

Preparing Preservice Teachers to Incorporate Geospatial Technologies in Geography Teaching

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INTRODUCTION

Geospatial technologies (GT) are ubiquitous in twenty-first century living and integrated in the lives of our twenty-first century “digital native” students (Nielsen, Oberle and Sugumaran 2011; Prensky, 2001). GT are recognised to enhance learning and teaching in geography and teachers are increasingly expected to embed these technologies into their lessons (Baran, Chuang and Thompson 2011; Bednarz 2004; Bowman 2015). Effective incorporation of GT in geography instructional settings greatly benefits from knowledges of content, pedagogy and technology (Doering and Veletsianos 2008). Based on Mishra and Koehler’s (2006) Technological Pedagogical Content Knowledge (TPCK) framework, Doering and Veletsianos (2008) proposed the Geographical-Technological Pedagogical Knowledge (G-TPCK) framework for preparing teachers to teach with and develop curriculum that includes GT. Doering and Veletsianos (2008) suggest that the inclusion of G-TPCK in the design and development of preservice teacher education programs is critical for the successful incorporation of GT in geography education. Building preservice teachers’ confidence to incorporate GT in their teaching practice is also essential (Nielsen, Oberle & Sugumaran 2011). There is little research on the implementation of GT in initial teacher education programs (Jo 2016), how to prepare preservice geography teachers to incorporate GT in teaching, and about which learning experiences may best support teachers to teach with and develop curriculum with GT (Baker et al. 2015). In response, this study evaluates GT learning experiences in two geography curriculum courses. The learning experiences were developed to prepare preservice geography teachers to plan and design GT learning experiences, and implement strategies and methods that successfully incorporate GT in the classroom to enhance student learning (Pope, Hare and Howard 2002). The study investigates which GT learning experiences preservice geography teachers perceived to be most effective

for preparing them to incorporate GT in teaching geography, and whether the learning experiences enhanced their confidence to do so.

The following section defines GT in terms of their role in geography education and their prominence in the Australian national geography curriculum. G-TPCK is then positioned in the context of education research, specifically Shulman's (1986; 1987) notion of Pedagogical Content Knowledge (PCK) and Mishra and Koehler's (2006) TPCCK. The literature review concludes with a discussion on factors influencing preservice geography teachers' confidence with regard to the uptake of technologies in the classroom.

Geospatial technologies

GT are a range of tools that are used for mapping and analysing Earth and human society, and include Global Positioning Systems (GPS) and GPS-enabled devices, Geographic Information Systems (GIS) programs, web-based GIS and virtual globes (American Association for the Advancement of Science 2016). GT are constructivist learning tools (Doering and Veletsianos 2008; Kerski 2003) that provide opportunities for students to develop their spatial thinking through collecting, storing, manipulating, analysing and displaying data, and interacting with spatial information from real-world locations (Australian Curriculum Reporting and Assessment Authority (ACARA) 2015; Baker et al. 2015; Bowman 2015). Access to GT has previously been limited by cost and the challenge of having to navigate complex hardware. Over the last decade, however, myriad GT have become more accessible to the general public and have slowly infiltrated the education sector (Doering and Veletsianos 2008). Their place in geography education in Australia was reinforced by the release of the *Australian Curriculum: Geography F-10* in 2013 and the subsequent *Australian Curriculum: Humanities and Social Science F-10* in which GT are

positioned "as an integral tool for teaching the skills and concepts of secondary geography" (Bowman 2015, 1).

GT in the classroom largely fall into two categories, each with distinct learning goals and activities: 1) learning *about* the technologies and 2) learning topics *with* or *through* the technologies (Baker et al. 2015; Sui 1995). Learning with or through GT is used in constructivist problem- or inquiry-based learning to focus on subject-area content and relies less on interaction with software than learning about technologies (Baker et al. 2015; Doering and Veletsianos 2008). Complexity of content and application of GT resources are wide ranging from online, simple GT that allow users to view datasets to complex GIS software that allows users to collect and manipulate their own data, create maps, and evaluate and make decisions based on the spatial data represented on those maps (Australian Geography Teachers' Association and Education Services Australia n.d.). The GT learning experiences that are the focus of this study are categorised as learning topics with or through GT.

Technological pedagogical content knowledge

TPCK builds on the work of Shulman (1986; 1987) who introduced the concept of PCK as a teacher's blending of pedagogy and content knowledge to organise, adapt and represent content from a subject area. PCK is at the intersection of pedagogical knowledge, content knowledge and curriculum knowledge. Shulman (1987) proposed that PCK is the capacity of teachers to transform the content knowledge from their subject area into pedagogically powerful content that is accessible to the diverse abilities and backgrounds of their students. Since its introduction, PCK has been used in much scholarship of teacher and subject matter education (Mishra and Koehler 2006), including in geography education and preparing preservice geography teachers (Blankman, van der Shee, Volman and Boogaard

2015; Cole and Ormrod 1995; Jo and Bednarz 2014; Lane 2009, 2015; Reitano and Harte 2015, 2016).

Mishra and Koehler (2006) adapted Shulman's PCK framework to include technology. They argue that while the PCK framework implicitly included "transparent technologies" (for example, textbooks and overhead projectors) (Bruce and Hogan in Mishra and Koehler 2006), the pervasiveness of digital technologies in twenty-first century society and learning "have changed the nature of the classroom or have the potential to do so" (Mishra and Koehler 2006, p1023). TPCCK is "the knowledge required by teachers for incorporating technology into their teaching in any content area" (Mishra and Koehler 2006, 1028). Quality teaching, therefore, requires teachers to interweave content, pedagogy *and* technology to develop pedagogically powerful content. The TPCCK framework provides a shared language to conceptualise professional development and teacher education programs that emphasise intentional technology use within the specific demands of content areas and pedagogical approaches (Doering, Koseoglu, Scharber, Henrickson and Lanegran 2014; Hammond and Manfra 2009; Harris, Mishra and Koehler 2009).

Geographical technological pedagogical content knowledge

Following the work of Shuman (1986; 1987) and Mishra and Koehler (2006), Doering and Veletsianos (2008) proposed G-TPCK, which is a useful framework for preparing preservice geography teachers to teach with GT and develop curriculum that includes GT. The G-TPCK framework includes the three domains of technology, content and pedagogy (Figure 1). Doering and Veletsianos (2008) emphasise the importance of integrating the three domains, such that the technology used is not separate but is linked to geographical content knowledge and pedagogical strategies. Embedded within the G-TPCK framework is geography PCK, thus connecting geographical content knowledge, pedagogical strategies and

GT use to curriculum. Technology knowledge is a teacher's knowledge about and capabilities using GT resources; pedagogical knowledge is the authentic, inquiry- and problem-based teaching strategies used to teach geography; technology pedagogical knowledge is the understanding of how GT can be used in geography education; and G-TPCK is the ability to pair GT to content, adapt teaching strategies, and design and implement geography curriculum materials that enhance and assess student learning (Bodzin, Peffer and Kulo 2012).

[Figure 1 here]

Preservice geography teachers' confidence

Pope, Hare and Howard (2002; 2005) found that stand-alone technology courses in initial teacher education programs have little impact of preservice teachers' ability to incorporate specific technology, such as GT in their teaching practices. A lack of confidence incorporating GT in teaching and limited opportunities for preservice teacher to build that confidence during teacher training are factors in low levels of uptake of these technologies in classrooms (Nielsen, Orberle and Sugumaran 2011). However, Strachan and Mitchell (2014) found that preservice teachers and younger teachers were more receptive than older teachers when it came to adopting GT in their teaching. This underscores the importance of providing opportunities for preservice teachers to integrate GT during their geography curriculum courses to help increase their confidence planning and designing learning experiences, and implementing strategies and methods that integrate these technologies in the classroom.

RESEARCH DESIGN AND METHODOLOGY

The study used a design-based research (Brown 1992; Collins 1992) approach to evaluate targeted GT learning experiences in two geography curriculum courses. Design-based research is "an emerging paradigm for the study of learning in context through the

systematic design and study of instructional strategies and tools" (The Design-Based Research Collective 2003, 5). Although there is no single prescribed research method, educational interventions in design-based research are "enacted through the interactions between materials, teachers, and learners. Because the intervention as enacted is a product of the context in which it is implemented, the intervention is the outcome (or at least an outcome) in an important sense" (The Design-Based Research Collective 2003, 5).

Context of the study

The study was conducted in two initial teacher education programs – Bachelor of Secondary Education (B.Ed.) and Graduate Diploma of Secondary Education (Grad Diploma). The B.Ed. preservice teachers complete six discipline courses for each of their two teaching areas in the first two years of their three and a half year initial teacher education program. Those studying to become geography teachers complete two geography curriculum courses (junior secondary and senior geography curriculum) in third year. Grad Diploma preservice teachers, who come from a wide variety of professional backgrounds, are assigned two teaching areas based on the discipline courses they completed in their undergraduate degree(s). The Grad Diploma is a one-year graduate entry program in which students undertake no discipline courses, only curriculum courses in their two teaching areas in addition to core education and professional experience courses. The study reported here was conducted during the two junior secondary geography curriculum courses, which are run in the first semester. The curriculum courses are completed in nine week blocks, during which time students have 36 hours of face-to-face contact in lectures, tutorials and workshops, as well as extensive online contact on the combined online learning environment (i.e. the B.Ed. and Grad Diploma junior secondary geography course sites are joined). Both B.Ed. and Grad

Diploma participants commence their first teaching practicum of their initial teacher education program at the end of the semester in which the study was conducted.

Geospatial technology learning experiences in the course

The targeted GT learning experiences in the two geography curriculum courses were designed to immerse preservice teachers in collaborative learning environments in which they are provided opportunities to develop their knowledge of GT, their confidence to plan and design GT learning experiences, and implement strategies to incorporate GT in their teaching practices. G-TPCK was used as a conceptual framework in the design and development of GT learning experiences discussed in this study. Figure 1 provides a visual schema of the alignment of the five GT learning experiences with the domains of the G-TPCK framework. Following an extensive review of the literature, Hohnle (2016) and his colleagues recommended features of effective training activities in continuing education of in-service teachers. Some of the key recommendations of that study are incorporated in the curriculum courses reported here. For example, the GT learning experiences were cumulative and provided preservice teachers with a combination of didactic instruction and practical activities. The GT learning experiences discussed in this paper are described in the following section.

GT workshop

A secondary school geography teacher with expertise in GT was invited to deliver two four hour GT workshops in the two geography curriculum classes. These workshops followed lectures and tutorials on the topic of planning for teaching, which included PCK and TPCK. The facilitator of the workshops provided myriad opportunities for hands-on exploration of a variety of GT resources and their application in the curriculum, and led

discussions about, and provided examples of, pedagogical strategies for incorporating the technologies in geography teaching. The *Queensland Spatial Educators' Toolkit* for the *Australian Curriculum: Geography* and the *Queensland Geography Senior Syllabus* (Law 2015a and 2015b) were also introduced in the workshop. The Toolkits are educative curriculum materials (Davis and Krajcik 2005) that align suggested GT resources to the curriculum, and provide pedagogical implementation ideas. Educative curriculum materials have been found to support teachers' professional development in the area of GT pedagogical content knowledge (Baker *et al.* 2015; Bodzin, Kulo and Peffer 2012). The author anticipated that the Toolkits and the workshops would be useful for preservice teachers in a number of ways, for example, to support the development of their G-TPCK and learning of subject matter knowledge, and provide implementation support (Bodzin, Peffer and Kulo 2012).

GT teaching resource folder

The GT teaching resources folder on the courses' online learning environment is a database into which all students were encouraged to upload GT resources that could be used for teaching geography. This folder was initiated in 2013 and follows students from junior secondary geography curriculum (semester 1) to senior geography curriculum (semester 2), and then rolls over to the new cohort of students the following year. It is a 'living database' that continues to accumulate a wide range and variety of GT teaching resources. Examples of GT resources in the folder at the time of writing this article include *National Geographic Map Maker*, *GRASS GIS*, *SpatialGenie*, *Queensland Globe*, *Aqueduct*, and *Null School Earth*.

Micro-lessons: developing lesson plans, teaching and observing peers

As a course assessment task all students had to develop sequential lesson plans. Each plan included inquiry-based learning sequences that incorporate GT and each student taught a

small (15 minute) section of one the lessons to their peers. The lesson plans were derived from unit plans that the students developed collaboratively in small groups. The unit plan and lessons plans were based on the content of the *Australian Curriculum: Geography 7-10* and followed the GT workshop, lectures and tutorials on inquiry-based learning, planning for teaching, PCK, TPCK and G-TPCK. The rationale for implementing the microteaching activities in the junior secondary geography curriculum courses was to provide the students with the opportunity to put theory into practice (Fernandez 2010) while building their teaching confidence (Brent, Wheatley and Thomson 1996) and developing their subject matter knowledge and pedagogical skills, and ultimately their G-TPCK (Amobi 2005; Cruickshank and Metcalf 1993; Doering and Veletsianos 2008; Golightly 2010; Harte and Reitano 2015). The micro-lessons provided multiple GT learning experiences, including planning lessons that incorporate GT, delivering lessons that include GT learning sequences, and observing pedagogical strategies of peer-delivered GT-enhanced micro-lessons. Examples of GT learning sequences in the participants' lesson plans and micro-lessons included student-led navigation on the Yangtze River using Google Earth, measuring distance and elevation using Google Earth, and students plotting locations on the school grounds using a GPS application on their mobile phones.

GT report

Students were required to write a report as a summative assessment task in which they referenced relevant, contemporary literature to justify the importance of incorporating GT in teaching students in junior secondary geography, and the opportunities and challenges of doing so. While students were exposed to contemporary literature over the course of the semester, they were also expected to undertake independent research for the report. The second half of the report required students to critically evaluate three GT resources that they

could use in a junior secondary geography classroom, including their potential inclusion in selected focus unit(s) from the *Australian Curriculum: Geography 7-10*. The report provided students with the opportunity to demonstrate their knowledge and understanding of geography education, technology education and GT literature, and apply this knowledge to evaluate the GT resources.

Research aims

The aim of this study is to evaluate the targeted GT learning experiences (described above) in two junior secondary geography curriculum courses. The objectives of the mixed method study are to determine, from the participants' perspective, which learning experiences were most effective for preparing them to incorporate GT in teaching practice and, whether these learning experiences developed their confidence to do so.

The research questions for the study are:

RQ1: Have the GT learning experiences enhanced participants' confidence to incorporate GT in their geography teaching practices?

RQ2: Which GT learning experiences did participants perceive to be most beneficial for preparing them to incorporate GT in teaching geography?

Participants

Letters of invitation to participate in the study were distributed to all preservice teachers enrolled in the two junior phase geography curriculum courses. A total of eighteen preservice teachers, which comprised seven Grad Diploma students and eleven B.Ed. students, agreed to participate in the study. One of the Grad Diploma students did not complete the final survey as she did not return to the campus for further study and she did not return an electronic copy of the survey. Participants were provided with a formal information sheet, which explained

the rationale for the research, that their participation was voluntary and they could withdraw their consent to participate at any stage during the project, and they were assured anonymity.

Surveys

The surveys included a combination of closed-ended Likert-type scale questions and open-ended questions. A self-report measure in surveys is a useful tool to gain insight to individuals' perceptions (Keengwe 2007) and was used in the surveys in this study. Participants completed three surveys: 1) at the start of the semester; 2) at the end of the semester before participants went out to schools on their practicum placement; and 3) on completion of B.Ed. participants' six week and Grad Diploma participants' seven week practicum placements in secondary schools. The second and third surveys were revised after each set of results was collated.

In the first survey, participants were asked about their knowledge of simple and common GT, and their general confidence using these technologies; their anticipated confidence incorporating GT in teaching geography as preservice teachers; and challenges they foresee incorporating GT in a real geography classroom (Table 1). Simple GT are defined as those that "typically offer a basic 'front-end', online interface that allows users to interact (to varying degrees) with spatial data" (Australian Geography Teachers' Association and Education Services Australia n.d. para1) and "trade complex features for usability" (Law 2013). The author anticipated that most participants would be familiar with 'common GT', such as Google Maps and Google Earth.

[Table 1 here]

In the second survey participants were again asked about their knowledge of GTS, and how confident they were using GT and incorporating simple and common GT in teaching geography. Participants were then provided with a list of GT learning experiences in the course and asked to indicate how effective ('unhelpful', 'helpful', 'very helpful', and

‘extremely helpful’) each was for developing their knowledge and understanding of GT and their confidence incorporating GT in planning to teach geography. Finally, participants were asked to indicate how likely they are to incorporate GT in their teaching while they were on their practicum.

In the third and final survey following the school practicum placements, participants were asked about opportunities that they might have had to incorporate GT into their teaching; the pedagogical strategies they selected; feedback from their supervising teachers; and whether the intended learning outcomes were achieved. They were also asked to indicate how effective each of the GT learning experiences was during the nine week junior secondary geography curriculum course for developing their knowledge and understanding of GT, their confidence incorporating GT in their teaching while they were on practicum, and how likely they are to incorporate GT in their future teaching.

Data analysis

The study used a mixed method approach to data analysis (Hesse-Bibe and Leavy 2006). Repeat quantitative questions allowed for a comparison of participants' perceptions over the course of the study (at the start of the semester, at the end of the teaching period, and following their school practicum placement). Quantitative data from each of the three surveys were correlated according to the program in which the participants were enrolled (B.Ed. or Grad Diploma) and analysed using descriptive statistical analysis. This allowed for comparisons to be made across surveys (surveys 1, 2 and 3) and between cohorts (B.Ed. and Grad Diploma). Data analysis for qualitative data consisted of the researcher reviewing qualitative content across all surveys to subjectively identify and code recurrent themes and the range and consistency of response within the themes. In addition, the author constructed two vignettes from qualitative data drawn from the three surveys. Hughes and Huby (2004,

37) state that the internal validity of vignettes "refers to the extent to which vignette content captures the research topic under question". These vignettes were selected as they encapsulate the research focus and are representative of the qualitative results. The vignettes also provide evidence to support the quantitative findings.

There are limitations of the study. The results are based on a small sample size of preservice teachers from one university. While a larger sample size of preservice teachers would enhance the ability to generalise the results, it would be difficult to extend the study to preservice teachers at other institutions because of differences in delivery of curriculum courses. To truly measure the participants' G-TPCK would also require classroom observations of their teaching. The subjective classification of qualitative data is recognised as an additional limitation of the study.

RESULTS AND DISCUSSION

The following section reports on and discusses the results of the surveys. Quantitative results are presented first, with supporting evidence from qualitative data second.

RQ1: Have the GT learning experiences enhanced participants' confidence to incorporate GT in their geography teaching practice?

Results from both B.Ed. and Grad Diploma surveys show a shift over the course of the semester in the level of participants' confidence using GT (Table 2), their confidence incorporating GT in their teaching practice (Table 3), and their likelihood of incorporating GT in teaching geography (Table 4). Despite low levels of confidence at the start of the semester, the participants recognised that GT are important in geography education as demonstrated by the following statements: "Spatial technologies open up new, interesting, effective and engaging opportunities for geography teaching. They also foster important skills

for life and future employment" (Grad Diploma participant, Survey 1). "It is necessary. It is extremely important for students to be able to [use GT to] spatially view the world, make comparisons and generalisations" (B.Ed. participants, Survey 1). The proportion of participants who indicated that they would incorporate GT in geography teaching is very encouraging and supports previous findings that preservice teachers are receptive to adopting GT in their teaching (Strachan and Mitchell 2014)

[Table 2 here]

[Table 3 here]

[Table 4 here]

The combination of learning experiences appears to have had a positive impact on most participants' confidence. Teaching in secondary school also appears to have had a positive impact, with overall higher levels of confidence using GT and in their abilities to incorporate GT in their teaching practice following their teaching practicum as illustrated in the following two vignettes. In the following statement before starting her teaching practicum, a B.Ed. participant (Survey 2) expresses a lack of confidence in her technology knowledge and describes why she thinks she does not feel confident to experiment with incorporating GT while on her practicum:

Long-standing teachers seem to be 'stuck' in their processes and therefore are not usually supportive of new technologies and teaching strategies that come with them. To counter this, as a preservice teacher, I would need to feel extremely confident with the technology to feel capable of implementing them in the classroom. The issue is by the time I graduate, my content knowledge will be high but my technology knowledge in these programs won't be, so it becomes safe to follow practices of already serving teachers.

Despite the participant's lack of confidence, she reported in survey 3 that she had successfully incorporated GT not only in geography teaching but also in history teaching (her second teaching area). She developed a lesson in her Geography class in which her students used archived synoptic charts and web-based GT resources to analyse weather patterns and predict bushfire risks in Australia. In her Year 8 History class, she developed a lesson in which her students used Google Earth to plot Christopher Columbus' journey to the Americas. She used the opportunity to "re-engage students" in the topic because "[the students] were covering a lot of source analysis and they were losing interest in the topic. I found this as an opportunity to let the students get hands on with the topic and move away from textbook work". When asked about feedback from her supervising teacher for the lessons in which she incorporated GT, the participant reported: "My supervising teacher loved the ideas and use of these technologies and we discussed with the other teachers in the staffroom for them to continue building on my lessons [after the end of the practicum]." The preservice teacher had, with the encouragement of a supportive supervising teacher, experimented with integrating GT in her teaching. In doing so, she appears to have inspired the very teachers she feared would be resistant to new technologies in their classrooms.

In the second vignette, another B.Ed. participant reported an average level of confidence using GT in his first survey. He felt his greatest challenge was "[my] lack of understanding of how to use spatial technologies." Nonetheless the participant reported in the final survey that, with the encouragement of his supervising teacher, he successfully incorporated GT when he taught catchment management to a Year 12 geography class. In the lessons he helped students manipulate and map water quality data using GIS technology. He also demonstrated to students how to access and use Queensland Globe (a Google Earth KML extension file) so that they could incorporate data from this resource in their report assignment. The participant reported that the students achieved the learning outcomes he set

for the lessons; he also reported in the final survey that his level of confidence using GT had shifted from 'average' to 'very high'.

The vignettes show that preservice teachers may still lack confidence in their competencies to incorporate GT in their teaching prior to having the opportunity to put their university learning into practise in a real classroom context. This is understandable, especially for those preservice teachers who have never taught in a school classroom, as was the case for the participants in this study. These results suggest that while it is essential to include multiple opportunities for GT knowledge, skills and confidence development in curriculum courses (Pope, Hare and Howard 2002; 2005), it is also important for teacher educators to encourage preservice teachers to experiment with GT implementation while on practicum, and the critical role that supervising teachers play in supporting preservice teachers to do so.

RQ2: Which GT learning experiences did participants perceive to be most effective for preparing them to incorporate GT in teaching geography?

Participants reported generally low levels of confidence in their knowledge and use of simple and common GT in the first survey. This was concerning given that the survey provided as examples of simple and common GT, Google Earth and Google Maps – GT that are ubiquitous and ones that many participants would most likely have used in previous discipline courses (B.Ed. participants), professional contexts (Grad Diploma participants), and on a regular basis in daily life (for example, Google Maps). Participants were therefore asked in survey 2 (i.e. after the end of the formal university teaching period following immersion in all learning experiences) to rate how effective each geospatial learning experience was for developing their knowledge of GT. This question was included because GT knowledge (defined as knowledge about and capabilities using GT (Doering and Veletsianos 2008) is an important element of G-TPCK, and a lack of confidence in this

domain is predicted to result in low uptake of GT in teaching practice. It was also useful to understand how, if at all, participants' GT knowledge had changed over the semester. 'Very helpful' and 'extremely helpful' responses were aggregated for each learning experience and represented as a percentage of the total number of participants for each of the two groups (B.Ed. and Grad Diploma). The geospatial teaching resource folder was the most highly rated learning experience for developing knowledge of GT by most participants in the study (n = 17) (Table 5). This was followed closely by the GT workshops (n = 16), developing sequential lesson plans that included planning for GT instruction and teaching a portion of one of the lessons to their peers (n = 14) and observing peers teach (n = 14), and the GT report (n = 11).

[Table 5 here]

In the final survey (i.e. following their in-school teaching practicum), participants were asked to rate how effective each of the learning experiences was for contributing to their developing G-TPCK. Again, the geospatial teaching resource folder was the most highly rated learning experience for contributing to participants' developing G-TPCK (n = 15). This was followed by the GT workshop (n = 14), developing sequential lesson plans that included planning for GT instruction and teaching a portion of one of the lessons to their peers (n = 13) and observing peers teach (n = 13), and the GT report (n = 11) (Table 6).

[Table 6 here]

The results for the second research question are interesting. With overall low levels of confidence in knowledge of GT at the start of the semester, it is not surprising that the teaching resource folder, which contains GT teaching resources uploaded by students and the author over a number of years, was rated highly by most participants for contributing their knowledge of GT. The folder was also the most highly rated for contributing to participants'

developing G-TPCK, however. Given that the folder developed as a space for preservice geography teachers to share GT teaching resources, this result requires further examination.

The author anticipated that participants would rate the GT workshop, with the inclusion of the *Queensland Spatial Educators' Toolkit for the Australian Curriculum: Geography* and the *Queensland Geography Senior Syllabus* (Law 2015a and 2015b), and the micro-lessons as the most effective learning experiences for preparing them to incorporate GT in their teaching practice. These two learning experiences covered all domains of the G-TPCK framework (ref to Figure 1). While overall these learning experiences were rated second and third, there were interesting differences in the B.Ed. and Grad Diploma results. For example, Grad Diploma participants valued most highly the resource folder, workshop, lesson plans and micro-lessons for contributing to their knowledge of GT and for contributing to their developing G-TPCK. B.Ed. participants found the resource folder and workshop most effective for contributing to their knowledge of GT and their developing G-TPCK. A lower proportion of B.Ed. than Grad Diploma participants found the lesson plans and micro-lessons to be beneficial. Both groups of participants reported that the GT report was least effective for contributing to their knowledge of GT and their developing G-TPCK.

CONCLUSION

Pope, Hare and Howard (2002) highlight the challenge of relying on stand-alone technology courses in teacher education programs to prepare preservice teachers to integrate specific technologies in their content areas. The research by Pope and her colleagues underscored the importance of ensuring preservice teachers are provided the opportunity to acquire the knowledge, skills and confidence to successfully integrate specific technologies, such as GT, that they will be required to use in the classroom. The challenge lies in providing, in a shortened semester, the most effective GT learning experiences for preservice

teachers to begin developing the required competencies (Doering & Veletsianos, 2008) and building their confidence (Nielsen, Oberle & Sugumaran 2011) in their ability to experiment with incorporating these technologies in their teaching practices.

This paper reports on a study that evaluated the efficacy of GT learning experiences in two geography curriculum courses to determine which learning experiences were most useful for developing preservice geography teachers' competencies and confidence to successfully incorporate these technologies in their teaching practices. The learning experiences were designed to provide a variety of opportunities that cover all domains of Doering and Veletsianos (2008) G-TPCK framework, presenting preservice teachers with opportunities to plan and design GT learning experiences and implement strategies and methods that integrate successfully GT in the classroom to enhance student learning (Pope, Hare and Howard 2002). The results indicate that the preservice teachers' confidence in their knowledge, understanding and use of GT increased over the course of the study. Participants found a combination of GT learning experiences to be useful for developing their competencies and confidence to incorporate GT in their teaching. These learning experiences provided the participants with opportunities to build their knowledge of GT, observe modelling of authentic GT teaching practices, plan and design GT learning experiences, and experiment with strategies to implement these in a safe learning environment. These findings are important because they highlight the value of integrating GT learning experiences in geography curriculum courses. The results also inform research on using G-TPCK as a framework to plan and develop GT learning experiences for geography curriculum courses and contribute to the literature on preparing preservice teachers to incorporate GT in teaching geography.

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