The Effect of Pre-Service Teacher's Knowledge-Building Activities on Their TPACK Knowledge and Design Belief

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Abstract: This study examines how pre-service teacher's knowledge building activities are related with their technological pedagogical content knowledge (TPACK) and design belief. The data sources included (1) pre-service teachers' online knowledge building activities to discuss and then create a web-based course interface in Knowledge Forum; and (2) the pre- and post-survey using two questionnaires--i.e., TPACK and design belief of teacher (DBT). Using a behavioral sequential analysis, it is found that participants' online knowledge-building activities to create a web-based course interface started from a more divergent process and then moved to a more convergent process. It was also found there was a significant difference in the pre-post change of participants' TPACK ($t=13.692$, $p<.05$) and DBT ($t=9.647$, $p<.05$). Overall, knowledge building activities seem to be conducive to enhancing participants' TPACK knowledge and design beliefs.

Introduction

The rapid technology development in a knowledge society has brought dynamic change in education. Many countries have now attempted to help their students learn with enhanced technologies for developing 21st century skills (e.g., innovative, creative, and design skills). Specifically design capacity to integrate technology-related knowledge for solving real-world problems has become critical for students to success in the future. Accordingly, many inter-disciplinary subjects (e.g., STEM or STEAM) also require student to engage in design and hands-on practices (Mary Dell'Erba, 2019).

In response to this new perspective of student learning, teachers also need to rethink "how to improve their teaching knowledge and accordingly develop proper beliefs, in order to design more effective lessons and activities in various courses to help transform learners into knowledge workers. All of these educational changes in the digital age require teacher to engage in design work and design-oriented thinking (Jim Parsons, Larry Beauchamp, 2012; Sharma Suniti, Lazar Althier M, 2018). Building on the above arguments, it is critical that teachers to develop the necessary design capacity that can help shape the kinds of learning and teaching required in the future knowledge society (Rikke Toft Noergaard, 2017; Mark Burgess, 2018).

Building on the TPACK (technological, pedagogical, and content knowledge) framework, when conceiving and implementing related lesson and activity design works in teachers' daily instruction, they have to exert various types of teaching knowledge to enable good design. And knowledge building (KB), as an innovative pedagogy, may help improve teacher's TPACK knowledge and their design belief (Bereiter & Scardamalia, 2014) as the implementation of knowledge building essentially requires a design-mode of thinking (Bereiter, 2002). Accordingly, the purpose of this study is to investigate whether the participants' (i.e., pre-service teachers) online knowledge building activities (to create a web-based course interface) can help foster these pre-service teachers' TPACK knowledge and design beliefs.

Methods

This study adopted a mixed-method to collect and analyze data. The participating pre-service teachers (N=38) were divided into ten small groups working collaboratively in Knowledge Forum—a knowledge building environment. They followed two iterations of lesson plan to develop and improve their lesson ideas on creating their web-based course interface with a specific, pre-selected topic of their choice/interest. In the process, they tried to capitalize on their TPACK knowledge learned in the teacher education program prior to this course in order to resolve various issues in developing their lesson plan.

In terms of specific knowledge building, students were guided through a process of idea-centered activities to create their web-based course interface as follows: (1) idea/problem germination: participants need to identify the main lesson challenge they want to tackle (e.g., the main challenge identified by group 2 was to teach kids about travel using their geography knowledge by using a website); (2) idea generation: participants started to think about lesson ideas for their web-based course regarding what and how to teach; (3) idea diversification: participants came out with various diverse ideas that might be suitable or not suitable for their web-based course content; (4) idea screening: participants choose the best ideas synthesized from their KF discussion; (5) idea building and testing: all promising ideas were then presented, with other groups help to evaluate the web-based course interface presented, and then give

feedback or suggestions for further improvement; (6) idea evaluation and revision: the participants try to revise and improve their lesson plan and web-based course interface design by integrating all suggestions and feedback received.

Before and after the course, two surveys (see Table 1) concerning design knowledge and beliefs (with 7-points Likert scale) was employed and the following analysis was performed using paired-sample t-tests. As for the knowledge building activities/discussion to create the web-based course interface, a lag behavioral sequential analysis (Allison & Liker, 1982) was performed, using a data set of the chronological action automatically recorded in the Knowledge Forum 6 (KF 6) database. Below is the coding scheme of all relevant behaviors identified from open coding (see Table 2).

Table 1 below shows all dimensions of the two surveys.

Dimension	Factors	Reliability
Technological-Integrated Pedagogy and Content Knowledge, TPACK)[1]	Technology Knowledge (TK)	α =0.90
	Technological Pedagogical Knowledge (TPK)	α =0.93
	Technological Content Knowledge (TCK)	α =0.92
	Technological Pedagogical Content Knowledge (TPACK)	α =0.95
Design and Belief of Teacher (DBT)[2]	Lesson Design Practice (LDP)	α =0.94
	Design Disposition (DD)	α = 0.91
	Teacher as Designer (TAD)	α =0.90
	Belief of New Culture Learning (BNCL)	α =0.93

Sources[1]: Chai, C. S., & Koh, J. H. L. (2017). Changing teachers' TPACK and design beliefs through the Scaffolded TPACK Lesson Design Model (STLDM). *Learning: research and Practice*, *3*(2), 114-129.
Sources[2]: Koh, J. H. L., Chai, C. S., Hong, H. Y., & Tsai, C. C. (2015). A survey to examine teachers' perceptions of design dispositions, lesson design practices, and their relationships with technological pedagogical content knowledge (TPACK). *Asia-Pacific Journal of Teacher Education*, *43*(5), 378-391.

Table 2. Definitions and examples of the coding scheme on knowledge building activities.

Types	Definition
Setting goals	To decide a subject area and a topic to teach and to prepare a draft layout as the initial interface proposal.
Selecting materials	To choose resources or materials that will be shown as web-based course interface components (typically contains teaching videos, graphics or audio materials).
Conceiving ideas	To meaningfully arrange the materials available at hand into a feasible interface, through judgement of one's teacher professional knowledge.
Enriching	To add, supplement, complement, or expand content into the interface.
Sophisticating	To furnish with lots of details or information with sophistication.
Deleting/ Modifying	To refine the design, to revise the original design by deleting or change the existing materials.
Connecting	To establish relationships between isolated or unrelated objects (such as linking picture with a proper title and making them look as a unit).
Organizing	To form small groups using the existing objects or to categorize them into a genre .
Elaborating	To give meaning via providing such as heading or title to specific picture/notes post, so as to enable viewers to understand better what each object means in the web-based course page.
Beautifying	Adding some decorations and convert the all words/files/documents into an illustrating chart.
Simplifying	To reduce redundant or lengthy words or structures, and to clean messy webpage, making it simpler for viewing.
Integrating/ Consolidating	To combine each independent section into a whole by integrating chapters, units, sections etc.
Presenting	To present their finished project to others or to re-present after improvement from the collected feedback or suggestions.

Result

The pre-service teachers developed and discussed their final project (i.e., online web-based course interface) in the knowledge building environment. Firstly, regarding knowledge building process, the findings from the behavioral sequential analysis showed that in the earlier KB stage (using midterm as a separation point) (see Figure 1, left) there were more divergent activities of choosing learning material for students, conceiving ideas, reorganizing ideas, and combining information, selecting, deleting, or modifying what has been discussed as learning contents, etc., in order to include as much ideas and information as possible. The KB process showed an overall idea diversification pattern for the participants' work for their web-based course interface. In contrast, in the later KB stage, the findings showed a more convergence pattern (see Figure 2, right) in that KB activities tended to focus on simplification and beautification of the interface, supplement and integration of all previously gathered information for the participants' work for their web-based course interface.

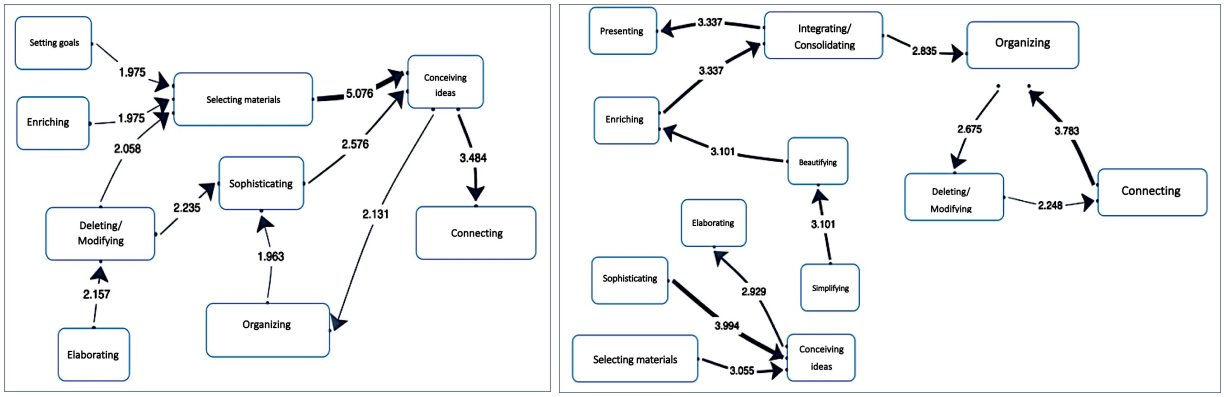

Figure 1. Behavioral differences in terms of the web-based course interface design between the two KB stages

**Note: (1) The adjusted residual is calculated by the z score of Allison & Liker (1982). If it exceeds 1.96, it will reach 0.05 significant level, indicating that the number of sequences is significantly higher. (2) The correlation coefficient is calculated using Yule'Q, between -1 and 1. Greater than 0 is a positive correlation and less than 0 is a complex correlation. Absolute value 1 is completely correlated, 0.7 to 0.9 is highly correlated, 0.4 to 0.6 is moderately correlated, 0.1 to 0.3 is low correlation, and 0.1 or less is uncorrelated.*

Below we briefly elaborate the behavioral transition from one to another as showed in Figure 1. At the beginning of the semester, for example, some pre-service teachers are interested in teaching kindergarten children about traffic laws, so they set this up as a teaching goal for creating their web-based course interface **(Setting goals)**. Next, some traffic signs were searched online, selected, and provided, such as pictures about traffic cone signs **(Selecting materials).** Immediately following this behavior, a name was given under the cone picture as "Activity 1" **(Elaborating)**. Sometimes after discussion, the group may decide that the designed or chosen material was not attractive, so they deleted this picture and change it with another more colorful and freshness images. For instance, one group's goal was to each cooking, and because the previously chosen teaching materials (which is a picture of vegetable) looks not so fresh, so they deleted and replaced it with a new one **(Deleting/ Modifying).** On the contrary, sometimes a group might also add some other more content to enhance the original arrangement, such that this same group added some safety information they thought that learner should acquire before they start their cooking course **(Enriching).**

Without a goal in mind, ideation follows to help create the web-based course interface with moving the selected materials around here and there **(Conceiving ideas)**. After that, the group members tried to make connections between the objects/figures/materials they chose to form a story or a paragraph of description required in a cover story **(Connecting)**. As conceiving ideas, groups often start to organize and re-organize ideas and materials. For instance, the group that intends to teach cooking tried to merge three seemingly separated cooking units together into one chapter **(Organizing)**. Oftentimes, a group failed to form a meaningful organization, so they keep adding things into the entire page with details, thus making the page become complicated but messy and with no focus **(Sophisticating)**.

At a later stage, some behaviors were repeated to minimalize the components in the page **(Simplifying).** For example: One group wanted to teach using Google Map, but there are too many details of processing the application Google Map in one page, so these details were being merge into a package of file instead. Some groups also tried to turn their learning materials using a series of words into a chart that is taken from some computer games to make the interface looked nicer **(Beautifying)**. Lastly, as can be seen the design of a web-based course contains activities, with

each being integrated from different units from various sections **(Integrating/Consolidating)** in order for them to present their project more effectively as the final behavior in the course **(Presenting)**.

Secondly in terms of KB outcomes, the results from quantitative questionnaires showed that pre-service teachers have significantly changed their TPACK knowledge and design beliefs through online KB activities (TPACK, t=13.629, p< .05; DBT, t=9.647, p<.05) (see Table 3 and Table 4 below). Figure 3 further show an example of the web-based course interface created by a group of students.

Table 3 Technology-related TPACK using Paired Sample t-Test

	Pre-Survey		Post-Survey		t
	M	**SD**	**M**	**SD**	
Technology Knowledge	5.789	0.899	6.184	0.793	5.478*
Technological Pedagogical Knowledge	4.174	0.930	5.458	0.813	11.931**
Technological Content Knowledge	4.421	0.976	5.560	0.892	11.525**
Technological Pedagogical Content Knowledge	4.342	0.908	5.572	0.824	9.923**
Technology-Integrated Pedagogy and Content Knowledge (TPACK)	**4.682**	**0.123**	**5.085**	**0.115**	**13.629****

*p<.05 **p<.001

Table 4 Design Belief of Teacher using Paired Sample t-Test.

	Pre-Survey		Post-Survey		t
	M	**SD**	**M**	**SD**	
Design Disposition	4.849	0.143	5.668	0.130	7.999*
Lesson Design Practice	4.711	0.121	5.588	0.136	10.213**
Belief of New Culture Learning	5.300	0.133	6.063	0.126	9.165**
Teacher as Designer	5.480	0.162	6.131	0.130	5.786**
Design Belief of Teacher	**5.085**	**0.115**	**5.863**	**0.112**	**9.647**

*p<.05 **p<.001

Figure 3. On the left side of the figure, it shows one group's web-based course interface focusing on the topic of travel and geography in the earlier KB stage. The first stage showed a complex but detailed content of interface, indicating that these pre-service teachers' intention to teach a lot of separate units using a very linear teaching approach. On the right side, the figure showed the same group's improvement in later KB stage for the web-based course interface. It became a clearer and more structured interface which has been simplified by using a metric array to present the learning units.

Conclusion

In the present study, knowledge building activities which require the participating pre-service teachers to integrate technology into their lesson plan while creating a web-based course interface, is found to improve teacher's TPACK knowledge and design beliefs. The behaviors sequential analysis of the participants' KB activities showed that they progressively demonstrated some higher-level knowledge or skills, such as: conceptual placement, integration,

organization, etc., which are more complicated and advancement (upward) integration, this is crucial important on developing novice teacher's lesson design practice.

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