Shih, JL. et al. (Eds.) (2023). Proceedings of the 31st International Conference on Computers in Education. Asia-Pacific Society for Computers in Education

Enhancing student teachers' collaborative interdisciplinary design through knowledge-building activities

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Abstract: This study aims to investigate student teachers' interdisciplinary design collaboration and integrated teacher knowledge in a knowledge-building environment. A class of 14 participants was divided into four groups to discuss interdisciplinary learning design ideas using Knowledge Forum. Data include (1) a pre- and post-questionnaire designed to investigate the participants' interdisciplinary design capacities (e.g., teacher efficacy, epistemic fluency, interdisciplinary design communication, integrated teacher professional knowledge) and (2) records of online activities such as numbers of notes generated, modified, and read. The findings showed that student teachers' perception of teacher efficacy to design interdisciplinary learning, epistemic understanding, interdisciplinary design communication, pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), and integrated technological, pedagogical, and content knowledge (TPACK) were significantly enhanced. The online knowledge-building activities were more likely to relate to student teachers' epistemic understanding and integrated teacher knowledge (i.e., TCK and TPK). The significance of practice-based, design-oriented activities for developing interdisciplinary collaboration in teacher preparation is discussed.

Keywords: teacher efficacy, epistemic fluency, interdisciplinary design communication, teacher knowledge, knowledge-building activities

1. Introduction

In today's world, interdisciplinary design practices are crucial in preparing students to tackle multifaceted, complex problems. The interdisciplinary curriculum combines skills and content from several subjects, allowing students to make meaningful connections across subjects. Traditional teacher training programs focus on single-disciplinary knowledge. Teachers should break the discipline boundary to consider students' interests when creating interdisciplinary curricula and relate the content to their lives (Chiang et al., 2020), recognize and participate in pedagogical design discourses to enhance their epistemic understanding when approaching problems and goals with different knowledge bases (Bopardikar et al., 2021). When teachers collaborate to create lesson plans from different disciplinary knowledge, they externalize design thinking and contribute design ideas based on their expertise to communicate and develop new understanding. Research is needed to ascertain how teachers from different fields establish a shared account of design tasks to synthesize their ideas to create interdisciplinary learning designs.

Interdisciplinary learning design entails how students learn to apply, conceptualize, model, and generate solutions from multiple disciplines (Capobianco et al., 2018). Teachers must integrate various subject knowledge and pedagogies to engage students. Technologies can support student engagement and provide adaptive scaffolds to explore an in-depth understanding of what they have learned (Ouyang & Chang, 2019). Hence, teachers' design capacities to integrate content knowledge from multiple disciplines and pedagogical uses of technologies are critical (Chai et al., 2011). TPACK is the synthesized knowledge for integrating technologies into learning content and classroom teaching. When teachers design interdisciplinary learning, they make a pedagogical decision in deciding how to present the learning content (i.e., PCK), consider how to use technologies to address specific learning contents (i.e., TCK), discuss how to use technologies to support student learning (i.e., TPK),

and knowledge of using technologies to facilitate students learn and create an understanding of subject matters (i.e., TPACK) (Chai et al., 2011). When teachers design, they share their understanding from different fields and consider how to engage students to approach solutions to the problems that may require fluent design talks about integrating technologies, pedagogies, and multiple learning content in design communities.

Knowledge building could facilitate student collaboration and take collective responsibility for improving ideas and pursuing more coherent explanations (Scardamalia & Bereiter, 2014). It enables student teachers to work adaptively with their initial design ideas, and through continuous discourse and redesign, they view community discourses as progressive problem-solving opportunities to generate better ideas and solutions (Yang et al., 2020). This study investigates student teachers' interdisciplinary lesson design by focusing on their efficacy in designing interdisciplinary learning, epistemic fluency, and interdisciplinary communication in developing integrated technological, pedagogical, and content knowledge practices through knowledge-building activities. The main research questions of this study are: Did student teachers enhance their efficacy, epistemic fluency, interdisciplinary design communication, and teacher knowledge across knowledge-building activities? Were their online knowledge-building activities related to the above variables?

2. Methodologies

2.1 Participants and learning activities

The participants were 14 students in an interdisciplinary learning course from a national university in Taiwan. They were heterogeneous and divided into four groups, three to four people a group, specializing in different domains. In this course, students were required to design an interdisciplinary learning micro-teaching plan based on sustainable development goals (SDGs) and present the lesson plan as course reports in a seven-week-long learning. The instructor adopted knowledge-building principles to engage students in design activities. For instance, in the first week, the instructor encouraged the students to provide ideas based on the SDGs topic they were interested in in Knowledge Forum (KF). Then, students read and discussed their initial ideas with group members before deciding on their group micro-teaching topic. Each week, there were lectures and group discussions based on the weekly assigned papers for two hours; the participants recorded their design ideas in KF and discussed them for an hour. The data of this study focused on the latter part.

2.2 Data source

Data sources included (1) online activity logs in Knowledge Forum and (2) pre- and post-questionnaires, including teacher efficacy to design interdisciplinary learning, epistemic fluency, interdisciplinary design communication (variables were validated in Lin et al., 2022), PCK, TCK, TPK, and TPCK (variables were validated in Chai et al., 2011). All items were scored on a 7-point Likert scale (i.e., 1 = strongly disagree to 7 = strongly agree).

3. Results

3.1 Student teachers' perception of interdisciplinary design capacities

A paired sample t-test was conducted to analyze student teachers' perceptions of efficacy, epistemic fluency, interdisciplinary design communication, and the development of integrated teacher knowledge. The results indicated significant differences in teacher efficacy (pre-test: $M = 5.86$, $SD = 0.81$; post-test: $M = 6.64$, $SD = 0.44$; $t = -3.91$, $p < 0.01$), epistemic fluency (pre-test: $M = 5.33$, $SD = 1.06$; post-test: $M = 6.36$, $SD = 0.30$; $t = -4.14$, $p < 0.01$), interdisciplinary design communication (pre-test: $M = 5.62$, $SD = 0.93$; post-test: $M = 6.60$, $SD = 0.47$; $t = -4.07$, $p < 0.01$), PCK (pre-test: $M = 5.14$, $SD = 1.25$; post-test: $M = 5.98$, $SD = 1.00$; $t = -2.65$, $p < 0.05$), TPK (pre-test: $M = 5.29$, $SD = 1.27$; post-test: $M = 6.26$, $SD = 0.64$; $t = -2.83$, $p < 0.05$), and TPACK (pre-test: $M = 5.38$, $SD = 1.31$; post-test: $M = 6.23$, $SD = 0.67$; $t = -2.41$, $p < 0.05$). However, TCK (pre-test: $M = 5.39$, $SD = 1.29$; post-test: $M = 5.33$, $SD = 0.32$; $t = 0.19$, $p = 0.85$) showed no significant enhanced.

3.2 Relations among student teachers' KF activities and perception of interdisciplinary

design capacities

This study calculated the changes in student teachers' perceptions of interdisciplinary design collaboration (i.e., post-test – pre-test) and analyzed their correlations to online interdisciplinary design discussion (e.g., # of notes generated, modified, and read). The Spearman's rho correlation analysis results indicated that idea generation was significantly related to their TCK and TPK (ρ= 0.60 and ρ= 0.59, $p < 0.05$), and idea modification was significantly related to epistemic efficacy (ρ= 0.62, $p < 0.05$).

4. Discussion

Previous literature on interdisciplinary curriculum and instructional design focuses on students' learning processes and competencies (e.g., Jiang et al., 2019), offers instructional guidance (e.g., Prain et al., 2023), and documents teachers' collaborative design processes (e.g., Bopardikar et al., 2021) through case studies. However, how student teachers collaborate in designing interdisciplinary learning and integrating multiple content knowledge, pedagogies, and technologies needs to be explored. The present study investigates student teachers' interdisciplinary design collaboration in online knowledge-building activities by employing pre- and post-questionnaires to assess their perceptions. The results indicated a significant enhancement in their efficacy in designing interdisciplinary learning, interdisciplinary design communication, epistemic fluency, PCK, TPK, and TPCK.

Regarding their participation in knowledge-building activities, student teachers' idea generation was related to the change in TCK and TPK. This may imply that the online knowledge-building environment may make their design ideas explicitly to discuss integrating technologies, learning content, and pedagogies. Furthermore, this study shows the potential relation of student teachers' idea modification relates to their epistemic efficacy. When they engage in collaborative interdisciplinary design, they share initial design ideas from different disciplines, and after discussion, they may formulate new information or restructure their existing knowledge. This study proves that knowledge-building activities enrich opportunities to support the social construction of interdisciplinary knowledge and learning activities.

Acknowledgments

This work was financially supported by The National Science and Technology Council, Taiwan (NSTC 111-2410-H-007-003-MY2).

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