking about use of blogs and wikis, not which sites or platform, or asking about online libraries of projects, not which of the libraries (Buck Institute for Education, n.d.). The response choices originally included different levels of awareness or use, but we found the answer that best distinguished teachers was whether they reported any use or not (awareness was common, frequent use was rare).

Teachers responded to the following: “For each of the following Internet-based features or capabilities, indicate whether you have seen or used this kind of online resource or tool for conducting PBL.”

- An online collection of high quality projects
- An online collection of PBL resources (e.g., rubrics, templates, examples, descriptions, suggestions, video)
- Tools created to help you or your students design and manage projects online
- A way for YOU to get feedback from teachers or adults on your projects or student work
- A way for your STUDENTS to post work to get feedback or be assessed by you or others
- Tools for linking you or your students to outside experts, mentors, or other schools
- Online collaboration tools (e.g., blog, wiki, listserv, social networking)

These are examples of technology uses teachers said helped them conduct projects. They enable teachers to learn about and manage projects more effectively; to share examples, experiences, and advice; and they make it easier for communication and feedback to occur between teachers and students or across different schools.

Perceived challenges were assessed using five items that were determined through conversations with teachers to be critical (e.g., “I lacked models or examples for using PBL in my subject area with my students.”). Items were scored on a 4–point scale (ranging from 1 = not a challenge to 4 = a major challenge). An index based on the mean of all five items had adequate reliability (standardized alpha = 0.80).

Sense of preparedness was assessed using nine items that asked teachers how prepared they felt they were to carry out

tasks related to conducting projects (e.g., “To what extent do you feel prepared to assess individual student’s content learning using PBL?”). Items were scored on a 4–point scale (ranging from 1 = not at all prepared to 4 = very well prepared). An index based on the mean of all nine items had strong reliability (standardized alpha = 0.91)

Additional variables included: (1) schoolwide emphasis on inquiry or PjBL-related practices which was measured using the single item, “Is there a schoolwide emphasis on problem-based, project-based, or inquiry learning at your school?” scored on a 3–point scale (1 = not at all, 2 = sometimes, 3 = always); (2) interdisciplinary instruction which was measured using the item “How often did you teach these subjects as multisubject/interdisciplinary courses, lessons, or projects?” scored on a 5–point scale (1 = never, 2 = sometimes, 3 = about half the time, 4 = most of the time, 5 = all of the time); and (3) teacher professional engagement was measured using a count of reported professional activities from a list of ten items, with this prompt: “In addition to your classroom teaching, were you involved in any of the following activities last semester? Check ALL that apply.” Choices mirrored Riel and Becker (2008) who asked about planning school technology use or helping others use technology (besides you and your students); mentoring or coaching of other teachers; coordinating or leading professional development efforts; attending or presenting at conferences. We also asked about participation in extracurricular activities; working with students before and after school; and involvement in curriculum planning, administrative duties, and other forms of professional engagement.

Data Analysis

We used Structural Equation Modeling (SEM; Amos 7 software, Arbuckle, 2006) to test the direct and indirect effects of online feature use on time spent on PjBL in a two-group model estimated separately for “reform network” and “non-reform network” teachers. SEM was chosen as the analysis method for this study because, unlike ordinary regression analysis, SEM allows for the estimation of a system or model of regression equations simultaneously, as well as the simultaneous fitting of the model to two groups—in this case, reform network and non-reform network teachers. We used descriptive data (means, effect sizes, and percent differences) and correlations to illustrate differences and provide examples of our findings for discussion.

Our primary analysis focused on evaluating the fit of a structural model linking online feature use to time spent on PjBL (or PBL in the SEM figures) with teachers’ sense of preparedness and perceived challenges acting as mediators of this relationship. To address the second research

question, we incorporated contextual/control variables for schoolwide emphasis on inquiry, teacher use of interdisciplinary teaching, and teacher professional engagement. This model was a good fit for the data based on generally accepted fit index thresholds ($\chi^2 = 625.089$, $df = 294$, $p = 0.000$; RMSEA = 0.059). The value of our chi-square statistic divided by the degrees of freedom was less than 3.0, and the value of the RMSEA (root mean square error of approximation) was below 0.06 (Garson, 2008). We also conducted a two-group confirmatory factor analysis (CFA) of the measurement model for the two latent constructs, perceived challenges and sense of preparedness, and tested for factorial invariance across groups. Our analyses indicated that the constructs had similar factor structures for reform network and non-reform network teachers. Accordingly, the item loadings were constrained to be equal in a structural model. All indicator loadings for both of the latent constructs were significant, and the model was an adequate fit for the data ($\chi^2 = 404.109$, $df = 164$, $p = 0.000$; RMSEA = 0.067). Table 1 provides descriptive statistics for all variables and item loadings for latent constructs.

Results

Our findings indicate online feature use is associated with decreased challenges, increased preparedness, and time spent on PjBL. Correlations between online use and time spent on this approach (Table 1) indicate significant relationships for reform network and non-reform network schools with correlations of 0.33 and 0.20, respectively. Table 1 also indicates that perceived challenges, preparedness, and other variables were often significantly correlated with online use and PjBL use. Our attempts to model these relationships with SEM reveal strong direct paths to PjBL use in reform network schools, not accounted for by the other variables. However, we do not see similar direct effects in the other schools (Table 2). Figures 1 and 2 show results of the full SEM models. To simplify, the figures only show pathways that were statistically significant in the models. For example, professional engagement was not related to time on PjBL in either model, so the path was dropped from the model.

Descriptive Findings

Descriptive data provided in Table 1 show means and effect size differences between reform network teachers and others indicating the extent to which the average responses differed. Reform network teachers reported more schoolwide emphasis and more time spent on PjBL-related practices (effect sizes > 1.00). There were also substantial differences (effect sizes > 0.60) in the amount of online feature use, as well as multi-interdisciplinary instruction, and challenges,

Table 1. Item loadings, means, effect sizes, and correlations to online feature use and time spent on PjBL.

	Effect Size	Range	Reform Network Schools					Non-Reform Network Schools						
			Mean	SD	Item Loading	Online Use	Time Spent on PjBL	Mean	SD	Item Loading	Online Use	Time Spent on PjBL		
Perceived challenges														
Lacked funds, materials, or resources	-.51	1 - 4	2.1	1.01	.42	-.08	2.63	1.08	.43	-.08	.07			
Lacked models or examples for using PBL	-.38	1 - 4	2.02	.99	.73	-.25**	2.39	.95	.82	-.18*	-.28**			
Lacked time to find, create, or plan projects	-.37	1 - 4	2.47	1.05	.71	-.11	2.85	1.02	.77	-.25**	-.22**			
Lacked time in the curriculum to carry out projects	-.89	1 - 4	1.96	1.02	.66	-.01	2.88	1.04	.70	-.23**	-.30**			
Lacked prof. development/coaching in PBL	-.24	1 - 4	1.7	.84	.69	-.29**	1.92	.99	.65	-.22**	-.16*			
Sense of preparedness														
Find existing projects that are high quality	.16	1 - 5	3.82	.81	.56	.20**	3.69	.82	.63	.38**	.13			
Plan and design new projects	.46	1 - 5	4.13	.76	.71	.18*	3.78	.75	.8	.35**	.32**			
Meet state or district standards using PBL	.43	1 - 5	4.08	.77	.75	.19*	3.73	.87	.77	.35**	.28**			
Assess individual students' content learning using PBL	.37	1 - 5	4.05	.76	.78	.25**	3.76	.82	.78	.25**	.18*			
Promote depth or quality in student work in PBL	.24	1 - 5	3.99	.78	.82	.18*	3.8	.82	.82	.22**	.29**			
Facilitate and manage students' work in groups	.00	1 - 5	3.92	.74	.73	.16*	3.92	.78	.72	.29**	.18*			
Structure student presentations so whole class learns	.10	1 - 5	3.71	.77	.67	.12	3.63	.81	.73	.33**	.17*			
Teach and assess skills beyond academic content	.33	1 - 5	4.09	.77	.69	.19*	3.83	.8	.70	.33**	.20*			
Assess students working in groups	.07	1 - 5	3.85	.8	.70	.15	3.79	.81	.73	.25**	.15			
Other variables in the model:														
Time spent on PBL (or PjBL)	1.12	1 - 6	4.73	1.21	---	.33**	3.40	1.17	---	.20**	---			
Online feature use	.64	0 - 7	3.57	2.32	---	---	2.14	2.15	---	---	---			
Multisubject/interdisciplinary instruction	.61	1 - 5	3.26	1.29	---	.15	2.46	1.33	---	.16	.33**			
Schoolwide emphasis on PBL or inquiry	1.41	1 - 3	2.81	.41	---	.02	2.02	.71	---	.22**	.10			
Professional engagement	.16	0 - 10	5.68	2.09	---	.22**	5.33	2.32	---	.15*	.16*			

Item loading represents standardized regression coefficient from SEM for the latent constructs. Effect sizes over 0.20 were statistically significant, $p < 0.05$ or better. For correlations * $p < 0.05$. ** $p < 0.01$.

Table 2. Summary of direct effects on PjBL use by school type

Variables in the SEM model	Relationship to Time Spent on PjBL (direct effects)	
	Reform Network	Non-Reform Network
Interdisciplinary instruction	.35**	.25**
Online feature use	.25**	.05
Sense of preparedness	.24*	.19~
Schoolwide emphasis on PBL/inquiry	.14*	.02
Perceived challenges	-.09	-.14
Professional engagement	—	—

* $p < 0.05$, ** $p < 0.01$, ~ $p < 0.10$

such as lack of time in the curriculum. We did not find statistically significant differences between school types in measures of teacher professional engagement, preparedness for finding projects, conducting and assessing group work, or structuring student presentations. Descriptive data for the technology features are available online in Ravitz and Blazevski (2010).

SEM Findings

The model was largely supported in reform network schools. There were multiple direct paths to time spent on PjBL in reform model schools, with coefficients ranging from 0.35 to 0.14 for interdisciplinary instruction, online feature use, sense of preparedness, and schoolwide emphasis on PjBL or inquiry (Table 2).

Perceived challenges were not significantly related to time spent on PjBL, although coefficients were in the expected (negative) direction. Sense of preparedness was positively related to time spent on PjBL for reform network teachers ($\beta = 0.24$), with some indication of this for non-reform network teachers ($\beta = 0.19$, $p < 0.10$). In addition, there may have been an indirect effect of online feature use via sense of preparedness for reform and non-reform network teachers (Sobel test, $p = 0.08$ and $p = 0.07$, respectively).

In addition to these primary analyses, several other components of our model were supported for both school types. As shown in Figures 1 and 2, online feature use was negatively related to perceived challenges for both reform and non-reform network teachers ($\beta = -0.21$, $\beta = -0.20$, respectively) and positively related to teachers' sense of preparedness ($\beta = 0.20$, $\beta = 0.38$, respectively). For teachers in non-reform network schools, schoolwide emphasis on inquiry was associated with decreased perceived challenges ($\beta = -0.18$) and with increased online feature use ($\beta = 0.17$), and teacher professional engagement was significantly related to online feature use ($\beta = 0.16$). In reform network schools, professional engagement was associated with a sense of preparedness ($\beta =$

0.28) and decreased perceived challenges ($\beta = -0.21$), but was not significantly related to online feature use.

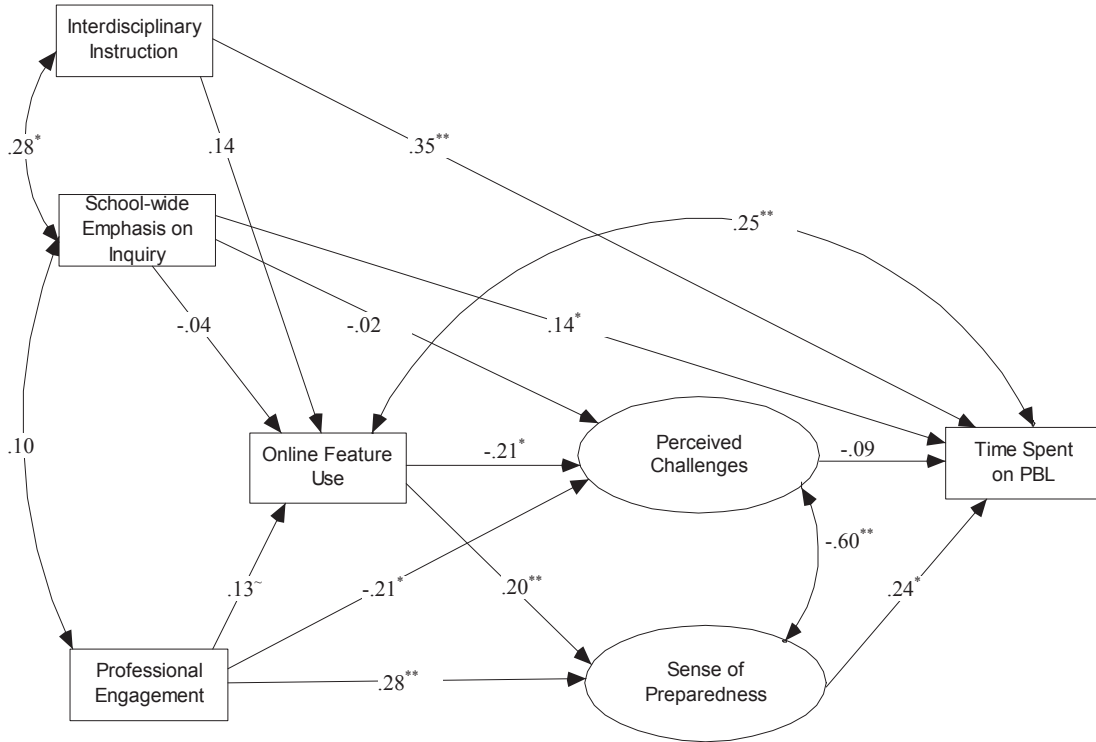
To summarize, there is an overall positive relationship between the use of online technologies and time spent conducting projects. In both types of schools, teachers report a greater sense of preparedness when they use more of the online technologies, and this, in turn, predicts more time spent on PjBL. However, our model is better supported for reform network teachers with multiple direct effects, including from online feature use to time on PjBL.

Discussion

Results of this study suggest that overall online feature use is associated with decreased challenges, increased preparedness and time spent on PjBL for both types of schools (Table 1). However, our attempts to model these relationships with SEM indicate that there are strong direct paths only for schools in the reform networks we studied. In these schools, our results seem to corroborate the findings of Becker (2000) linking technology use to teaching reforms. Moreover, we have accounted for the influence of professional engagement, as well as school type and other contextual and mediating variables, therefore reducing the plausibility of alternative explanations for this relationship.

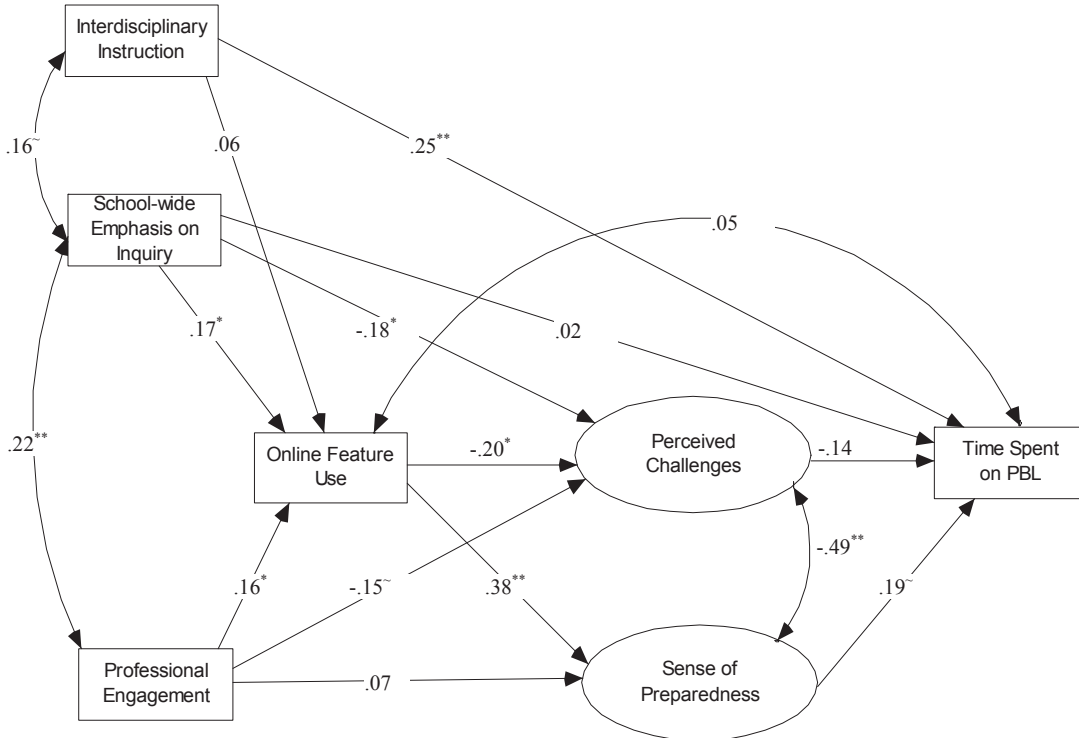
For schools outside the reform networks, a substantial amount of work is still needed to establish viable paths to PjBL that include the role of technology. We do not see evidence that technology is playing as significant a direct role. We do find support for some of the expected relationships, including that online feature use was positively related to sense of preparedness and negatively related to perceived challenges. However, lack of support for other relationships, including direct effects on PjBL, suggests the importance of other variables in non-network schools, for example, school or teacher characteristics we did not consider in our model (Ravitz, 2008b; Ravitz, 2010). Perhaps there are fewer oppor-

Figure 1. Path analysis for reform network teachers (n = 164).



$\chi^2 = 625.089, df = 294, p = 0.000; RMSEA = 0.059. * p < 0.05, ** p < 0.01, \sim p < 0.10.$

Figure 2. Path analysis for non-reform network teachers (n = 166)



$\chi^2 = 625.089, df = 294, p = .000; RMSEA = 0.059. * p < 0.05, ** p < 0.01, \sim p < 0.10.$

tunities or incentives to use projects in these schools, even if teachers otherwise feel prepared.

There were other notable differences between the two models. In reform network schools, schoolwide emphasis on PjBL or inquiry was related to time spent on PjBL and not online feature use. However, in non-reform network schools, schoolwide emphasis was related to online feature use but not to time spent on PjBL. We tentatively conclude that a general emphasis on inquiry—without a specific model that specifies use of practices—may result in more general student-centered approaches or uses of online technologies (Land & Hannafin, 2000; Pedersen & Liu, 2003), but not PjBL as we defined it. A schoolwide *model* and being in a network is more significant than a schoolwide *emphasis* on instructional reform. What matters seems to be having a specific approach with structures and supports. We have a similar interpretation for findings on professional engagement. In reform network schools, professional engagement was related to sense of preparedness for PjBL but not online feature use. In non-reform network schools, professional engagement was related to online feature use instead of preparedness. This suggests that professional engagement in non-reform network schools (like schoolwide emphasis on inquiry) may be channeled into online feature use rather than time on PjBL.

Another finding is that the perceived challenges measure was not directly related to PjBL use in either model. Despite acceptable reliability and significant bivariate correlations, this measure is not functioning as expected. Infrequent users may avoid challenges that confront frequent users (e.g., having to create their own projects and finding sufficient time in the curriculum), while frequent users might be more generally dissatisfied with the status quo (Ely, 1991) and perceive challenges from trying to change their classrooms in more substantial ways.

It would be helpful to revisit classroom studies to see how the relationships we found are manifested for different teachers and schools. Item-by-item comparisons provided by Ravitz & Blazevski (2010) suggest ways that use of online technologies may reduce challenges and increase preparedness for PjBL. For example, in reform network schools, 81% of teachers who used online tools to design and manage projects felt prepared for these tasks, whereas only 58% of those who did not use online tools felt prepared. In non-reform network small schools, use of online tools to help design and manage projects was related to *all nine* types of preparedness (see Table 1 for a list of preparedness items). In large, comprehensive high schools, teachers who used an online library of resources were less challenged by lack of time, professional development, or coaching. These differences may be worth investigating more closely.

Limitations

The survey instrument used in this study was informed by qualitative understandings developed in interviews with teachers prior to and during the piloting stage. However, our study lacks a qualitative component that would allow us to draw conclusions about how, why, and under what conditions online technologies support certain teaching practices. The survey only asked about technology features for planning or implementing projects and about the general features of technology use. We did not focus on specific web sites, software platforms, or interventions, or on specific project designs. As a result, the data shown are limited to the aggregate experiences of teachers across various online resources and PjBL approaches. In-depth case studies could shed light on the findings. We recommend that studies address qualitative differences in use of PjBL and online technologies, including how effective use of one or two technologies might have an impact.

Like any single wave survey study, ours only provides a snapshot in time. It cannot address changes over time. We collected our data in 2007, prior to the avalanche of new technologies like smart phones and iPads, or new kinds of online tools like Twitter, and Edmodo. We recognize that technology has continued to progress since the point of data collection, however, because the rate of adoption of classroom technologies is generally found to be slow, and because the categories of online resources we investigated can include most recent trends (e.g., we asked about collaboration tools rather than specific technologies or applications like Twitter), we do not consider the data to be outdated and expect the underlying relationships to be valid in the current context.

Our study addressed teacher professional engagement, but we did not address other characteristics of innovativeness (Rogers, 1983) or the perceived benefits for PjBL and technology use (e.g., Ely, 1991; Ravitz, 1999). It would be useful to explore teachers' rationale for conducting projects and using technology and whether there is a progression or hierarchy of use and challenges as with other innovations (Hall & Hord, 1987; Moersch, 1995).

Although our study represents a wide range of PjBL-using high school teachers, sampling from over 2,500 teachers from 12 different strata across multiple organizations, there are some limitations to the representativeness of our sample. Midwest and southern states are somewhat underrepresented. In addition, we obtained much better response rates from teachers in the reform network schools (Ravitz, 2008a). As a result, conclusions about reform network teachers may be more representative than conclusions drawn about teachers in other schools, and lack of findings outside the reform networks could be a result of response bias we did not evaluate.

Conclusion

In order to pursue the kind of investigation advocated by Becker and Lovitts (2003), future research should identify teachers engaged in PjBL with and without different technology uses. For example, one might explore how project management tools or online project libraries in non-network schools help teachers implement PjBL compared to others. Another area to investigate is how knowledge and practices can be transferred between reform network schools and others. Research from reform networks could advance use of PjBL practices in non-network schools; however, it is unclear if lessons can be applied across school types or if some ideas or practices, including intensive use of PjBL, require a more comprehensive reform model and network. Despite our focus on high school settings, we can envision the same questions being asked at other educational levels where similar diffusion issues (e.g., Rogers, 1983) exist.

On the technology horizon, there seem to be trends toward virtual reality or game-based learning (Gee, 2005; Pedersen & Liu, 2003; Watson & Fang, 2012), use of online lectures in the flipped classroom (Ash, 2012), and massively open online courses (Bell, 2011). We do not know what the impact will be on use of PjBL practices. Lessons learned about student engagement and assessment in games suggest there is room for codevelopment (Watson & Fang, 2012), especially for scaffolding learning and assessment (Gee, 2005), while flipped classrooms may encourage use of PjBL as a way to “focus precious classroom time on more interactive problem-solving activities that achieved deeper understanding—and foster creativity” (Martin, 2012, p. 27).

Other advances in technology that could influence PjBL use include the rise of mobile devices, ability to share and mark up videos (Goldman, Pea, Barron & Derry, 2007), and to manage performance assessments (e.g., Project-Based Learning Systems, n.d.; ShowEvidence, n.d.), including for Common Core State Standards (Willhoft, 2012). These newer technologies largely fit within the framework of online features we studied (sharing student work, getting feedback, etc.). Except for mobile technologies, we see little reason the role of technology would be substantially different. In fact, it is surprising how durable some of the relationships identified in earlier studies are across generations of technology.

On balance, we would expect the relationships we have identified to be stronger with more recent emerging technologies than with more established technologies whose use has become widespread. It is possible adoption of newer technologies could signal a move away from full-fledged PjBL. However, it seems these technologies could be integrated to create new kinds of projects and opportunities for learning, especially in the reform network schools. The challenge will

be identifying the most beneficial uses of new technologies and how they can best be used to support PjBL use in a wider range of schools.

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