

Understanding and Profiling Teachers' Technological Pedagogical Content Knowledge Development Patterns

Joyce Hwee Ling Koh, Chai Ching Sing and Tay Lee Yong

THIS STUDY EXAMINES how Singapore teachers develop TPACK in course-based and school-based contexts. The findings indicate that teachers enter ICT courses with different levels of confidence in TPACK and multiple design opportunities during ICT courses are effective for levelling up teachers' ICT design competencies. This is especially useful for teachers who were less confident in their TPACK when beginning the course. In a school-based context, Cultural/Institutional factors can potentially divert teachers away from extensive discussion of TPACK during lesson design. The presence of agendas and facilitation of design talk by teachers who are experienced educational technologies can deepen the discussion of TPACK.

INTRODUCTION

Technological Pedagogical Content Knowledge (TPACK) describes teachers' knowledge for Information and Communication Technology (ICT) integration. TPACK has been widely adopted as a knowledge framework to plan ICT curriculums for teacher education. Yet, to date, very little is understood about how teachers develop TPACK through ICT courses as well as in school-based ICT innovation contexts. This study seeks to describe how teachers develop TPACK as well as the teacher demographics and contextual factors that may influence teachers' TPACK development. The purposes of this study are to:

- Examine how Singapore pre- and in-service teachers develop TPACK through pre-service and graduate ICT courses, and draw implications for the planning of ICT courses to develop TPACK in teachers; and
- Examine how teachers develop TPACK through participation in

KEY IMPLICATIONS

- Future IT Masterplans need to pay more attention to teacher development in the areas of Teachers' Content Knowledge, Teachers' Pedagogical Knowledge, and TPACK.
- Teacher engagement in multiple design cycles can help them develop TPACK in ICT courses.
- Agenda setting and appointment of experienced facilitators can improve TPACK development through ICT lesson design teams. Teacher professional development through facilitation of design talk is needed.

school-based ICT innovation projects, and draw implications for mentoring and facilitating school-based ICT innovation projects.

RESEARCH DESIGN

Mishra and Koehler (2006) characterized TPACK as teachers' combination of their technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK) to formulate intermediate forms of knowledge—pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and TPACK. These seven kinds of teacher knowledge make up the TPACK framework. Previous TPACK studies have found that teacher involvement in design can help teachers develop TPACK as the design problem helps them to make connections between technology, pedagogy and content (Koehler, Mishra, & Yahya, 2007). Koh and Divaharan (2011) found that pre-service teachers developed TK before they developed TPK. Survey studies have found that teachers showed significant improvement in TPACK perceptions after attending ICT courses (e.g., Chai, Koh, & Tsai, 2010; Graham, Burgoyne, Cantrell, Smith, St. Clair, & Harris, 2009) but specific patterns in their TPACK development have not yet been identified. This study seeks to address this gap because without a concrete understanding of teachers' TPACK development patterns, it is difficult to plan how to enhance teachers' TPACK when designing ICT courses (Cox & Graham, 2009).

Data was collected between April 2011 and December 2012. Teachers' TPACK development in a course-based context was examined through pre- and post-course TPACK surveys administered in both pre- and in-service teacher education programmes. Pre-service teachers' data were collected from 109 teachers attending a compulsory ICT course during their teacher education programme. Data from in-service teachers were collected from 102 teachers who were attending the ICT Mentor Programme conducted by the Ministry of Education (MOE). In both courses, a design-driven pedagogy was applied in which teachers learnt ICT integration strategies through engagement in multiple cycles of design and redesign of ICT lessons. Using teachers' ratings of TPACK constructs as well as expert ratings of their lesson plans (pre-service teachers only), cluster analysis was carried out to profile teachers' TPACK development.

Teachers' TPACK development in a school-based setting was examined through the whitespace discussions of 22 teachers from Beacon Primary

School who were working in 9 level-based design teams. (Whitespace refers to time and space specially allocated to exploration of new ideas and learning.) Audio recordings of 21 whitespace discussions (16 hrs and 11 mins) were collected and analysed by two coders using content analysis. Inter-rater reliability was established through the two coders negotiating inconsistencies until an overall Cohen's kappa of at least 0.80 was derived for all coding categories. The frequency counts of the categories coded were subjected to chi-square analysis, and the results verified through qualitative thematic analysis. Focus group discussions with five teachers were also carried out to triangulate the data collected from the whitespace discussions.

KEY FINDINGS

TPACK development through ICT courses

1. From the pre-course survey, two clusters of pre-service teachers were identified. Cluster 1 teachers were more confident in all seven aspects of their TPACK than Cluster 2 teachers, but there were no differences between Cluster 1 and Cluster 2 teachers by age or gender. By the end of the ICT course, Cluster 1 teachers showed significant positive change in their confidence for TCK and TPACK whereas Cluster 2 teachers showed significant positive differences in all aspects of their TPACK. Large effect sizes were obtained in the technology-related constructs of TCK, TPK, and TPACK. To assess the teachers' enacted TPACK, a TPACK assessment rubric, drawn with the guidance of the pedagogical approaches of constructivist-based Dimensions of Meaningful Learning designed by Howland, Jonassen, & Marra (2012), was validated (see Koh, 2013). This assessment rubric was used to rate the lesson plans designed by pre-service teachers during the ICT course. No significant differences were found between the two clusters.
2. For the in-service teachers, two clusters were also found. Cluster 1 teachers were more confident in their pre-course ratings of TK, PK, TCK, TPK, and TPACK than Cluster 2 teachers. There were no significant differences in their CK, PCK, age, gender, or years in service. After attending the ICT Mentor course, Cluster 1 teachers showed significant positive change only in TPACK. In comparison, Cluster 2 teachers showed significant positive change in

the technology-related aspects of their TPACK (i.e., TK, TCK, TPK, and TPACK). There were no significant differences in their PK, CK and PCK.

TPACK development in school-based context:

3. In a school context, the teachers' discussion of lesson planning centred on Cultural/Institutional factors including logistical issues such as the scheduling and organizing of class tests, show-and-tell sessions, and field trips (65.5% of discussion units coded). The other contextual factors that emerged were categorized as Intrapersonal (comments about teachers' personal beliefs about teaching, learning, students or themselves as teachers), Interpersonal (comments about interactions with colleagues or stakeholders) and Physical/Technological (comments about school's hardware, software or access to technology). These factors comprised only about 5% of the units coded. The rest of the coded discussion units were related to the seven TPACK constructs, involving issues pertaining to content, pedagogy, and technology use.
4. Chi-square analysis of frequencies of discussion units uncovered five profiles among the design teams:
 - a. Contextual Focused—Three teams where positive standardized residuals that are above expected were derived for only contextual factors. When teams focused primarily on Cultural/Institutional factors, the emergence of TPACK was stymied, whereas teams that focused on the other contextual factors showed a more balanced representation of TPK and TCK in their discussion.
 - b. Contextual and Pedagogical (Non-ICT)—Two teams, where positive standardized residuals were above expected, were derived for both contextual and TPK. These teams moved between the discussion of contextual issues related to their lessons and pedagogical strategies for improving upcoming lessons. However, the pedagogical strategies did not feature extensive consideration of ICT as the standardized residuals for TPACK were below expected.
 - c. Contextual and Pedagogical (ICT)—Two teams with positive standardized residuals

that were above expected in both contextual factors and TPACK. These teams were able to effectively manage talk on Cultural/Institutional issues so as to prevent these issues from dominating discussions of ICT integration. They achieved this largely through adhering to pre-planned specific agendas to focus their whitespace discussions on ICT integration.

- d. Pedagogical (Non-ICT)—One team showed a profile featuring more attention to PK and PCK rather than contextual factors. This team not only optimized their whitespace discussion to focus on pedagogical issues, it was also able to integrate consideration of ICT strategies into their discussion of pedagogy.
 - e. Pedagogical (ICT)—One team's profile showed engagement in comprehensive discussion of pedagogical issues including TK, PK, CK, PCK, TPK, and TPACK. The discussions in this team were facilitated by a Head of Department who was an experienced educational technologist.
5. Content analysis of teacher interviews revealed that teams showing stronger evidence of emerging TPACK typically had a mixture of young and older teachers, as well as experienced and less experienced teachers. These kinds of team dynamics allowed for the cross-fertilization of ideas. Younger teachers were perceived to be keener in trying out technology, but the experienced teachers were richer in PCK and could point out potential problems with the implementation of ideas using technology. Given the advantage of a mix of age and experience, the development of TPACK in a team context may be difficult for subjects such as Tamil Language where the pool of teachers in a school is usually small. Age level of students was also perceived as a limiting factor as teachers felt that planning lesson for younger students involved more logistical considerations.

IMPLICATIONS

For Policy

With the implementation of the IT Masterplans in Singapore, student teachers are increasingly improving in their ICT competencies. This is reflected in the study results, which show that pre- and in-service teachers in both clusters did not differ in ICT

competency in terms of age and gender. Yet at the point of entry into ICT courses, there were differences in teachers' TPACK perceptions for the factors of TCK, TPK and TPACK. Future IT Masterplans need to pay more attention to teacher development in these areas. In a school-based context, administrative and logistical issues were Cultural/Institutional barriers that appear to curtail opportunities for teachers to discuss their design of technology-integrated lessons. Opportunities for teachers to enact TPACK within Cultural/Institutional, Physical/Technological, Intrapersonal, and Interpersonal contexts can be spelt out. This would enable schools to plan how time dedicated to pedagogical improvement can be integrated into the school's systems.

For Practice

Comparison of design teams by the kinds of TPACK generated found that teams who set up specific agendas related to ICT integration in their whitespace discussions were better able to have higher-than-expected occurrences of TPACK. The same result was observed in teams led by experienced educational technologists as facilitators. These practices of organizing the discussion of ICT design teams in school-based environments can be adopted in schools.

For Teacher Training

The method of multiple design cycles, already implemented within NIE's ICT course and MOE's ICT Mentor courses, appears to have an impact on developing teachers' TPACK and raising teachers' capacity for ICT lesson planning. It is a strategy especially useful for teachers in Cluster 2 who were less confident at the beginning of ICT courses than teachers in Cluster 1 in most aspects of TPACK. Within the school context, teachers' capacity for designing technology integration is evidenced in how they circumvent the barriers of administrative duties, exploit available technology tools and the school's resources to create opportunities for TPACK enactment. Further teacher professional development can be achieved by facilitating teachers' talk about design to generate more meaningful discussion of TPACK.

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ABOUT THE AUTHORS

Joyce Hwee Ling KOH and Ching Sing CHAI are with the National Institute of Education, Nanyang Technological University, Singapore. Lee Yong TAY is with Beacon Primary School, Singapore

Contact Joyce Koh at joyce.koh@nie.edu.sg for more information about the project.

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