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Support Structures and Activities for Teachers Preparing for Game-Based Learning

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Abstract: In this paper, we share the experience of teacher preparation for game-based learning by describing a series of technical, pedagogical, and content support activities that helped teachers design and implement Minecraft-based modules in their classes. The teachers made use of the What-If Hypothetical Implementations in Minecraft (WHIMC), a set of Minecraft worlds that students can explore to learn more about astronomy, geosciences, and ecology. Technical support included setting up of the WHIMC server and Minecraft accounts for teachers and students, and teacher support familiarization of the WHIMC worlds. Pedagogical support included module reviews and a dry run that allowed teachers to refine their learning modules. Content support included assisting teachers with ensuring alignment between curricular goals and WHIMC functions and features. These support activities helped teachers achieve some success in their module implementations. Additional opportunities for improvement include a separate hands-on orientation session for students and peer observation to disseminate novel pedagogical strategies. Overall, this paper illustrates how teachers need to be supported in order to prepare and deploy a game-based learning module successfully.

Keywords: WHIMC, Philippines, TPACK, Teacher Professional Development, Game-based Learning

1. Introduction

In an article published in 2011, Ketelhut and Schiffer said that technology has grown so rapidly that schools have had difficulty keeping pace. Students were adept at computer gaming, social networking, and anytime, anywhere interactions, and were able to transition from one technology to the next near-instantaneously. Teachers, on the other hand, are challenged to move to the new just as they are becoming comfortable with the old. The technology type in which rapid technological change, student proficiency, and teacher hesitance are most notable is that of computer gaming. Computer gaming plays to the strengths and preferences of students, but are generally underused by teachers. In the decade that followed, these observations still ring true. Games are not used extensively in the classroom because teachers have limited time to prepare, have limited knowledge of games in general and specific games in particular, struggle with designing appropriate assignments and with integrating games with curriculum efficiently and effectively (Molin, 2017; Oluwatayo, Anyikwa, & Obidike, 2020). Furthermore, schools suffer from a lack of technology infrastructure and insufficient budgets to pay for high game licensing costs (Molin, 2017).

Many of these concerns can be addressed with adequate teacher professional development programs and initiatives. However, teacher preparation for use of games in the curriculum is not something that the literature commonly discusses. Indeed, some researchers point out that there is a dearth of literature on teacher professional development on the use of games that focus on pedagogy and/or impact on professional practice (Hébert, & Jenson, 2019; Molin, 2017).

This paper contributes to bridging this gap by bringing together two themes: teacher professional development the Technology, Pedagogy, and Content Knowledge (TPACK) framework, and game-based learning. We describe how our research team in the Philippines (PH) prepared a group of teachers for the use of What-If Hypothetical Implementations in Minecraft (WHIMC) in their classes. We describe the technological, pedagogical, and content support that we provided during module development and implementation to illustrate the level of support that teachers required to succeed in their information and communications technology (ICT) integration.

2. Related Literature

This section discusses the three themes of this paper: teacher professional development, TPACK, and game-based learning. In doing so, it positions the work of this paper in the larger body of literature.

One of the determinants of successful ICT in educational practice is teacher preparation. Studies have shown that ICT professional development increases the teachers' tendency to use ICT in their classrooms (Albion, Tondeur, Forkosh-Baruch, & Peeraer, 2015; Alt, 2018; Dlamini & Mbatha, 2018). In a 2021 review of the literature, however, Hu and colleagues (2021) found that although most teachers had positive attitudes towards the integration of ICT in teaching and learning activities, they also lacked the confidence and competence to do so because they were inadequately prepared. While pre-service and in-service ICT training is available to teachers, training content is typically limited to the use of productivity tools. Teachers are taught the functions of these tools, but not how to make use of them in innovative ways (Marcial & Rama, 2015; Torii, Kamidate-Yamaguchi, & Kubota, 2019).

Training that is focused on technology rather than pedagogy often fails to translate into meaningful outcomes for students (Fernández-Batanero, Montenegro-Rueda, Fernández-Cerero, J., & García-Martínez, 2020). Ideally, teacher preparation should include training in technology, pedagogy, and content knowledge. Content knowledge refers to the knowledge about the subject matter that teachers need to teach and students need to learn. These include concepts, theories, ideas, frameworks, and others. If teachers fail to master content knowledge, the students' knowledge will be ill-formed. Pedagogical knowledge is knowledge of the purposes and aims of education, an understanding of how students learn, and knowledge about the most appropriate methods for communicating with students. Technology knowledge refers to a mastery of ICT for communication, information processing, and problem-solving. Pedagogical content knowledge refers to knowledge of the best ways to represent and communicate the content. Technological pedagogical knowledge is an understanding of how teaching and learning change with technology, and an appreciation of what a particular technology platform can and cannot communicate well. Technological content knowledge is an understanding of how technology and content constrain each other, and an ability to choose which technologies are best suited for a specific domain.

At the center of the diagram is TPACK. TPACK is a framework described as, "the basis of effective teaching with technology, requiring an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge to develop new epistemologies or strengthen old ones." (Koehler & Mishra, 2009). TPACK requires an understanding of the relationships and interactions between technology, pedagogy, and content, and how each informs the choice, use, and expression of the other.

This kind of teacher preparation cannot be achieved through one-shot workshops. Rather, teachers need continuing support and resources (Vrasidas & Glass, 2007) as well as opportunities to learn and collaborate with peers (Li, Yamaguchi, Sukhbaatar, & Takada, 2019). Exposure to inquiry-based methods such as project-based learning, problem-based learning, and challenge-based learning can be particularly beneficial (Tondeur, Forkosh-Baruch, Prestridge, Albion, & Edirisinghe, 2016). They can help teachers move away from traditional modes of teacher-centric instruction to student-centered methods that encourage lifelong learning.

One such student-centered approach is game-based learning, which is defined as "a pedagogical approach that involves the design and implementation of curricula using existing games." (Foster & Shah, 2020). Games have been shown to add value to student learning because, in addition to delivering content, they are motivational, encourage problem-solving and imagination, create a fun and relaxed learning environment. A meta-analysis of the game-based learning literature (Lei, et al., 2022) found a link between game-based learning and science achievement. Stronger effects were seen in Eastern rather than Western countries, among primary school students rather than students from high levels of education, and for interventions between 4 hours and 1 week.

However, teaching with games is not something teachers intuitively know how to do and, therefore, needs to be the subject of continuing professional development. Teachers need awareness of a game's contents, as well as its affordances and constraints (Foster & Shah, 2020). Teachers need to understand how games can be used for learning, how to plan game-based activities, how to monitor progress within a game, and how to connect the game's contents with curriculum and broader world realities (Hébert & Jenson, 2019). Furthermore, teachers need to appreciate the social, structural, and technological factors that may support or derail the successful implementation of a game-based lesson (Foster & Shah, 2020). The TPACK framework specifically has been cited as a representation of the dynamic knowledge and skills that teachers have to continuously grow in their practice of using games for teaching and learning (Forster & Shah, 2020). Without sufficient preparation and continuous growth, teachers will use games on a trial-and-error basis (Molin, 2017).

Several authors (Foster & Shah, 2020, Hébert & Jenson, 2019; Molin, 2017) have pointed out that the literature regarding teacher preparation for game integration in curriculum is sparse. Much of the existing literature tends to focus on games and their design (Hébert & Jenson, 2019). The teacher's role in designing and selecting instructional approaches, methods, pedagogy, and how teachers are supported and empowered tend to be underplayed (Hébert & Jenson, 2019; Molin, 2017). Foster and Shah (2020) point out a few studies that have focused on the process involved in teaching with games.

This paper describes how a PH team prepared and supported a group of teachers in their use of WHIMC for their science and math classes. In doing so, we hope to provide readers with an estimate of the amount of support teachers need in order to use games for teaching and learning.

3. Overview of Minecraft and WHIMC

Minecraft is an open-ended, sandbox-type video game first launched in 2009 (Bitner, 2021). It is open-ended in that it has no goal or agenda. Instead, players mine resources and craft or build new objects, often in collaboration with other players. Over 180 million copies of Minecraft have been sold to date, making it one of the best-selling games of all time. Its impact has therefore extended beyond entertainment to, among other fields, education. Over the last decade, teachers have been using Minecraft as a vehicle to teach math, science, social science, and language (Baek, Min, & Yun, 2020), as well as 21st century skills such as collaboration, critical thinking, communication, and creativity and innovation (Hebert & Jenson, 2020).

WHIMC is a set of Minecraft worlds created by the University of Illinois Urbana-Champaign (UIUC). Learners can explore these worlds as supplementary activities to learn more about science, mathematics, engineering, and technology in general. Specifically, they would learn about astronomy, geosciences, and ecology. WHIMC makes use of Minecraft's natural physics and mechanics to simulate science-related concepts. Finally, WHIMC immerses learners in simulations of conditions on certain exoplanets and on alternate versions of Earth, logging both the ways in which learners traverse these words and the observations that learners make during their explorations.

Learners first explore the Rocket Launch Facility (Figure 1), modeled after that of the National Aeronautics Space Agency (NASA). Here, learners can visit mission control and Mars rover test sites, for example, and talk to simulated NASA scientists. Then, the Lunar Base LeGuin (Figure 2) is made up of quests where learners get to learn about different experiments and research studies being done in the moon. They also get to practice measuring and recording temperature, oxygen, pressure, and wind speed. The Space Station includes an unaltered version of Earth in which learners practice making different kinds of observations. The Space Station is also the jump-off hub from which learners travel to the different worlds.

Figure 1. Rocket Launch Facility, Mission Control.

Figure 2. Lunar Base LeGuin.

The alternate versions of Earth present learners with opportunities to observe the planet under altered conditions. Although the worlds are fictional, they are created in consultation with scientists: They accurately depict conditions on Earth under these circumstances. For example, what if Earth had no moon? There would be no seasons, days would be shorter, and winds would be stronger. What if Earth had a slightly colder sun? Water might only be able to exist in liquid form in a limited strip of green, and this is where we would all be forced to live.

4. Teacher Preparation and Support

This section describes the various stages of preparation and support that the PH team provided to the teachers and their classes before module development, during module development, during implementation, and after implementation.

4.1 Technical Preparations

The PH team established a formal partnership with the UIUC team to gain access to WHIMC's content, code and configuration details. While the partnership enabled the PH team to run its experiments using the UIUC server, the team instead decided to set up its own parallel server. The UIUC server was in a state of constant experimentation and improvement. Having our own PH server allowed us to control updates, download data, provide technical support, reset progress, and so on without having to constantly coordinate with the UIUC team.

The PH team also purchased a total of 150 Minecraft Java Edition licenses which were lent to the teachers and students who were participating in the study. It was possible for teachers and students to use their personal Minecraft accounts. However, lending them PH team-owned accounts enabled us to offer students and teachers greater anonymity. Each Minecraft account was linked with PH team-owned Gmail and Microsoft-registered account. When students completed the WHIMC-related lessons, the PH team reset the passwords for each of these accounts and their quest progress in the WHIMC worlds.

4.2 Teacher Recruitment and Onboarding

The PH team established institutional partnerships with three basic education schools in the Philippines. One school had two campuses: one in Manila and one in Laguna. The other school is in Cagayan de Oro City. We asked the partner schools to nominate at least two (2) science, technology, engineering and math (STEM) teachers to participate in the study.

A total of seven (7) teachers participated in the study, five (5) females and two (2) males. On average, they had thirteen (13) years of experience teaching science and/or math at the grade school level. By the time they participated in this study, they had been teaching online for around nine (9) months because of the COVID-19 pandemic. One out of the seven teachers had an award related to ICT, which was a bronze award for Best K-12 EdTech Leadership in EduTech Asia, Singapore. Meanwhile, Three out of seven of the teachers had an ICT-related certification (e.g. Google teaching certificate, Apple Certification, Microsoft certification). A total of 276 students participated in the modules.

The PH team then scheduled a separate project briefing and planning with the teachers. During the briefing, the teachers were told about the goals of the project, an overview of the WHIMC worlds, and the tasks that they were requested to complete. The tasks included an exploration of the WHIMC worlds, module preparation, deployment, and participation in review and debriefing discussions.

4.3 Module Preparation and Review Process

The project team gave the partner teachers 30 days to explore the WHIMC worlds themselves. After familiarizing themselves with the game, the partner teachers identified specific topics within their respective academic levels' curriculum where they thought a specific WHIMC world would fit. They developed the module and submitted it to the project team, through the project manager, for initial review. Table 1 shows that teachers used the modules in a variety of ways—synchronously or asynchronously; as a supplement or as part of the main lesson. Most lessons involved inquiry-based learning, which indicates the teachers' desire to encourage students' active participation.

Table 1. Summary of teaching modes and strategies.

Teacher	Modules and Topics	Grade	Mode	Type of Integration	Strategy/ies used
1	Rocket Launch Facility: People and Places	6	Synchronous	Supplement	Inquiry-Based Learning (Guided Inquiry), Active Learning (Discussion), Visual Thinking Routine (I see/think/wonder), Use of online brainstorming board (Jamboard)
	Explore the Moon Base		Synchronous	Supplement	Inquiry-Based Learning (Guided Inquiry), Active Learning (Discussion),Use of online brainstorming board (Jamboard)
	What If the Earth Has No Moon?		Synchronous	Supplement	Inquiry-Based Learning (Guided Inquiry), Active Learning (Discussion),
2	Tilted Earth	6	Synchronous	Supplement	Inquiry-Based Learning (Guided Inquiry), Active Learning (Discussion), Venn Diagram
	Exoplanets – Kepler 186f, Gliese 436b, Cancri 55e and Trappist 1e		Synchronous	Supplement	Inquiry-Based Learning (Guided Inquiry), Associative Brainstorming
	Exoplanets – Kepler 186f, Gliese 436b, Cancri 55e and Trappist 1e		Synchronous	Supplement	Inquiry-Based Learning (Guided Inquiry), Active Learning (Discussion)
3	Rocket Launch Facility	5	Synchronous	Motivation activity	Inquiry Based Approach
	Lunar Base LeGuin - Biodome		Synchronous	Motivation activity	Inquiry Based Approach
	Lunar Base LeGuin & Observation Training		Synchronous	Supplement	Science Process Skills/5Es

Table 1. Summary of teaching modes and strategies.

	Lunar Base LeGuin		Synchronous	Supplement	Science Process Skills/5Es
	Lunar Base LeGuin	4	Synchronous	Supplement	Science Process Skills/5Es
4	Earth Unaltered and What-If Earth with No Moon	5	Synchronous	Motivation activity	Concrete - Pictorial - Abstract (CPA) Approach
	Rocket Launch Facility	4	Synchronous	Supplement	Concrete - Pictorial - Abstract (CPA) Approach
5	Propositions	11	Synchronous	Performance task	Digital Learning
	Conditional and Equivalent Statements		Synchronous	Performance task and reflection activity	Digital Learning
6	Sun-Moon-Earth System: Solar Energy, Habitable Zone	7	Asynchronous	Motivation activity	Self-discovery
			Synchronous	Pre-lecture activity	Inquiry-based learning
	Sun-Moon-Earth System: Seasons		Asynchronous	Motivation activity	Self-discovery
			Synchronous	Pre-lecture activity	Inquiry-based learning
7	Ecosystem	8	Asynchronous	Pre-lecture and motivation activity	Digital Learning
			Synchronous	Lecture	Inquiry-Based Learning (Guided Inquiry) Active Learning (Discussion)
	Biodiversity and Evolution - Adaptation		Asynchronous	Pre-lecture and motivation activity	Digital Learning
			Synchronous	Lecture	Inquiry-Based Learning (Guided Inquiry) Active Learning (Discussion)

The project manager checked for the alignment of the learning design with the technical requirements of the WHIMC server and gave feedback on the general direction that the teachers envisioned for the module. The project manager also gave comments regarding feasibility, alignment of objectives to the flow of the lesson proper and/or project, or suggestions on alternative activities. The project manager then forwarded the reviewed first draft to the project lead for additional feedback or guidance. The project lead would provide comments related to the content, flow and suggestions on how to improve the module overall. The project manager would then forward the document with comments to the partner teacher. After receiving the reviewed document, the partner teacher revised the draft and resubmitted it to the project manager for review. Once the project manager completed the review, the revised module would then be forwarded to the project lead for review again.

Once the module draft seemed to comply with the learning design requirements sought for, the project team scheduled an internal dry run. The participants of the dry run were representatives of the project team, usually the project manager as the facilitator and the student assistants who acted as the teacher's students. The dry run usually ran for two hours: an hour for the module implementation, and the next hour for feedback-giving/processing. The teachers conducted the dry run as they would conduct a class. They went through the lesson and asked the participants questions. All other participants responded to the teacher's prompts. After the module dry run, the participants provided feedback about the session. They identified what they liked about the learning design and what they thought could be improved. After the dry run, the partner teacher revised and finalized the module. Figure 6 shows an excerpt of a final module.

4.4 Student Onboarding

To help teachers get their students ready for the WHIMC module implementation, the project team provided the teacher with the following documents/presentations for their reference:

- Summarized Research Protocol – This document contained the WHIMC project's overall objective, general data collection process, and data collection instruments.
- Minecraft Launcher Installation Guide – This document provides the instructions on how to install the Minecraft launcher, and a link to a basic tutorial video of how to play Minecraft.
- WHIMC Server Guide – This document contained step-by-step instructions on how to add the WHIMC server, and the information the students would need to input such as the server address. The project team suggested that the partner teacher only provide this when he or she already wanted them to access the WHIMC server for their asynchronous activity, or one (1) to two (2) days before the official synchronous session as designed in the module developed.

Three (3) weeks before the module implementation, the project manager gave the teacher the Minecraft account credentials to be assigned to each student who would be participating in their class. The teacher would then decide when he or she would distribute these credentials to the students. The PH team recommended that teachers send these credentials at least two (2) weeks before the module implementation date. The project team's technical support team was also on stand-by via the Viber messaging application for any concerns from the teachers (e.g. students unable to download the Minecraft launcher or students unable to sign in).

4.5 Implementation support

During the implementation of the module in the actual classes, only the teacher interacted with the students. The PH team did not interact with the students directly. However, members of the PH team, usually the student assistants, were available inside the Minecraft server for the duration of the asynchronous activities and synchronous class sessions to help troubleshoot student issues that may arise. Examples of these included getting stuck in a hole or inability to enter a portal. In these cases, the PH team would teleport students to the target destination so that they could continue with the game. The student assistants supporting the teacher would answer questions through the Viber messaging application or through a synchronous online meeting with the teacher.

4.6 Post-implementation Debriefing

About two weeks after each module implementation, the partner teacher was invited for an online debriefing session with the project lead, project manager, and the student assistant/s who acted as the teacher's technical support during the module implementation period. The project manager was the main facilitator for the debriefing sessions. The student assistant was present to take notes and to share his/her perspective.

The goal of the debriefing was to determine the following:

1. Whether the teachers regarded the module implementation to be successful or unsuccessful.
2. What factors contributed to the implementation's success.
3. What opportunities there are for improvement of the module design and implementation process.

Some teachers expressed feeling nervous and anxious prior to module implementation, worrying about their inexperience with Minecraft as a teaching tool and uncertainty about how well the students would learn from the experience. However, after module implementation, the majority of teachers reported that their implementations were successful both cognitively and affectively. Student responses to discussion questions were satisfactory to very satisfactory. Teachers were impressed that the students' answers to the questions had high levels of quality and depth. Teachers also said that students were enthusiastic, demonstrating a high level of appreciation for this computer-based interactive class activity. Students also showed a willingness to help when a classmate was encountering technical difficulties.

The teachers cited examples of factors that contributed to the module design and implementation success. Some factors related to the administrative and pedagogical support that the research team provided. For example, teachers said they were given enough time to familiarize themselves with the game, prior to crafting their modules. They appreciated that the research team provided them with tips about possible student pitfalls and roadblocks. The feedback sessions and the dry run also helped them refine their module content as well as the actual implementation process. Other factors were internal to the teacher himself or herself. For example, teachers said that prior experience with online teaching or with tools such as EdPuzzle bolstered their confidence. Prior experience using scientific inquiry as a teaching strategy also enabled them to craft a module that used WHIMC appropriately. Teachers' personal resources such as having two laptops at their disposal made technical implementation much easier.

Teachers also cited some opportunities for improvement. In terms of the module preparation, the first partner school who implemented said that the requirement for post-module assessment was not made clear to them. This should have been explained during the module design process so that they could have better prepared for an evaluative assessment. For the other partner schools, however, the need for an evaluative assessment in their modules was clearly communicated. During the actual WHIMC session with the students, it was relatively common for students to have problems with logging in, accessing the server, and navigating around WHIMC. These problems were resolved by the technical support team and by their classmates. One teacher had a particularly problematic implementation because the students were not able to set up their Minecraft accounts and complete the Minecraft launcher installation prior to the scheduled implementation day, so the implementation had to be rescheduled. These technical difficulties led some teachers to suggest that one session should be allotted for a "tech run" or student familiarization with the WHIMC environment before the actual implementation.

There were also opportunities to contribute to teacher professional development. While most teachers agreed that WHIMC was aligned with their curriculum, they also noted that WHIMC contained information that was unfamiliar to them. It would therefore be useful if the teacher did some reading on these topics prior to or during module design so that they can better refer to this content. Teachers with no prior experience of using games in their classes said that it would benefit their peers to observe a WHIMC session to enable fellow teachers to learn how to use the worlds in their classes.

5. Discussion and Conclusions

The goal of this paper was to contribute a description of teacher preparation activities for game-based learning. In doing so, it hoped to help fill an existing gap in the literature regarding the essential role that teachers and teacher preparation play in the integration of games in curriculum.

The technical, pedagogical, and content knowledge support that PH team provided enabled teachers to integrate a WHIMC module in their classes with some success. In terms of technical support, the PH team made the WHIMC server and Minecraft accounts available to the teachers and their students. We provided an onboarding process for the teachers in which they were familiarized with the WHIMC environment. For students, the onboarding process was limited to written guides and should be expanded to a guided hands-on session to ensure a smoother module implementation session.

To support teachers pedagogically, we familiarized them with the goals of the WHIMC project. More importantly, we reviewed teacher-designed modules at least once, conducted a dry run and provided detailed feedback immediately after the said run. These processes helped teachers refine their module designs and build confidence to implement the modules developed. The teachers identified one more method of pedagogical support that can assist in future implementations: peer observation. If fellow teachers were allowed to observe the module implementations, the exposure may teach them new methods of using ICTs, specifically games, in their classes.

Although most content knowledge sprung from the teachers themselves, the PH team's support was in ensuring alignment, to the extent possible, between curricular goals of the partner school and WHIMC activities. The PH team encouraged teachers to leverage on conversations with characters in the game, tasks the students had to perform within the game, or tools students had to use in order to complete the game missions.

From this experience of supporting teachers as they developed and implemented their WHIMC modules, the PH team derives four reflections:

First, teachers are enthusiastic about trying out new technologies, even if doing so is time-consuming. The teachers who participated in this study were all teaching full-time. Furthermore, the study was conducted in the middle of the pandemic. This meant that their participation was another task added on to their already busy schedules. Still, they participated willingly and were able to deliver their assigned tasks.

Second, teachers need comprehensive and continuous support if they are to move beyond productivity tools to more innovative, inquiry-based, student-centered learning activities. The teachers who participated in this study were already quite proficient with ICT. Several of them had been certified and one had even won an award for ICT integration. However, they still expressed apprehension as the technology needed to mount something like game-based learning is usually less familiar than productivity tools or online polls. The technology platform therefore has to be established and debugged, afterwhich, teachers need help learning it and students need help navigating it. The pedagogical approaches will also depart from traditional lecture-based instruction, so the activities have to be planned such that they are free enough to allow exploration but guided enough to achieve learning goals. Teachers need content support to ensure alignment, and coupling between the technology and the curriculum.

Third, even when these supports are made available, there is no guarantee of success. Students will get lost. Timing of lessons will get derailed. Alignment or coupling with curriculum will be weak. The best that these support frameworks and structures can do is increase the probability of a successful module design and implementation.

Finally, there is the challenge of scaling up. The experience narrated in this paper was of a small group of teachers and a relatively small group of students. It exemplifies the reality of innovations of this kind: they are islands whose examples do not get diffused. For these innovations to make a difference to more learners, they have to be implemented systematically and at scale (Tondeur, Forkosh-Baruch, Prestridge, Albion, & Edirisinghe, 2016). This requires a sharing of experiences—something teachers are eager to do—and a scale up of TPACK support.

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