Virtual environments and the ongoing work of becoming a Singapore teacher

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A R T I C L E   I N F O

Available online xxxx

Keywords:
Virtual environments
Educational games
Constructivism

A B S T R A C T

The study explores the intersection between cyberinfrastructure and models of teacher education and professional development in Singapore. A case study explores how a pre-service and an in-service workshop in a virtual environment support efforts to understand and enlist constructivist pedagogies for classroom learning and to foster continuous teacher learning. The study involves a survey of participants' concerns and perceived challenges in light of prior experiences, to understand potential similarities and differences between current and future teachers. The results indicate complementary experiences between in-service and pre-service participants. Results also indicate the need for further inquiry into using virtual environments to support integrated models of professional development and teacher education.

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1. Introduction

There are many symptoms of a paradigm shift in schooling and educational research, particularly in the Asia-Pacific region. As one case in point, the recent formation of the World Educational Research Association (WERA) punctuates a longstanding progression towards a global collaborative education agenda (http://www.weraonline.org/). WERA includes 8 Asia-Pacific national education organizations amongst the 25 founding bodies. Such a collective can galvanize shared agendas towards high standards and comparability and, in turn, motivate collaborative contributions to open educational resources. In this way, organizing such an expansive network valorizes not only communication across disparate locales but also understanding the different, yet often complementary, viewpoints that necessarily underlie an integrated global educational research community. There is, in short, a logic in diversity that productively contributes to addressing the challenges of both schooling and education (e.g., Page, 2007). However, as with any beginning, it also entails concerted efforts to look at the symptoms already manifest in the Asia-Pacific region. To this end, a series of teacher workshops featuring an international educational platform and virtual environment called Quest Atlantis (QA) illustrates how individuals and organizations in Singapore are shaping the ongoing work of becoming a teacher.

The Quest Atlantis teacher workshops provide a lens for understanding one instantiation of a global education agenda like WERA because it lies at the intersections of teacher education and educational technology. Every next generation of teachers and pre-service participants. Results also indicate the need for further inquiry into using virtual environments to support integrated models of professional development and teacher education.

Asia-Pacific region, these crossroads are beginning to shape synergies that benefit learning both in and out of schools (e.g., Resnick, 1987). As one example, Cheng (2009) suggests that teacher education programs must leverage a confluence of global, local, and individual resources in order to maximize opportunities to learn. Coordinating and integrating Cheng’s three levels underscores the value of cyberinfrastructure such as broadband and mobile networks as well as social media and virtual environments. In fact, cyberinfrastructure increasingly constitutes one fulcrum for teacher education because it can reorganize boundaries within and across education communities, or simply dissolve boundaries altogether (Cheng, 2005; see also Zuiker, 2010a). In this way, it enables borderless access to open educational resources that catalyze not only Cheng’s (2005; 2009) global, local, and individual resources but also, by extension, shared goals in both the Asia-Pacific region and WERA. With the prospects of digitizing boundaries in mind, a case study of QA workshops in Singapore affords consideration of possible ways in which cyberinfrastructure can simultaneously contribute to a shared international agenda and customize a unique local strategy. It can also draw implications for teacher education and ongoing professional development in Singapore.

To these ends, the article is organized into seven sections. It presents a conceptual framework for considering cyberinfrastructure in education and in teacher education as an ongoing process. Against this backdrop, three sections serve to contextualize the research and the setting in which it was conducted by overviewing the idea of cyberinfrastructure, by presenting general research on teaching in Singapore, and by reviewing prior research on virtual environments in Singapore. Next, the article details the process of methodic inquiry enlisted to understand an in-service and a pre-service teacher QA workshop. The results section then provides descriptive, analytical, and interpretive findings that illuminate both the symptoms of a constructivist paradigm shift in the Asia-Pacific region as well as a
range of related challenges and concerns. Finally, the article concludes by drawing connections between the findings derived from these workshops and its implications for teacher education and cyberinfrastructure in Singapore, the Asia-Pacific region, and for global shareholders in cyberinfrastructure.

1.1. Research questions

This case study examines how in-service and pre-service teachers from Singapore explore the possibilities for constructivist pedagogy using virtual environments. The research questions include:

1. What relevant experiences do in- and pre-service participants bring to the workshop?
2. What challenges and concerns do in- and pre-service teachers raise about virtual environments and constructivist pedagogy?
3. What similarities and differences exist in the ways that in- and pre-service teachers interpret experiences with virtual environments during multi-day workshops?

2. Conceptual framework

This study is organized around the fundamental idea that teaching involves an ongoing process of learning to teach. When framed in this way, the process of becoming a teacher does not begin and end with pre-service teacher education nor turn on and off during in-service professional coursework. Instead, becoming a teacher involves a continuous cycle of reflective practice from moment to moment during a lesson, from week to week during a semester, and from year to year across the arc of one’s career. These different timescales communicate that cycles are not only ongoing but also progressive. In this way, teaching is not only certification or professional development, though both are important.

The idea of becoming reflects general views about learning to be a teacher or any professional. A profession entails the work of individuals but, importantly, the mutual efforts of all who participate in the practices of a profession, or what is often termed communities of practice (Wenger, 1998). Even more broadly, Dewey (1916) used the word becoming as a way to conceptualize a concerted developmental evolution in an individual’s relations to people, places, and things. Becoming connotes the experience of a changing self, of being somebody different or new. Such a lens applies to the work of becoming a teacher.

The general idea of becoming is a lens for understanding the ongoing, progressive work of learning to teach (e.g., Bullough, 1997). This work reveals that the process of becoming is far from a simple indoctrination into a community; rather it is an idiosyncratic process (Yee, 1990). It involves a complex and ongoing interplay between students and teachers, amongst established and emerging teachers, and across schooling institutions and a broader set of educational organizations (Lawson, 1992; Richardson & Placier, 2001). Therefore, it is fundamentally a social and cultural process as much as a cognitive one. Reflecting a broad, general views of social constructivist theories (e.g., Case, 1996), the idea of becoming assumes that it is difficult to separate what is in the head, on the one hand, and what the head is in, on the other hand (Cole, 1996). Conceptualizing a process of becoming as an ongoing social and cultural interplay therefore provides a framework for examining relations about Cheng’s (2009) global, local, and individual levels and, in particular, the interplay with people and the things that surround a teacher at any given point and the second considers how these three are woven into a teachers interactions and experience across time. The process of becoming a teacher involves interplay between these two aspects. That is, the set of people, places, and things that surround an individual teaching at a particular moment in time and the set that weave together the process of teaching across time together build, maintain, and at times, destroy the relations that constitute a process of becoming.

3. Cyberinfrastructure for teaching and learning

Complementing work in information and communication technologies, a wide range of interactive digital media supports teachers
in developing the relations between people, places and things that underlie a repertoire of practice (e.g., the “bugsscope” project above). Building on visions of cyberinfrastructure for science and engineering (Atkins et al., 2003), social sciences and the humanities (Courant et al., 2006), and education (Ainsworth, Honey, & Johnson, 2005; Borgman et al., 2008), it is important to consider how these burgeoning global resources can productively mediate what has historically remained an interplay between individual and local influences.

The Singapore government introduced a range of initiatives in the late 1990s to spur the growth and development of an increasingly interconnected and globalized nation. The InfoComm Development Authority was established to spearhead a national agenda for building a world-class knowledge economy including cyberinfrastructure. In education, aptly titled initiatives like Thinking Schools, Learning Nation and Teach Less, Learn More coalesced many of the pedagogical implications of this zeitgeist, promoting themes like diversified educational opportunities, innovative constructivist pedagogies, and a national culture of lifelong learning. These and a still unfolding succession of other initiatives both reflect shifting policy agendas and, in broad terms, systematic attempts to foster innovation in the everyday practices of schooling. Two among many consistent foci are the creation of technology spaces and open time for teachers to explore new agendas for learning. In effect, the intention of these initiatives is to foster generative conditions that can mobilize schools towards the goal of optimizing teaching and learning (Hogan et al., 2006, p. 18). It is against this backdrop that teachers and administrators have explored a range of possibilities for action.

With respect to networked technologies in Singapore, a growing media ecology of digital production tools and attendant user-generated content complements more established information and communication technologies, like presentation software, learning management systems, or digital libraries. The idea of an ecology, however, generally considers relationships and interdependence. In the case of interactive media, an ecological framework focuses on how the scale, persistence, and immediacy of digitally portable tools and resources can both drive and be driven by the social dynamics of people brought together by common interests.

In light of these initial insights about media ecologies, this article argues that cyberinfrastructure and its attendant participatory architectures can create both teaching and learning experiences within peer communities that reflect basic practices of constructivist teaching. This study begins to consider how this media ecology can support the work of teaching and the work of teacher education by understanding and comparing how pre- and in-service teachers appropriate virtual environments like QA.

Cyberinfrastructure organizes new pathways to participation and forges new relations, evolving social relations and interdependencies. Such relations may be fleeting or sustained but, either way, contribute to a social ecology, and these interrelations increasingly enable meaningful engagement around complex tools and both the challenge and problems they give rise to. The openness and portability of digital (problem) spaces increases the likelihood of finding people who share similar goals, particularly problem spaces organized around interests or affinities (Gee, 2005). Openness and portability also enable self-organization and diversity, which can be powerful resources for learning. However, understanding how these digital ecologies may be used to enhance the learning of teachers must also consider the unique constraints and affordances of cultural and social practices in Asia-Pacific countries.

Understanding the potential of using cyberinfrastructure to enhance both teaching and learning in schools, the Singapore Ministry of Education unveiled a progression of three masterplans over the last decade. Each plan is only another signpost in a rapid succession of policy initiatives intended to propel the education system forward through central planning and coordination. The rapid pace of technological change also means that Singapore’s policy initiatives are, at once, reactive and proactive. For example, they address the pressure on older generations to shift skill sets at the same time that they begin to take up the demand of younger generations for “hands on, minds on, plugged in” engagement (McWilliam, 2009, p. 286). Most relevant to this study, the most recent masterplan seeks to leverage information and communication technologies as well as interactive digital media in order to customize learning through self-directed and collaborative approaches.

These aims underscore that cyberinfrastructure can play an important role. However, they obviously entail more than wiring homes and schools or creating an island-wide internet cloud. It entails the embedment of these and other tools of cyberinfrastructure in the work of learning and teaching. Singapore’s three masterplans exemplify a concerted and planful effort to advance reflective practice and curriculum innovation while also recognizing the role of media and technology in knowledge economies. The full impact of these policies remains to be seen but decades of similar educational technology agendas have been met with skepticism and underscore the central role that teachers play in leveraging these resources (e.g., Cuban, 1986).

4. Lifelong learning and teacher education in Singapore

Despite inspiring policy initiatives, Singapore classroom communities retain many features and practices of transmission models of schooling. In order to explore and qualify these features and practices, this section focuses primarily on science and English teaching because QA is driven by a written narrative and emphasizes science, mathemetics, and language education.

In order to understand learning and teaching in Singapore, both macro- and micro-level research is detailed. To begin, an empirical, large-scale baseline study of pedagogical practices in Singapore schools suggests that English, mathematics, and science teaching remain grounded in basic knowledge transmission with infrequent forays into complex knowledge construction (Luke, Freebody, Lau, & Gopinathan, 2005). That is, observations of classroom social interaction revealed that many teachers tended to adopt one-way or monologic activities consistent with disseminating subject matter content, often limited to (and constrained by) the narrow scope of high-stakes examinations. Building on insights from these baseline studies, Kramer-Dahl et al. (2005) consider pedagogical tensions particular to English and Science. They note, for example, that relatively strong emphasis on the products of learning constrained English instruction and made extended writing fragmented. Meanwhile in science courses, a primary emphasis on textbooks was linked to consistent patterns of authoritative and didactic pedagogy and a general adherence to multiple-choice and short-answer worksheets. Similarly, Chen, Guo, and Sam’s (2006) analysis of transcripts from Singapore science classrooms reveals pedagogical structures that leave little flexibility for the dynamics of constructivist approaches. Altogether, these findings describe general patterns of monologic, transmission models of teaching and learning, but they do not pertain to all Singapore teachers.

In contrast to the broad strokes provided above, Chin’s (2007) case study of exemplary teachers argues that some kinds of teacher-centered practices can be effective constructivist tools in Singapore’s schools, even in the absence of any student-centered activities. Chin examines teacher-questioning techniques during whole-class activities in science classrooms. She reports several ways in which relatively linear, teacher-centered structures enable classrooms to realize some aims of constructivist pedagogy. Thus, teacher-centered instruction operated differently in these classrooms than Chen et al., (2006) study above. In examining a particular practice like teacher-questioning, Chin’s (2007) analysis reveals that different repertoires of practice give rise to different pedagogical structures. In sum, these micro-analytical cases resonate with macro-analytical findings presented by Luke et al. (2005) in that they illustrate how teachers, students, schools, and policy makers together collaboratively co-
construct learning and teaching in any particular classroom. Building on insights like these, more recent research considers the institutional conditions in which the work of becoming a teacher evolves and new possibilities for action emerge.

As one consideration of the learning opportunities that teachers navigate during in-service workshops, Albright et al. (2009) underscore longstanding tensions and policy shortcomings in support of lifelong learning amongst Singapore teachers. Teacher professional development intensified with the advent of Thinking Schools Learning Nation. For teachers, it encouraged research and innovation, emphasizing reflective practice and augmenting pedagogical repertoires. One key focus of these efforts is the general idea of group work. Rather than enlisting group work as a primary activity structure of student-centered learning, it often serves, instead, as a regulatory mechanism or a break from the routine of whole-class instruction. Other strategies for encouraging research and innovation encouraged through the policy are school-based action research projects and in-service workshops, both of which increased greatly. On average, teachers now complete 100-h of professional development activities annually, often including time spent on research projects. Nevertheless, familiar impediments remain.

Albright et al. (2009) identify three central challenges to teacher learning: lack of time, lack of coherence, and a failure to consider cultural norms. Teachers often struggle to secure time for meaningful learning or exploratory efforts. The centrality of high-stakes testing demands a broad focus on exam content. The opportunities to explore new resources or strategies remain ad hoc and therefore disparate, if not altogether incoherent. Teachers often select and combine professional development from a “buffet” of in-service workshops and sharing sessions. These “piecemeal” experiences lack degrees of coherence necessary to master complex pedagogies (Salleh, 2008) and, it follows, fail to synergize. Finally, the enduring influences of cultural norms and beliefs lead teachers to reject some resources or limit when and how they are enlisted. In response to these three tensions, Albright and colleagues recommend a more rational system of learning opportunities that synergize rather than either contradicting or competing with one another; sustained professional learning in teams can redistribute isolated parallel efforts into collaborative programs. Such an effort also entails distributing pedagogical leadership across teachers and schools. Finally, they point to the need for new assessment regimens aligned to the goals of teaching. Balancing external and internal systems of assessment can align teaching with evolving systemic pedagogical goals. In sum, the impediments and recommendations help to construct a deeper understanding of teacher learning in Singapore, and point to potential levers for sustainable lifelong teacher learning.

While teachers navigate the narrow boundaries of syllabus objectives, timetables, and policy initiatives, they must constantly survey “the pedagogical landscape for ways and means of bringing pleasure and rigor together” to their students (McWilliam, 2009, p. 291). Work with Quest Atlantis in Singapore schools provides one example where cyberinfrastructure begins to make these traditional barriers more porous. Therefore, the next section discusses research with virtual environments and QA.

5. Virtual environments in the Asia-Pacific region

Research involving virtual worlds remains underdeveloped but continues to grow rapidly. Over 180 virtual world projects were concurrently under development or in use in recent years (de Freitas, 2008). Meanwhile, Hew and Cheung’s (2010) review of publication databases using the keyword “virtual world” suggests that empirical studies lag far behind development. Their search generated a corpus of 455 articles but uncovered surprisingly few that feature empirical research. In fact, only three percent featured data of any kind, and just two of these fifteen considered populations outside North America or Europe. Complementary search terms (e.g., virtual environments, MUVE) yield additional empirical studies (e.g., Lim, Nonis, & Hedberg, 2006) but, regardless of the proportion of development to research, generating empirical research is perhaps more easily addressed than generating data from diverse settings. Therefore these summary statistics, more than anything else, call attention to the imperative and the potential to collaborate and compare designs, data, and ongoing development both within and beyond education systems.

Given the twin aims of generating empirical research and building linkages, Quest Atlantis (QA) serves as one example that is building evidence of its efficacy while also supporting international collaborations across five continents. At its core, QA attempts to foster meaningful contexts for learning and teaching (Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005) and organizes pathways for teachers to share and discuss how they enlist QA in their classrooms.

The design of QA environments such as the one in Fig. 1 arranges interactive sequences of activity called missions. Each mission organizes transactions among peers and with digital spaces that enable students to explore problems and improve the questions they ask about it. Consistent with general tenets of constructivist pedagogy, QA missions and larger units composed of multiple missions enlist inquiry-, problem-, and case-based strategies in order to create realistic, complex, and authentic play spaces. QA curricula share a common set of design principles including situative embodiment (Barab, Zuiker, et al., 2007) and transactional play (Barab et al., 2009). This article only briefly synthesizes ongoing collaborations with Singapore schools and the Ministry of Education’s Educational Technology Division in order to frame the teacher education study reported below.

Building on prior work in Singapore that enlisted earlier versions of QA (e.g., Lim et al., 2006), three partner schools used a QA science unit called Taiga. The missions in the Taiga unit were developed and refined through design studies conducted by Barab and colleagues in collaboration with US teachers and students (Barab, Sadler, Heiselt, Hickey, & Zuiker, 2007; Barab, Zuiker, et al., 2007). These studies generated statistically significant content learning gains on pre-post measures, warranting initial consideration in Singapore. To this end, pre-post data collected in each of four Singapore secondary school implementations generated statistically significant learning gains on multiple-choice content items (Zuiker, 2010b), replicating the US results. Further, the existing continuous assessment strategy at one partner school enabled a comparison of one class using Quest Atlantis with two other classes using ministry-approved textbooks. (All classes targeted the same objectives specified in the Ministry of Education’s geography syllabus). In this within-school, between-class comparison, the QA-based class outperformed the textbook-based classes on the geography department’s continuous assessment. Taken together, these findings are promising. At the same time, a complementary aspect of this work involved scrutinizing the opportunities to learn that arise when teachers and students engage a QA unit in Singapore classrooms. Interactional analyses (Jordan & Henderson, 1995) illuminated some productive episodes of peer and whole-class discussion but many more non-trivial challenges consistent with the findings of Luke et al. (2005) described above. Together, these changes exemplify how interactional dynamics shape and are shaped by both classroom communities and the resources they enlist in pursuit of their goals and objectives. The learning gains achieved in spite of these tensions motivated an expanded agenda that explores how to support teachers more directly by means of formal workshops, which is the subject of methodic analysis in this paper.

6. Methods

Two exploratory workshops were conducted with in-service and pre-service teachers respectively. This section therefore describes the workshop participants, format, and data as well as the analytical procedures enlisted to arrive at the results reported below.
6.1. Participants

For the in-service workshop, 11 primary and 15 secondary level teachers participated based on their interest and availability, constituting a convenience sample. All participants paid a workshop fee and received credit towards their annual professional development goals. For the pre-service workshop, 24 pre-service teachers who were enrolled in a twelve-month certification program participated as part of a required educational technology course. Focusing on these disparate teacher populations aims to increase variation in prior experiences with teaching and gaming.

6.2. Quest Atlantis workshop

The QA workshops were developed and designed by Indiana University. They blend a brief, expository walk-through presentation of QA's functionality and an extended, exploratory hands-on experience organized around a series of teacher missions. The missions focus on guiding principles such as balancing the content and context of a discipline and providing feedback on student work. Beyond the QA environment, the workshop also organizes discussions that provide a forum for exchanging ideas. Altogether, the walk-through presentation, teacher missions, and discussion activities enable participants to explore whether and how QA serves their goals and the expectations of Singapore stakeholders.

6.3. Data generation

The study generated both discrete data (e.g., surveys) and continuous data (e.g., digital recordings). Prior to the workshop, participants completed 13 open-response questionnaire items about their primary needs and goals for the workshop as well as their prior experiences with teaching (years of experience, subject area, and grade level) and videogames (frequency, genres, and complexity). During the workshop, participant observation provided a lens for documenting and discussing interactions between and with teachers. Discussion activities were video or audio recorded and subsequently transcribed in order to review and code utterances. These discussions additionally included focus group interviews organized by subject area. Questions targeted what participants would emphasize if they used the missions, what additional activities, if any, they would include, and how they might customize QA quests. During QA missions, all participants’ responses to multiple-choice and open-ended questions embedded in the QA missions were collected in a database. Between and after workshop sessions, the authors engaged in routine discussions in order to refine and expand handwritten fieldnotes into digital records. Finally, at the end of the workshop, in-service participants completed an evaluation survey with 18 Likert-scale items about the workshop and instructors roles.

6.4. Inquiry procedures

Consistent with methodic naturalistic inquiry (Lincoln & Guba, 1985), the authors’ progressively developed descriptions, analyses, and, at times, interpretations while engaging in reflexive practices such as negative case analysis in order to illuminate and temper subjectivities. After organizing and reviewing the data corpus, three stages of inquiry addressed the three research questions. Survey responses about prior experiences were tallied and descriptively summarized in order to understand general differences between the workshop populations (RQ 1). In order to document and characterize participants’ concerns, utterances from transcripts and written responses from questionnaire items were collected, numbered, and individually labeled by means of open coding. A recursive review of these codes built categories with internal homogeneity and external heterogeneity (Guba, 1978), arriving at an exhaustive list of participants’ concerns and challenges that were organized into themes (RQ2). At the same time, the interplay of convergence and divergence involved in building categories and sorting themes also generated deviant cases. These cases illuminate the tensions faced in constructing the categories and provide a basis for comparing the workshop groups based on the intended maximum variation of the populations (RQ3). The aim across this inquiry is to understand trajectories of participation in becoming teachers and to trace how
pre-service and in-service teachers appropriate virtual environments like QA. In the next section, these descriptions, analyses, and occasional interpretations are presented using descriptive statistics, themes in the coding, and illustrative episodes.

7. Results

This section employs the inquiry procedures detailed above to transform the raw data collected before and during the QA workshop into descriptions, analyses, and interpretations that address the three research questions presented at the outset of the article. It also briefly overviews both workshop experiences before addressing each research question in turn.

7.1. Workshop implementations

This sub-section details how the workshop was customized and the resources were enhanced to better adapt to the needs and demands of Singapore participants. It also briefly overviews how each workshop generally unfolded.

7.1.1. In-service teacher workshop

The in-service participants and QA workshop facilitators enacted the intended workshop design with only one minor change. Based on feedback from the pre-workshop survey, the authors mapped the featured QA math, science, and English curricula to the respective Singapore subject area syllabus objectives then distributed the document to all participants in advance. Apart from providing these additional materials, the workshop unfolded normally and as planned, generally reflecting the intended design. Participants developed perspective through actual gameplay and discussed their interpretations in small groups with other teachers in the same subject area as well as during whole group presentations. Although most were unfamiliar with virtual environments or videogames, only modest disparities in progress were ever apparent as participants worked to complete the QA teacher missions. When confusion arose, a neighbor usually resolved any uncertainty. At the close of the workshop, participants reported positive experiences and, in particular, that they valued both hands-on interactivity and working in disciplinary groups. While the pre-service workshop generated similar feedback, it entailed a more substantive revision to the workshop design.

7.1.2. Pre-service teacher workshop

The pre-service workshop served as a module in a mandatory educational technology course taught by the author (Zuiker). The flexible design of the course enabled students to vote for three modules from among twelve options and QA was among the top three. In order to fit the course schedule, the QA workshop was divided into three separate two-hour sessions. In addition to the three sessions, pre-service teachers completed assignments between each session, totaling approximately 10–12 h. All 24 participants completed the introductory missions and three-quarters completed at least one discipline-based mission. In the interest of time, the four focus group interview questions featured in the in-service workshop were integrated into whole class presentations. Much like the in-service workshop, participants gained perspective but with general differences in international dynamics. Specifically, there was infrequent discussion but cascading episodes of laughter sparked by online chat. Otherwise, like the in-service workshop, the participants progressed through the missions as expected and shared positive reflections on the experience at its close. Together, these implementation overviews underscore that participants meaningfully engaged the presentations, QA missions, and group discussions. These workshop experiences provide a foundation on which to consider how Singapore teachers explore and interpret resources for constructivist teaching such as QA, beginning with the prior experiences of participants to which the workshop inevitably must connect.

7.2. Prior experiences with teaching and videogames

The first research question considers participants’ prior experiences, focusing on the two most relevant aspects of the workshops: teaching in classrooms and playing videogames. 20 in-service participants completed the pre-workshop questionnaire (77% response rate). With a mean of ten years teaching experience, the data underscore the diversity of classroom experiences in Singapore math, science, and English classrooms at primary and secondary levels. In contrast, only three participants (15%) indicated that they play videogames. Asked to elaborate on the kinds of games they play, two indicated relatively complex games and one indicated more casual games only (e.g., Preskyn, 2005). Similarly, 20 pre-service teachers completed the questionnaire (83% response rate). While they have no teaching experience in Singapore classrooms, thirteen (65%) indicated that they play videogames; ten indicated that they played casual games only, and three indicated that they played complex games as well. These responses constitute a general comparison of prior experiences in teaching (10 years versus 0 year experience) and playing videogames (15% versus 65% play experience). The differences only suggest a general pattern about each group’s prior experiences, but reflect a prevailing discourse about growing up digital (Tapscott, 1999; Brown, 2000). More importantly, with respect to the conceptual framework of this study, the comparison serves to highlight the inevitably different but equally relevant opportunities that participants have had and can draw upon during the workshop. In other words, the same workshop engages groups at different developmental points along trajectories of becoming a teacher and these contrasting trajectories and associated repertoires of practice can lend insight to the concerns, challenges, and opportunities that surface for Singapore teachers. It is against this backdrop that the participants’ workshop experiences are now considered.

7.3. Common concerns across workshops

Research on Singapore classroom teaching reported above suggests that many teachers remain focused on transmission models of instruction. Constructivist models like QA therefore present new risks for teachers and students alike. The QA virtual environment provides structures to help manage the non-linearity, and perhaps also the uncertainty, associated with student-centered instruction. Given the general background in Singapore and the unique possibilities that virtual environments like QA present, it is important to understand the concerns and perceived challenges as they relate to teacher education and professional development, as framed by the second research question. Participant comments during the workshop and questionnaire responses beforehand generated a set of concerns about using QA in Singapore classrooms. Table 1 presents an exhaustive list. Importantly, the list reflects both in-service and pre-service teachers as their comments both reflect these common categories. The table also features selected participant comments that both illustrate each category and three general themes that organize the categories. The table presents eight common categories that communicate teachers’ concerns about three general themes: fit, efficacy, and friction. The first theme, fit, addresses a confluence of concerns that communicate a focus on the suitability of QA for their schools. Participants raised wide-ranging concerns about how QA experiences can be integrated into school timetables and departmental curriculum planning (i.e., scheduling) and into the national syllabi to which the school is accountable (i.e., curricular alignment). Both groups also wondered how they might tailor QA quests, missions, and units in

Please cite this article as: Zuiker, S.J., & Ang, D., Virtual environments and the ongoing work of becoming a Singapore teacher, Internet and Higher Education (2010), doi:10.1016/j.iheduc.2010.05.006
order to enhance alignment with their institution and education system (i.e., customization). The second theme, efficacy, reflects participants concerns about the benefits of using QA. Participants raised primary questions about student comprehension and the readability of QA’s narrative-driven units; presuming comprehension, secondary questions about whether or not the complexity of QA activities and ideas were developmentally appropriate also surfaced. Participants in both workshops also formulated evaluation-oriented questions such as what underlying mechanisms make virtual environments educational, and not simply entertaining, and whether or not QA could achieve either its intended aims or teachers’ goals in the Singapore context. Lastly, the third theme, friction, brings together the range of perceived impediments associated with enlisting virtual environments in Singapore schools. Teachers expressed basic concerns about the software and services necessary to use virtual environments, emphasizing the barriers associated with mastering technical details, managing equipment, and mitigating limited internet bandwidth in Singapore schools. Altogether, eight total categories reflect both survey responses and workshop utterances that collapsed into these three themes, generating an exhaustive list of the concerns raised by in-service and pre-service participants alike as expressed through survey and discussions.

The analysis of participants’ written and spoken comments appears incongruent with their prior experiences in important ways. At the level of whole groups, for example, the differences in prior experiences reported above would suggest different group-level perspectives; however, each category reflects comments in both workshops. That is, regardless of the amount of teaching or gaming experience, each group collectively constructed a relatively comparable set of concerns. On the one hand, the fact that all but one participant are Singapore citizens who studied in local schools provide a common foundation that accounts for some of these similarities. On the other hand, it is noteworthy that the benefit of teaching experience did not generate fundamentally different kinds of concerns. Meanwhile, at the level of individual participants, a subset of comments from pre-service participants only ambiguously fit the categories and themes in Table 1. These comments represent deviant cases beyond those detailed above. Therefore, the next section complements the descriptive and analytic accounts in this section with a cautious interpretive account of deviant cases beyond the eight categories listed. However, in sum, these themes and categories underscore that both workshop groups generated relevant concerns and productive insights into the relationship between teaching and learning with virtual environments in Singapore.

### 7.4. Unique concerns within workshops

The third research question considers similarities and differences in the ways that pre- and in-service teachers interpret experiences with educational games during multi-day workshop experiences. Methodologically, the interplay involved in working to converge coded comments into possible patterns and diverge these patterns of sorted codes into distinct categories involves subjective decisions. While an exhaustive list of concerns and challenges emerged, it necessarily remains an incomplete account, providing only partial perspective on participants concerns and challenges. The deviant cases discussed in this section serve as unique or uncommon concerns that communicate the tensions involved in arriving at Table 1, and further illuminate the broader webs of significance in which these concerns ultimately reside.

Two deviant instances described below illustrate a depth of analysis that surfaced only in the pre-service workshop. They did not necessarily resonate with the categories constructed from the data in the section above but do resonate with a broader pattern in the literature. To begin, the first deviant case did not relate to any of the categories or themes because it was the only comment to incorporate a clear and specific pedagogical link. In considering the missions she just completed, a pre-service teacher interprets QA in terms of student motivation in the following way. “I think it promotes self-directed learning where [students] want to finish the mission. I mean I wanted to finish the mission before I shut it down so it promotes self-directed learning.” The idea of wanting to finish frames the missions in terms of an intrinsic interest or engagement, and highlights how it can be a resource for constructivist pedagogy. It also makes a direct connection to a broad course theme on individual agency, intrinsic motivation, and self-directed learning. The absence of pedagogical comments comparable to this one begs questions about the lens through which participants considered the possibilities for QA in their classrooms. On one level, the participants implied a pragmatic pedagogical lens by expressing interest in efficient curricula that effectively address syllabus objectives. Beyond this, the basis of their critiques was not easy to understand, making this kind of explicit pedagogical link exceptional.

As a second deviant case, the next comment proved difficult to categorize as a remark about the theme of efficiency in Table 1. “I think the introduction part leading to the actual task is quite lengthy. And having to navigate around was a bit of a chore. Not sure what’s the intention of that.” The quote begins with a typical efficiency comment concerning, in this instance, the proportion of time invested in the initial experiences in the mission relative to the completion of a written task. However, the second sentence recasts these concerns in terms of the QA designers’ intentions. That is, “the intention of that” suggests a view of QA from the vantage point of a designer. By considering the set of possible aims, and therein the purpose of the introductory missions, these comments may be less about efficiency and more about critical assessment of the mission’s design. Insofar as this is the case, such a comment constitutes a noteworthy exception in the workshop discourse. It introduces a provocative perspective for the individual and group alike, sometimes called design thinking. According to Gee (2007), design thinking considers how parts fit together into a whole under both internal and external constraints. Internal constraints include what is in the designed system. External constraints consider what that system is in (e.g., users, social systems, institutions, and the world). In this excerpt, the participant relates the

<table>
<thead>
<tr>
<th>Theme</th>
<th>Category</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fit</td>
<td>Scheduling</td>
<td>The time needed for carrying it out may eat into the already limited curriculum time.</td>
</tr>
<tr>
<td></td>
<td>Curricular alignment</td>
<td>Not sure how to incorporate the activity with the curriculum.</td>
</tr>
<tr>
<td></td>
<td>QA customization</td>
<td>Training of teachers for crafting of tasks.</td>
</tr>
<tr>
<td>Efficacy</td>
<td>Comprehension/</td>
<td>How instructions or the programme can be tweaked to cater to Normal Technical students who are not so strong in their command of the</td>
</tr>
<tr>
<td></td>
<td>readability</td>
<td>English language</td>
</tr>
<tr>
<td></td>
<td>Developmental alignment</td>
<td>Level of difficulty of content areas for students.</td>
</tr>
<tr>
<td></td>
<td>Evaluation</td>
<td>How are the students going to cope with the concepts — the real concepts of the topic?</td>
</tr>
<tr>
<td>Friction</td>
<td>Technology barriers</td>
<td>Not familiar with the operation of the software and the navigation</td>
</tr>
<tr>
<td></td>
<td>Infrastructure barriers</td>
<td>IT specifications, infrastructure required to run the software, booking of computer labs</td>
</tr>
</tbody>
</table>

Please cite this article as: Zuiker, S.J. & Ang, D. Virtual environments and the ongoing work of becoming a Singapore teacher, Internet and Higher Education (2010), doi:10.1016/j.iheduc.2010.05.006
purpose of the introduction and learning task to one another in order to express confusion about the intention or strategy underlying the design. In this way, thinking about QA in terms of design reflects a critical literacy for the speaker. It may also provoke reflection amongst his classmates about the intended design of their shared QA experiences. In relation to the first deviant case concerning a pedagogical link to motivation, this second deviant, albeit ambiguous, case may highlight a similar depth of analysis in relation to design and, ultimately, its relationship to pedagogy. Infrequent and incongruent with the categories, comments such as these suggest a deeper understanding of the virtual environments than do other comments in the categories above.

Comparing the complementary and contrasting perspectives the participants shared in the preceding sections begins to characterize repertoires of practice amongst these groups of pre- and in-service teachers while also highlighting the constraints and affordances of the QA environments in the context of Singapore schools. While these concerns did not resonate with prior experiences in the ways the broader literature suggests, these findings nevertheless underscore that repertoires of practice reflect the opportunities to learn available to individuals. At the same time, these findings do not imply that one or the other group is more capable or competent, but rather that practices evolve with unfolding experiences and the process of becoming a teacher. On the basis of these qualified results, the next section draws conclusions about the two QA workshops and the guiding questions of this inquiry.

8. Discussion and conclusions

This article develops a case study of descriptions, analyses, and interpretations about two teacher workshops. Conducted in Singapore utilizing the QA virtual environment, the study provides insight at the intersections of cyberinfrastructure and constructivist pedagogy among both established and emerging Singapore teachers. In general, observations indicate that participants found the workshops useful and productive. However, the major focus of this study considered the perceived obstacles and the attendant concerns that participants shared with one another and the facilitators. This section therefore details tentative conclusions based on the cases presented, qualifies these conclusions based on the inherent limitations of the data collected and the analytical procedures enlisted, then closes with a discussion of the contributions this case study makes to teacher education research in Singapore, the Asia-Pacific region, and global shareholders in a cyberinfrastructure.

The results reported generate several summary conclusions. To begin, a comparison of prior experiences among the pre-service and in-service workshop participants revealed basic differences in the amount of experience each group has had teaching in classrooms and playing videogames. And yet, despite these disparities, their commentary before and during the workshop, both in written and spoken form, reflect a common, if not shared, set of perceived challenges and concerns. These commonalities are detailed across eight categories that establish three general themes associated with enlisting virtual environments in Singapore classrooms, namely fit, efficacy, and friction. The fact that disparate prior experiences between workshop groups generate a common perspective about workshop experiences is at once a seeming incongruence and a noteworthy observation. It begs questions about the relative influence of each group’s prior experiences and perhaps also relationships between teaching, gaming, and constructivist pedagogy. Are virtual environments constructivist resources embedded in the fabric of schooling? If so, years of teaching experiences should provide critical insights. Is learning a constructivist process enmeshed in the grid of cyberinfrastructure? If so, videogaming experiences should provide critical insights too. Such a polarization belies a productive tension at the intersections of teaching, teacher education, and cyberinfrastructure.

These descriptive and analytical results do not clearly resolve this interplay and it therefore remains an open question, but one that the interpretive results of this study further hone.

Complementing the analysis, interpretations of ambiguous comments communicate the process of analyzing teacher perspectives in terms of a methodological tension. A coding process that establishes common perspectives also necessarily qualifies them in terms of deviant cases. In general, this small set of cases reflects the indeterminacy in reducing complex social interactions to codes, and an inescapable tension between foregrounding and backgrounding aspects of a phenomenon. Meanwhile, interpretations of two unassignable cases indicate uncommon but equally noteworthy aspects of the study. Each case illustrates ways in which pre-service teachers, in particular, link the QA workshop experiences to pedagogical and design perspectives associated with constructivist principles, intimating an uncommon depth of analysis. While infrequent and ambiguous, these deviant cases nevertheless suggest both possible distinctions between groups and a potentially synergistic foundation. However, before looking forward to future work, it is important to first recognize the limitations of this study.

As with any preliminary case study, conclusions remain tentative. Many questions linger as Singapore teachers explore and evaluate curricula to achieve both efficiency and effectiveness. Short-answer questions about prior experience, for example, are convenient but limiting, highlighting only basic differences between pre- and in-service teachers. Even a more extensive survey would only provide broad, general contrasts in participants’ prior experiences. More complex, long-term studies are necessary to resolve whether and how accelerating technological transformations uniquely inspire, enable, and empower one generation relative to the next (e.g., Tappscott, 2009); and corresponding research must consider how such transformations can mediate the various professionals engaged in an ongoing process of becoming a teacher. The study also remains tentative because the naturalistic setting in which data were collected constitutes an imperfect trade-off between isolating influences and preserving real-world conditions. The authentic environments and social settings of a professional development workshop influence which topics surface and which ones remain unstated. Ultimately the setting also shapes the ways that participants choose to formulate their ideas. The congruence between questionnaire responses and workshop discourse constitutes a form of data triangulation that bolsters the trustworthiness of the categories and themes emerging from participant comments, but the data remain a partial perspective. Two complementary lines of inquiry may serve to further triangulate this partial perspective. First, it is critical to understand why and how participants enlist the workshop experience to enact QA in their classrooms, or to understand why they choose not to do so. Second, it is important to understand key aspects of the unique media ecology that Singaporeans produce and consume. Characterizing the educational landscape in light of this ecology provides a backdrop against which to understand workshop concerns more deeply. Recognizing these limitations and the need for further research, this section now closes with a forward-looking discussion of how this case study contributes to teacher education in the Asia-Pacific region.

Case study research can be a powerful resource in the social sciences (Flyvbjerg, 2001), but its contributions depend on the substantive significance of the findings. On one level, significance inevitably depends on a reader’s judgment. To this end, the article methodically builds evidence by linking the data generated before and during the workshop with the descriptive, analytical, and interpretive results constructed during and after the workshop. On another level, substantive significance depends on whether or not the study provides a deeper understanding of teacher education in Singapore or the Asia-Pacific region, whether or not it can help guide ongoing inquiry, and whether or not it resonates with prior research and ongoing work being conducted. It is these three aspects that are the focus of this discussion.
This case study highlights a set of common concerns shared by current and future teachers that illuminate teacher education and professional development in Singapore. First, these cases reveal that contrasting prior experiences with teaching and gaming still lead to a shared understanding. Second, it is reasonable to assume that such convergence is, in part, a symptom of a highly organized education system that communicates clear goals. These shared understandings can be a powerful resource for teacher education and professional development alike. Of course, thirdly, these commonalities across workshops reflect longstanding local challenges that teachers face in adopting innovative practices and tools for classroom teaching. Ambitious syllabi and policy agendas in Singapore often challenge students and teachers alike to manage the opportunity cost of departures from established routines. The common concerns that surfaced in these workshops underscore systemic pressures associated with these syllabi and policies to weigh the benefits of longer, deeper coverage of only a subset of topics against the attendant relative impact on high-stakes national exams. In sum, these points relate the above results to the broader workings of the Singapore education system, but they also signal avenues for related future studies.

The substantive significance of the study also lies in opportunities for ongoing inquiry. That pre- and in-service teacher comments are actually quite similar blurs discrete boundaries between teacher education and professional development in Singapore. Complementary perspectives, in general, are a foundation for the mutual exchange of experiences. This study therefore raises questions about whether it is more productive to sequester pre- and in-service teachers or to leverage their shared understandings in order to foster an interdependent relationship. Pedagogical innovations involve practices that develop over time. These practices build on repertoires that precede a degree program or professional workshop but also demand sustained effort after a degree is awarded or a workshop is completed. In this way, the study provides a foundation on which to explore an integrated approach for supporting the work of becoming a teacher that leverages virtual environments, and perhaps other aspects of cyberinfrastructure. In other words, while the results certainly do not validate a model of professional development or teacher education, they do suggest a productive interplay between these models.

Based on these insights, models of reciprocal apprenticeship represent one opportunity for ongoing inquiry into integrated models of professional development or teacher education. Both the asymmetries in expertise and the shared understandings across workshops in this study are necessary to foster such a model. In-service teachers bring classroom experiences to a novel learning environment while many pre-service teachers bring gaming experiences to novel pedagogical aims. In general, an apprenticeship is reciprocal when a mutual exchange of ideas is organized around shared goals in a common problem space. In this case, an exchange of ideas about constructivist pedagogy can be organized around the interrogation of tools and resources related to virtual environments. The deviant cases presented, in particular, exemplify the kinds of discourse-based interaction that constitute productive exchanges. Such comments help to manage challenges and concerns associated with virtual environments while also illuminating a deeper pedagogical structure. These insights resonate with earlier theoretical conjectures in teacher education (Smith, 1981), in prior studies of reciprocal apprenticeships between pre- and in-service teachers (Stuve, 2003), and in research with virtual environments and videogames (Steinkuehler, 2006). The ongoing work of becoming a teacher involves the provocation that emerging and established professionals offer one another and therefore may provide a new resource in this shared work. After all, the vitality and challenge of teaching lies in engaging and evolving cultural goals, social dynamics, and supporting tools. On an individual level, such phenomena are already familiar such as when pre-service teachers work as change agents during practicum experiences (e.g., Adams & Tulasiewicz, 1995). On a more collective level, these conditions and mechanisms reflect a broader pattern of cultural change that Tomasello (1999) describes in terms of a ratchet effect. Ratcheting culture communicates a shift in one aspect of practice, and how that shift depends upon stability in its relations to other practices. In a reciprocal apprenticeship, what shifts and what remains stable may differ based on prior experiences and repertoires of practice. In Singapore, such an agenda resonates with the recommendations that Albright et al. (2009) offer for enhancing teacher professional development. That is, by organizing teaching teams with a diversity of experiences and repertoires of practice, the ongoing work of becoming a teacher can tap on larger professional networks, provide opportunities to co-plan, support richer and more varied exploration, and organize backchannels for informal sharing. Together with the preceding paragraphs, these points underscore the substantive significance of this article in terms of its insights into teacher education in Singapore as well as its connections to prior and ongoing research.

In conclusion, it is worthwhile to return to the idea of becoming that organizes the conceptual framework for this study. In considering the broader context in which Dewey’s (1916) notion of becoming operates in his writing, it is noteworthy that he envisioned schools not as separate or sequestered but as working towards creating social systems across institutions (Shulman & Quinlan, 1996). Whether and how enlisting cyberinfrastructure to expand and extend participation in ecologies of teacher learning remains an open question. This case study does not validate an approach to lifelong learning for teachers but rather builds a plausible argument for extending research into whether and how virtual environments can integrate teacher education and teacher professional development to support constructivist pedagogy. The digital architecture of cyberinfrastructure emphasized in this study, however, can only help or hinder interplay among generations of teachers. Alone it does not drive productive interplay; rather, it is individual teachers working together and, more broadly, organizations like a World Education Research Association that achieve these ends.

Acknowledgements

We thank the teachers who worked with us as well as Sasha Barab, Bronwyn Stuckey, Donna Stevens, and Anna Arici among others who developed the Quest Atlantis professional development missions; Melissa Gresalfi who co-organized the in-service teacher workshop; and both Jooy Koh and Jane Ross who provided support in Singapore and the United States respectively. This research was funded by grant RFP02-08SZ17 from the Office of Educational Research at the National Institute of Education, Singapore.

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