STEM Education

STEM Education, 3 (2): 89–102
DOI: 10.3934/steme.2023007
Received: 05 May 2023
Revised: 01 June 2023
Accepted: 15 June 2023
Published: 26 June 2023

https://www.aimspress.com/journal/steme

Research article

Enhancing technology leaders' instructional leadership through a project-based learning online course

Min Lun Wu[1*], Lan Li[2] and Yuchun Zhou[3]

[1] Department of Educational Studies, Ohio University, 1 Ohio University, Athens, OH 45701, USA; wum@ohio.edu
[2] Bowling Green State University; lli@bgsu.edu
[3] Ohio University; zhouy@ohio.edu

*** Correspondence:** Email: wum@ohio.edu; Tel: +1-517-775-8897.

Academic Editor: Xuesong Zhai

Abstract: This study detailed the course design principles and implementation of project-based learning (PBL) in a technology-themed graduate-level online course. Students were trained to develop knowledge and skills in instructional leadership, such as the capability to design, deliver, and evaluate educational technology professional development programs. Pre- and post- survey data were collected to examine any change in students' knowledge and skills in instructional leadership by completing this course (N = 18). Quantitative findings revealed positive learning outcomes, and there was statistical significance regarding student improvement in knowledge and skills of instructional leadership, rendering the PBL approach viable.

Keywords: instructional leadership, project-based learning, online education; educational technology, professional development

1. Introduction

The importance and utility of technology have been further exemplified in recent years since the outbreak of the COVID-19 pandemic, as technology-mediated online education has been foregrounded, demonstrating that delivery of quality education can be accomplished when face-to-face instruction is deemed undesirable. In this backdrop, this study aimed to explore an effective pedagogy to train future technology leaders in developing technology competency and

instructional leadership through an online course.

Instructional leadership is traditionally recognized as an ability needed for principals, administrators, and policy makers who can affect large scale and long-term change. In both public and private sectors, instructional leadership encapsulates the knowledge, skills, and vision to manage personnel, identify problems, gather information, and design quality and effective solutions or professional development (PD) programs to tackle problems.

In the realm of education, teachers and educators need to develop and practice instructional leadership so that learners can benefit from well-designed curricula, instruction, and PD programs. Regarding instructional leadership, Elmore [7] stated "in a distributed leadership system the job of leaders is to buffer teachers from extraneous and distracting non-instructional issues so as to create an active arena for engaging and using quality interventions on instructional issues (p. 24)." In a similar vein, Ylimaki [17] discussed the capacity model for school improvement, in which the principal or administrators model appropriate instructional leadership behaviors and invite teachers and other professionals to join efforts to improve administrative and teaching practices. Further, Edwards and Hinueber [6] argued that a joined instructional leadership team would provide teachers an opportunity to lead positive changes in their school, which would eventually benefit students. In sum, effective instructional leadership requires a shared vision and responsibilities between school administrators and teachers.

Various efforts are made to encourage and guide the establishment of meaningful instructional leadership. For example, Jaipal-Janani et al. [9] used a Professional Development (PD) workshop to develop teachers' technological pedagogical content knowledge model (TPACK) and help them move from technology learners to technology leaders, who can induce changes in technology integration for students and administrators. While the importance of teachers' technology leadership is widely recognized, it is unclear how the leadership is connected to technology integration in the classroom. Raman and Thannimalai [13] surveyed 90 respondents and found there was no positive significant relationship between the five constructs of technology leadership with teachers' technology integration. The five constructs studied were systemic improvement, visionary leadership, excellence in professional practice, digital age learning culture, and digital citizenship. Claasen et al. [4] administered an online survey to 546 personnel in municipal administration and found there was a need to develop a standardized instrument for measuring digital leadership. To fill the gap in literature, this current study aims to explore the development of and examine the effectiveness of a standardized instrument for measuring instructional leadership hinged on the integration of technology in K-16 educational settings.

Researchers of this study subscribe to the tenets of project-based learning (PBL), in that the pedagogy promotes student-centered learning, autonomy, interdisciplinary collaboration, teacher serving as facilitator, and the principle of "learning by doing" advocated by John Dewey. The projects students complete through PBL must require them to apply theory to practice, be relatable to real-life tasks, and induce real-life implications. King and Smith [10] used a graduate-level mathematics education course as PD to develop in-service teachers' leadership. Findings revealed that the teachers created a vision of themselves as leaders who can reflect and revise instructional practices with feedback. Aas and Paulsen [1] studied a national strategy to support instructional leadership of school principals. They found that PBL served a critical role in promoting collaborative learning among participating principals. Albritton and Stacks [2] engaged students in a pre-service

leadership program using the PBL approach. The approach was successful, as students learned to apply knowledge in conducting a standards-based evaluation of critical issues in their school settings.

2. Research purpose and question

The purpose of this study is to explore the effectiveness of a PBL integrated online course to promote the development of instructional leadership knowledge and skills. Instructional leadership within the confine of the research context involved creating a shared vision, using technology equitably, collaborating with educational stakeholders, and designing and evaluating PD programs.

The research question of this study is as follows:

Is there a significant improvement in students' self-rated knowledge and skills of instructional leadership through student completion of the PBL online course?

3. Course design

This fully online PBL course is designed to achieve two goals. First, the course aims to equip technology leaders and coordinators as role models for instructional and administrative use of technology in schools and other locales to develop visionary leadership. Course tasks revolve around principles of PBL and involve both individual devotion, communication, and semester-long collaboration among groups. The course reviews adoption and diffusion of technology in K-16 settings, technology planning, policy consideration and design, hardware, and software procurement. Second, the course places a particular emphasis on PD and technological and instructional leadership. Components that develop this theme include communication, organization, argumentation, use of technology, needs assessment, program evaluation, adult learning models and PD design and development, and strategies for organizational development.

Core technologies used to facilitate the PBL course include Google Drive as content repository, BlackBoard Learn for grade-keeping, and Zoom, Us, and Microsoft Teams as synchronous online communication platforms for group meetings with the instructor and among members.

Topics of discussion as pertained to assigned course readings include the distributed cognition perspective on teacher assessment, accountability, and policy implementation, logic of loose-coupling, structure for school leadership, categories of instructional leadership, core features of effective PD, acquisition and budgeting, and equity with learning technologies.

4. Alignment with national technology standards

Aligning with the International Society for Technology in Education standards for technology coaches (ISTE-C), this PBL course requires students to complete three culminating individual and team-based projects—design a digital learning experience, plan, and budget for re-innovation, create a technology toolbox.

To develop visionary leadership, the course inspires technology coaches and requires participation in the development and implementation of a shared vision for the comprehensive integration of technology to promote excellence and support transformational change throughout the instructional environment. This course was designed to meet the following five standard-based objectives adapted from the ISTE-C standards:

1. Shared Vision

Demonstrate the development, communication, and implementation of a shared vision for the comprehensive use of technology to support a digital-age education.

2. Strategic Planning

Demonstrate planning, development, communication, implementation, and evaluation of technology-infused strategic plans at the organizational level.

3. Advocacy

Demonstrate advocacy for policies, procedures, programs, and funding strategies to support implementation of the shared vision represented in organizational technology plans and guidelines.

4. Innovation and Change

Implement strategies for initiating and sustaining technology innovations and manage systemic change processes.

5. Design

Design, develop, and implement technology-rich professional learning programs that model principles of adult learning and promote digital-age best practices in teaching, learning, and assessment.

Furthermore, technology coaches need to design effective PDs and practice program evaluation. They learn to progress in conducting needs assessments, developing technology-related professional learning programs, and evaluating the impact on instructional practice and student learning.

The three culminating projects required of the course are designed in line with tenets of social constructivism and PBL, in which learners engage in consistent communications and problem-solving to co-construct viable solutions and a shared knowledge base. Formative assessments are done by the instructor periodically, and feedback is given to teams. Students are invited to correct, update, and improve the three projects anytime during the semester.

The discussion below describes the genesis and objective of the three projects:

Project 1 – Design a Digital Learning Experience (meeting objectives 1, 2, 3, and 5)

Project 1 requires students to design a sample digital learning experience while incorporating PD strategies. The instructor encourages students to work on Project 1, preferably as a team, but students may work individually when granted. This project starts with a defined and clear position toward engaging, motivating, and progressing learning around technology use in professional contexts. The project integrates an understanding of policies, procedures, programs, and funding necessary to implement throughout, and focuses on design, development, and delivery of a professional learning experience.

In this project, each team develops a shared vision paper that advocates a vision for PD and how the team would lead in this regard for a digital age learning environment. Further, the team develops programmatic examples of a digital asset that students would begin adding to after being hired in the

workplace (e.g., interactive video training, game-based learning curriculum, learning management system, workshop, course syllabi, etc.). The PD learning program should be technology-rich both in topic and in delivery of content.

The following elements are to be included in the team-designed digital learning experience.

- *Shared vision paper*
  Students explain what they know about adult learning and PD in best practice, justify what the PD would look like in a public venue or workplace, explicate the process for developing a shared vision, provide a plan for effective communication internal to the team's vision for learning, and outline an implementation plan for teaching and learning to support digital-age education.
- *Planning, development, communication*
  Each team should demonstrate planning and development of a strategic plan for an organization and create all relevant materials, handouts, digital assets, and tools needed to commence the PD. Students write up a strategic plan, describe needed communications, and document the implementation of the PD program.
- *Implementation and evaluation*
  Each team works with other teams in the class to conduct the PD with a small audience and collect formative and summative evaluation data. Students use the data for evaluation of the program and draft a final report delineating the division of labor, PD delivery, outcomes, and evaluations. In this report, they summarize the event, effect, affect, and feedback from participants toward a revision plan for future implementations.
- *Final presentation*
  Each team organizes all of the above-stated elements into a 15-minute presentation in which the team demonstrates effective speech and presentation skills in presenting findings and outcomes of the PD learning program. The team presentation promotes and models multi-modal practice in teaching, learning, assessment, and leveraging feedback.

Project 2: Plan and Budget for Re-Innovation (meeting objectives 2, 3, and 4)

Students work in a team and are asked to consider and propose a plan for a new "learning space" that will facilitate a shared vision of an educational practice of their choice. To move it forward, the team must express leadership in planning at the organization level and policies, procedures, and programing for the location that the space will be built around. Teams must conduct a needs assessment in a local organization or one the team may gain access to in real life, identify funding capacity, and gather organizational support perceptions for the shared vision. With organizational support, teams seek to implement the proposal with the partnering organization and document strategies for initiating and sustaining innovations and the change process.

The team re-innovation proposal includes the following elements:

- An identified school, or learning organization, in the area that this proposal would be presented to. Teams contact the school personnel (e.g., administrator, technology coordinator) and request a tour of the facilities and resources the institute already has. The institute is identified in the proposal.
- *Strategic Plan*

Each team presents organizational shared vision and goals for a particular physical space that requires re-design. In this presentation students define the space and goals and summarize the shared vision and strategic plan for the space, development process, communication plan, and timelines for implementation. Lastly the team includes the projected plan for evaluating the success of the design.

- *Funding Strategies*
  Each team composes a budget summary on one page, using a spreadsheet. The team has an imaginary (with emphasis) $50,000 budget that represents funding strategies to support progress and implementation of the re-designed learning space.
- *Funding Justification*
  Each team writes a budget explanation document with functional hyperlinks to hardware and software procurement costs and purchasing portals.
- *Proposal Visualization*
  Teams use images to communicate a full room design model or drawing. Teams may use 2D graphic design software or 3D graphic design software and provide a video screencast walkthrough or website of the space. The floor plan would measure the room carefully and account for electrical and wiring needs. Teams may use graph paper or software like MS Project, Google SketchUp, MS Visio, floorplanner.com, TinkerCAD.com or homebuilder.com.
- *Project summary*
  Teams meet with partnering organizational leadership and propose the strategic re-innovation plan to them. They document the leadership's reactions, suggestions, and intentions to move or not move forward with the proposal. (They too can pretend they have $50,000 as an operating budget). Teams clearly explain insights they can provide on implementation strategies and how to initiate and sustain innovation and manage systemic changes proposed.
- *Present Findings*
  Each team gives a 15-minute presentation, in which they describe the proposal, summarize feedback and findings, and discuss the follow-up plan.

Project 3: Tech Toolbox (meeting objectives 2 and 5)

Project 3 asks students to design and develop a technology-rich learning program. The project is to be done by an individual, be heavily design-oriented, and help the student hone in on his/her technology adoption decision-making and design mindset. As an emerging expert in technology for education, the student should be prepared to share resources and have a working framework for how to organize and keep track of appropriate assets for educational leaders, teachers across content areas, and students. A personal technology toolbox is one venue to organically and meaningfully communicate new resources and ideas across a workplace.

While Project 1 and Project 2 focus on professional and institutional growth, Project 3 is predicated on each student's own personal organization and capacity for growth. A student's toolbox is a design challenge that can take any shape but should exemplify capacity for design, development, and implementation of a personal learning program that will extend beyond the course and into his/her career. The tech toolbox should exemplify and promote digital media solutions for teaching, learning, and assessment.

The toolbox project includes the following elements:

- *Access*
  The student builds a toolbox that identifies and provides easy access to resources. It includes resources for leaders, teachers, and students, and is designed so that anyone would be able to see the organizational system and find relevant resources quickly. The toolbox should take into consideration sharing, cloud storage, privacy issues, and exporting capacity.
- *System Design*
  The student organizes and creates intuitive navigation through open education resources (OER). The organizational model should be clear and have an apparent connection to elements of work for each of the audiences and potential sub-audiences.
- *Development and Implementation*
  The student product-tests the toolbox with at least two professionals who would resonate with the student's personal needs for resources. The student observes the professionals "talk aloud" as they use the toolbox. Finally, the student records, summarizes, and presents revisions made to the technology-rich toolbox based on the professionals' feedback.

Developing Instructional Leadership and Designing Professional Development (meeting objectives 1, 2, 3, 4, and 5)

The summative assessment of the course draws exemplars from the three projects and adds an explanatory narrative that links to the completed projects. Each student should operationalize his/her project work with the goals of the course and clearly demonstrate capacity, learning, and strategies developed for each project component. Students may provide screenshots, links, and example quotes, and all evidence should be brought together in a single digital portfolio in the form of a comprehensive website, clickable PDF, or Google Doc. Students submit the digital portfolio for final evaluation and documentation of proficiency in the ongoing development of instructional leadership and capability to design effective PD.

5. Method

Guided by a post-positivism paradigm, this study intended to investigate students' improvements in instructional leadership. A one-group pretest and posttest design (also called a within-participant design) was used to evaluate the effectiveness of the PBL online course in this study (Shadish et al, [14]). The pretest was conducted at the beginning of the course, whereas the posttest was conducted after 15 weeks at the end of the course.

Masters and doctoral graduate students who took the PBL course titled "Technology Leadership and Professional Development" in the spring of 2022 were invited to participate in this study. At the point of course-taking, the participants were graduate students, administrators, technology coordinators at K-12 schools, schoolteachers, and instructional technologists at higher education institutes. The students were already involved in the adoption and usage of technology at their respective workplaces to varying degrees. A total of 21 students agreed to participate in the study on a voluntary basis. The background expertise of the participants included higher education, African studies, and instructional technology (See Table 1).

Table 1. Participants' demographic information.

Demographics	Total Counts	Instructional Technology	African Studies	Higher Education
Academics Level	Masters' Students (8)	7	1	
	Doctoral Students (13)	12		1
Gender	Females (11)	9	1	1
	Males (10)	10		

To best measure students' knowledge and skills in instructional leadership, a survey instrument was devised based on adaptation of the ISTE-Coach standard descriptors, including 14 items to measure subjects' self-rated knowledge in instructional leadership, and another 14 items to measure subjects' perceived skills in instructional leadership. The measurement scale was on a 5-point Likert with "1" indicating the lowest agreement and "5" indicating the highest agreement. The survey was administrated online via Qualtrics. A link of the online survey was sent to participants at the beginning and at the end of the spring semester 2022. As a result, 18 out of 21 participants completed both the pre- and post- surveys, and only complete responses were used for analysis. It should be noted that traditionally this online course had been offered in the spring semester of every academic year, with a range of student enrollment between 10 to 25 students. Within the confine of enrollment, the 18 completed responses of both pre and post-test was considered sufficient in this study to delineate the growth of students' instructional leadership. A paired T-test was run in SPSS 28. Before averaging the item scores for T-test analysis, a Cronbach's alpha analysis was conducted to confirm the internal reliability of the instrument.

6. Results

The internal reliability analysis results indicated that the Cronbach's alpha was .97 for the 14 items in the scale of knowledge at pretest, .96 for the 14 items in the scale of knowledge at posttest, and .97 for the 14 items in the scale of skills at pretest and posttest, respectively.

With the high reliability coefficients, it was reasonable to use scale scores instead of items scores in the follow-up analysis. Accordingly, four scales were generated by averaging their items scores, i.e., pretest knowledge, posttest knowledge, pretest skills, and posttest skills (see Table 2). The descriptive statistics results indicated that the scale means increased while the standard deviations decreased at the posttests compared to those in the pretests.

Table 2. Descriptive statistics

	M	SD	N
Pretest Knowledge	3.41	.76	18
Posttest Knowledge	4.45	.46	18
Pretest Skills	3.62	.80	18
Posttest Skills	4.46	.48	18

The paired T-test results further demonstrated that the students' knowledge in instructional leadership was significantly improved by 1.04 on a 5-point scale with a 95% confidence interval of

such mean difference at [.70, 1.39] (t (17) = 6.40, p <.001, Cohen's d = 1.51) (See Table 3 and Figure 1). The students' perceived skills in instructional leadership were also significantly improved .84 on a 5-point scale with a 95% confidence interval of such mean difference at [.50, 1.19] (t (17) = 5.14, p <.001, Cohen's d = 1.21) (see Table 3 and Figure 2). In addition to the improvements in students' learning outcomes, the students' positive response to teaching evaluation (Mean = 4.90 out of 5, SD = .29) provided another evidence of the teaching effectiveness of the PBL online course.

Table 3. Paired T-Test results.

Pair	Mean Difference [95% CI]	t	df	p-value	Cohen's d Effective Size [95% CI]
Posttest Knowledge – Pretest Knowledge	1.04 [.70, 1.39]	6.40	17	<.001	1.51 [.81, 2.18]
Posttest Skills – Pretest Skills	.84 [.50, 1.19]	5.14	17	<.001	1.21 [.56, 1.74]

Note: N = 18

Figure 1. Comparison between pre-test and post-test of students' knowledge.

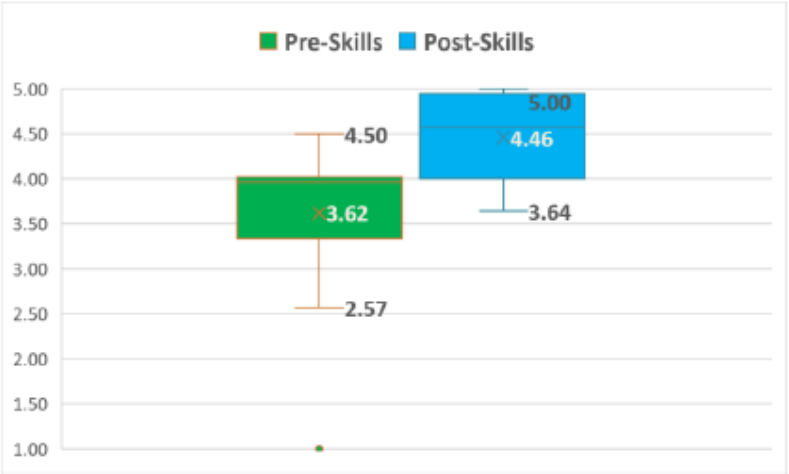

Figure 2. Comparison between pre-test and post-test of students' skills.

7. Discussion

The findings of the study indicated that PBL was effective in facilitating students' development of instructional leadership. Students gained knowledge and skills applicable in completing projects that may embody far reaching real-life implications. PBL enabled the students to wield creativity, for instance, in re-designing a middle school's library and media center, while presenting arguments in a Shark Tank style screencast. One team conducted research and designed a PD virtual technology center using web-authoring tools while targeting higher education faculty as an audience. Another team did needs assessment and budgeted the re-innovation of a physical learning resource center for under-represented students in Kuwait. These projects motivated students to explore innovative use of technology in real-life settings and enhanced their critical thinking through thoughtful negotiation, collaboration, and discussions within groups and with potential partnering entities.

The researchers believe the pedagogy of PBL is empowering and the key principles in making it work effectively to enhance instructional leadership are as follows. Most of the following principles, if not all, should apply generically in most educational and organizational settings.

1. Team-building – Facilitating interdisciplinary communication and collaboration among students so they can plan steps, create a shared vision, negotiate meanings, resolve conflicts, overcome challenges, benefit from the teamwork process, and learn from each other's background of expertise. Team-building is not always a smooth process, and the rapport and mutual trust between the instructor and the teams and among team members need to be fostered over time. Multiple projects should be designed in sequence to help students or trainees develop their team-building ability. For instance, in this study, Project 1 and Project 2 required members of a team to self-nominate a team leader, and the leader had to learn on the go, through trial and error, in terms of assigning tasks, monitoring progress and scheduling, managing personnel needs, and coping with conflicts if any. Team members learned about leadership style and role-taking through teamwork and observational learning. Technology leaders in all phases of project development and execution in every line of work require leadership and team-building, as efficient teamwork is the bottom line to success.
2. Scaffolding – The instructor must scaffold student learning by providing on-demand and just-in-time feedback. For instance, the instructor can share with the class some exemplar projects so learners can model after and learn from best practices. The instructor can also arrange periodical meetings with teams to troubleshoot any issues that may impede with project development. Students in this course learned from a technology leader, the instructor, about how to scaffold learning as they themselves benefited from such mechanism throughout the semester. Technology leaders need to profess scaffolding as a form of formatively assessing progress and steering the ship toward the desired direction.
3. Real-life implications – Core elements of the projects must tap into the workplace so that the co-created artifacts will serve the purpose of design, intended functionality, and implementation, thereby creating real-life impact and implications. Technology leaders need to bridge theory to practice and bring out the best of conceptually designed artifacts by implementing it and more importantly in a broad sense, making people's lives better. The instructor of the course deliberately designed the three PBL projects by prioritizing creating

real-life implications at the front end, as the projects should not end with a course grade but potentially future application and improvement to people's lives.

4. Alignment with international, national, or state standards – Project work needs to reference and align with standards so there is a set basis for standards-based assessment and evaluation. Commonly adopted standards for assessing instructional and technological leadership are ISTE Coach standards, interstate school leaders licensure consortium (ISLLC) standards, and interstate teachers assessment and support consortium (InTASC) standards. Technology leaders must familiarize themselves with standards and develop assessment literacy so they can design appropriate forms of assessment (e.g., diagnostic, formative, summative, accumulative, etc.) and evaluate performance in alignment with existing standards.
5. Accountability and reflection – Accountability need to be addressed by laying out division of labor in team-oriented projects and each individual member producing a thoughtful documentation/reflection of his/her project completion contribution and process. Assignment structures should be designed in a way to eschew sucker effect and free rider effect so that participation can be optimally and equally distributed. Technology leaders are behooved to take accountability into consideration as they tend to make top-down decisions and policies at the macro-level, thus effecting change and impact at the micro-level. Reflection is an important practice for technology leaders, as habitual reflection-in-action and post-action lay the foundation for critical insights useful for pinpointing the big picture, PD re-design, and effective implementation.

Many of the above-stated principles resonate with Britton and Stack's [2] study where they found scaffolding student learning and alignment to standards as basis for evaluation of student work imperative. Taken altogether, the three projects of the course helped students develop knowledge and skills in creating a shared vision, conducting strategic planning, demonstrating advocacy, catalyzing innovation and change, and practicing purposeful design, all of which constitute instructional leadership.

8. Conclusions

We offer the following pedagogical suggestions for like-minded practitioners intent on designing projects to promote PBL and engage students in developing instructional leadership:

- Regarding course design, the projects students take on should involve opportunities for teamwork, reflection, assessment on self and team learning, and the completed projects tapping into the workplace. Allow room for adjustment during the semester, as students may display heightened interest or lack of understanding on certain themes. Scaffold learning by providing extended readings, giving students freedom in choosing which article(s) to read in order to strengthen their understanding of topics.
- Regarding content delivery, set the tone in the introductory class meeting that the instructor has high expectations on student performance and provide pacing mechanisms (e.g., timeline reminder, component completion checklist) to help students stay on track in the project progress. Be a flexible facilitator and not the "sage on the stage." Monitor student progress holistically and make due-date adjustment when situations call for it, as the quality of the

project proposal should outweigh set deadlines. Immediacy of feedback is important in online classes, as the instructor strives to respond to student inquiries within 24 hours.

- Regarding assessment of student learning outcome, use a variety of assignments to cover the bases of conceptual learning and hands-on experiential learning. In addition to knowledge build-up, the instructor should use an array of quests to introduce students to emerging technologies and enrich their toolset. The technologies can be repurposed for their Project 3 technology toolbox when appropriate. Quest-based learning allows for options, as a student can choose to take on a quest fitting his/her interest (i.e., engendering intrinsic motivation), and this student-centered strategy has worked effectively in tandem with PBL, exemplifying the notion that there are multiple routes to achieving success in the course. Students may revise and update their projects anytime during the semester to earn back deducted credit or earn extra credits. This strategy works to motivate most graduate students, as they are internally driven to perform better in coursework.

For future research, researchers still have much to explore about using PBL rigorously to assist student learning of technology and instructional leadership. Some of students' completed projects were eventually put to practice at schools, workplaces, and partnering community entities. Artifacts such as websites, information kiosks, digital games, mobile device applications, and virtual road trips were installed or made accessible at varying locales to promote diffusion of information, boost user traffic, strengthen community and university collaboration, and enrich student learning. It is safe to assume the lasting impact of these PBL projects on learners and other educational stakeholders could be far-reaching (Dani et al., [5]).

Berkovich and Hassan [3] examined digital instructional leadership's and found its positive impact on teacher motivation and student learning during the pandemic. Suyundi et al. [16] found that there is positive effect of principals' instructional leadership and teaching creativity on student satisfaction. Lambrecht et al. [11] found positive relationship between instructional leadership and the provision of collaboration and equity in individual educational planning. Shaked [15] interviewed 26 Israeli principals and found instructional leadership can be strengthened by cultivating four intra and interpersonal relationships: with themselves, with school mid-level leaders, with teachers, and with external stakeholders. In all, instructional leadership holds gravity and seems imperative for technology leaders such as principals and technologists as its manifestation creates a trickle-down effect of institutional learning at both the individual and organizational level.

In terms of limitations, the small sample size of this study posed a threat to generalizability of the results. Albeit the researcher-developed instrument for measuring instructional leadership received high reliability, it still needs to be further validated. Nevertheless, one important implication of this study is that it marks a pedagogical exploration where researchers leveraged PBL as a design principle in devising contents, activities, and projects to engage students in learning and developing instructional leadership knowledge and skills. Another significance of the study is that PBL has been proven effective, in many prior studies, in transcending students to the role of leaders, enhancing students' leadership knowledge and skills, and their ability to design, deliver, and evaluate effective PD programs (Albritton & Stacks, [2]; Helle & Okinurora, [8]; King & Smith, [10]; Larmer et al., [12]; Raman & Thannimalai, [13]).

Acknowledgments

We would like to thank the reviewers for the constructive feedback.

References

1. Aas, M. and Paulsen, J.M., National strategy for supporting school principal's instructional leadership: A Scandinavian approach. *Journal of Educational Administration,* 2019, 57(5): 540–553. https://doi.org/10.1108/JEA-09-2018-0168
2. Albritton, S. and Stacks, J., Implementing a Project-Based Learning Model in a Pre-Service Leadership Program. *International Journal of Educational Leadership Preparation*, 2016, 11(1): n1.
3. Berkovich, I. and Hassan, T., Principals' digital instructional leadership during the pandemic: Impact on teachers' intrinsic motivation and students' learning. *Educational Management Administration & Leadership*, 2022, 17411432221113411. https://doi.org/10.1177/17411432221113411
4. Claassen, K., Dos Anjos, D.R., Kettschau, J. and Broding, H.C., How to evaluate digital leadership: a cross-sectional study. *Journal of Occupational Medicine and Toxicology*, 2021, 16(1): 1–8. https://doi.org/10.1186/s12995-021-00335-x
5. Dani, D.E., Wu, M.L., Hartman, S.L., Kessler, G., Grey, T.M.G., Liu, C., et al., Leveraging Partnerships to Support Community-Based Learning in a College of Education. *Handbook of Research on Adult Learning in Higher Education,* 2020, 58–89. https://doi.org/10.4018/978-1-7998-1306-4.ch003
6. Edwards, B. and Hinueber, J., Why teachers make good learning leaders. *The Learning Professional*, 2015, 36(5): 26.
7. Elmore, R., *Building a New Structure for School Leadership*. Albert Shanker Institute. 2000.
8. Helle, L., Tynjala, P. and Olkinurora, E., Project-based learning in post-secondary education: Theory, practice and rubber sling shots. *Higher Education,* 2006, 51: 287–314. https://doi.org/10.1007/s10734-004-6386-5
9. Jaipal-Jamani, K., Figg, C., Collier, D., Gallagher, T., Winters, K.L. and Ciampa, K., Developing TPACK of university faculty through technology leadership roles. *Italian Journal of Educational Technology*, 2018, 26(1): 39–55.
10. King, B. and Smith, C., Using project-based learning to develop teachers for leadership. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, 2020, 93(3): 158–164. https://doi.org/10.1080/00098655.2020.1735289
11. Lambrecht, J., Lenkeit, J., Hartmann, A., Ehlert, A., Knigge, M. and Spörer, N., The effect of school leadership on implementing inclusive education: How transformational and instructional leadership practices affect individualized education planning. *International Journal of Inclusive Education*, 2022, 26(9): 943–957. https://doi.org/10.1080/13603116.2020.1752825
12. Larmer, J., Mergendoller, J. and Boss, S., *Setting the standard for project-based learning: A proven approach to rigorous classroom instruction*. Alexandria, VA: Association for Supervision and Curriculum Development. 2015.
13. Raman, A. and Thannimalai, R., Importance of technology leadership for technology integration: Gender and professional development perspective. *SAGE Open,* 2019, 9(4): 2158244019893707. https://doi.org/10.1177/2158244019893707

14. Shadish, W.R., Cook, T.D. and Campbell, D.T., *Experimental and quasi-experimental designs for generalized causal inference*. Houghton, Mifflin and Company. 2002.
15. Shaked, H., Perceptions of Israeli school principals regarding the knowledge needed for instructional leadership. *Educational Management Administration & Leadership*, 2023, 51(3): 655–672. https://doi.org/10.1177/17411432211006092
16. Suyudi, M., Rahmatullah, A.S., Rachmawati, Y. and Hariyati, N., The Effect of Instructional Leadership and Creative Teaching on Student Actualization: Student Satisfaction as a Mediator Variable. *International Journal of Instruction*, 2022, 15(1): 113–134. https://doi.org/10.29333/iji.2022.1517a
17. Ylimaki, R.M., *The New Instructional Leadership*. Routledge. New York, NY. 2014. https://doi.org/10.4324/9780203112885

Author's biography

Dr. Min Lun Wu is associate professor of instruction in Innovative Learning Design and Technology with Ohio University, USA. He is specialized in educational technology. His research areas are digital game-based learning, gamification, instructional leadership, computational thinking and educational game design, and online education.

Dr. Lan Li is professor of Classroom Technology with Bowling Green State University, USA. Her research interests include technology-assisted teaching and learning, teacher preparation, peer assessment, and online education.

Dr. Yuchun Zhou is associate professor of Educational Research and Evaluation with Ohio University, USA. Her research areas include mixed methodology, scale development, validation analysis, SEM, and program evaluation.