Principle-Based Guidance to Foster Adaptive Teaching Practice

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Abstract: This exploratory study investigated the effects of engaging teacher-education students in collaborative lesson design activities guided by knowledge building principles on their mathematics teaching practices. The study context was a university course concerning mathematics teaching practice. Analyses focused on (a) online collaborative lesson design activities, and (b) classroom teaching practices. Results showed that the principle-based guidance (a) was conducive to progressively more collaborative knowledge work, and (b) was able to engage the participants in gradually more adaptive mathematical teaching practice.

Keywords: Principle-based, adaptive teaching, knowledge building

Introduction

An essential goal for teacher-education programs is to cultivate competent future teachers. To this end, a popular approach to teacher preparation is to help prospective teachers acquire core teaching knowledge and skills identified in literature or from exemplary model teachers (Hirsch, 1996; Slavin & Madden, 2001; Tileston, 2000). Such practices are often associated with direct instruction that encourages practices based on word-for-word teaching scripts (Adams & Engelmann, 1996; Engelmann, 1980; Sawyer, 2004; Slavin & Madden, 2001). In contrast, an alternative approach is to guide teacher-education students to assume the role of theory-builder or researcher, and to develop more adaptive disposition for sustained improvement in their teaching practices (Bereiter, 2002). The purpose of this study was to investigate whether engaging teacher-education students in principle-based knowledge-building activities during their lesson design would help them perform more adaptive teaching practices.

Mathematics teaching practices

Practice is essential to gain expertise. According to Hatano and Inagaki (1986), there are two general types of expertise: routine and adaptive. They conceptualized routine expertise as a core set of competencies that is developed through high, but rather narrow, procedural proficiency. An essential dimension of routine expertise is 'efficiency'. As argued by Hammerness, Darling-Hammond, Bransford, Berliner, Cochran-Smith, McDonald, et al. (2005), efficiency means "greater abilities to perform particular tasks without having to devote too many attentional resources to achieve them" (p. 361). In relation to teaching practices, routine expertise implies that a teacher is able to retrieve and appropriately apply a set of well-defined knowledge and skills to solve recurring teaching-related problems. When routine teaching expertise is pursued as an important goal for teacher-education, its aim is to help teacher-education students master some specified teaching knowledge and skills and apply them efficiently to solve common classroom problems. Typically, such knowledge and skills are identified through research or model teaching (Goodnough, 2003; Hirsch, 1996; Slavin & Madden, 2001; Tileston, 2000) and are useful for implementing highly structured scripted teaching (Adams & Engelmann, 1996). With routinized knowledge and skills, teachers can manage their class more efficiently, have control over what is to be taught, and cover the curricular materials more thoroughly. Previous research suggests that mastery of routinized teaching knowledge and skills improves students' academic achievements in mathematics (Adams & Engelmann, 1996). Nevertheless, there are also disadvantages of such mode of teaching practice, as it emphasizes simple tasks more than complex problem-solving. Also, the teacher can become concerned mainly with measurable learning outcomes. More importantly, this way of teaching does not take the teacher's creativity and personality into consideration (Sawyer, 2004).

In contrast to routine expertise, Hatano and Inagaki (1986) conceptualize another type of expertise—the adaptive type—as the ability and attitude to make adjustments in and add to core competencies in order to remain adaptive for future learning and development (Bransford & Schwartz, 1999; Schwartz & Martin, 2004). Unlike routine expertise, which emphasizes 'efficiency', an important dimension of adaptive expertise is 'innovation'; it means "moving beyond existing routines and often requires people to rethink key ideas, practices, and even values in order to change what they are doing" (Hammerness et al., 2005, p. 361). Accordingly, adaptive expertise in teaching implies that a teacher is able to solve recurring or novel teaching problems by improvising alternative solutions, and can keep improving these solutions (Darling-Hammond &

Bransford, 2005). When adaptive teaching expertise is deemed a primary knowledge goal to be pursued in a teacher-education program, learning (to teach) is more likely to emphasize the ability to adapt to new instructional situations and to generate fresh ideas or solutions for addressing emerging teaching problems. Typically, such knowledge and skills are difficult to pre-define, and can only be gradually developed during the process of progressive problem-solving or knowledge-building for better teaching (Hong & Sullivan, 2009; Zhang, Hong, Scardamalia, Teo, & Morley, 2011). The essence of such teaching practices is therefore not to model one's teaching after some exemplary teaching skills, but to engage in a mode of sustained improvement of one's own practices (Bereiter, 2002; Cohen, 1989; Sawyer, 2004; Darling-Hammond & Bransford, 2005; Hargreaves, 1999; Bereiter & Scardamalia, 1993).

Knowledge building

Knowledge building, also known as "deep constructivism" (Scardamalia, 2002, p. 4), is defined as a social process focused on sustained community knowledge advancement (Scardamalia & Bereiter, 2006). Unlike most educational approaches that highlight learning through acquiring and accumulating well-established knowledge (Paavola, Lipponen, & Hakkarainen, 2004; Sfard, 1998), knowledge-building employs ideas as building blocks for advancing deeper knowledge around a specific theme or topic. The importance of valuing ideas as basic units of thought or objects of inquiry can be manifested by means of Popper's (1972) 3-World epistemic conceptualization. Popper refers to World-1 as an objective, natural/physical/material world, World-2 as a subjective psychological world constructed within the human mind, and World-3 as a conceptual world constituted mainly by ideas (e.g., theories, models). He argues that ideas are the creative results of human beings (such as engineers, scientists, researchers, artists, and the like) and that all forms of human knowledge are related to the creation of ideas in a human community (Scardamalia, 2002). Bereiter (2002) further argues that ideas are conceptual objects which, once produced in a public domain, can possess a social life of their own and can be continually tinkered with, modified, and improved.

To bring about productive community knowledge advancement through improving ideas, Scardamalia (2002) proposed a set of knowledge-building principles. For example, the principle of 'idea diversity' states that "[i]dea diversity is essential to the development of knowledge advancement, just as biodiversity is essential to the success of an ecosystem. To understand an idea is to understand the ideas that surround it, including those that stand in contrast to it. Idea diversity creates a rich environment for ideas to evolve into new and more refined forms" (p. 79) (see Scardamalia & Bereiter, 2010, for detailed descriptions for all principles). Typical classroom work is usually defined by pre-specified procedures (see e.g. Dick & Cary, 1990; Mager, 1975), clear rules and scripts (cf. Sawyer, 2004), or highly structured, routinized learning activities (e.g., Merrill, 1983; Gagne, Briggs, & Wagers, 1992) that represent fixed rather than improvable classroom procedures (cf. Hong & Sullivan, 2009). In contrast, knowledge-building highlights the use of abstract principles as guidelines to illustrate some pedagogical challenges that would pave the way towards sustained knowledge advancement for the community's work (Bereiter & Scardamalia, 2006).

The present study

In the field of computer-supported collaborative learning, there have been studies dedicated to teacher learning (e.g., Barab, MaKinster, & Scheckler, 2003; Greiffenhagen, 2012; Song & Looi, 2012). Particularly, there have been studies investigating the relationships between computer-supported collaborative knowledge building and teacher preparation or development (e.g., Cesareni, Martini, & Mancini, 2011; Chan, 2011; Chan & van Aalst, 2006; Laferriere, Lamon, & Chan, 2006; van Aalst & Chan, 2001, Oshima et al., 2006) Nevertheless, few studies have actually explored specific instructional models or approaches in the knowledge building area for fostering adaptive mathematic teaching practices. To address such a challenge, this study proposes and tests a principle-based design approach (Hong & Sullivan, 2009; Zhang, Hong, Scardamalia, Teo, & Morley, 2011). Overall, the principle-based instructional design model is very different from conventional instructional design models that are inclined to foster routinized practices; for example, task-driven instructional design models (Dick & Carey, 1990), Criterion Referenced Instruction (Mager, 1975), and Component Display Theory (Merrill, 1983). Such design approaches tend to emphasize the importance of employing well-defined procedures, rules, and/or componential tasks (Reigeluth, 1996) in order to help students acquire pre-defined knowledge and skills. In contrast, the proposed principled approach is characterized by the use of abstract principles to guide students' knowledge work. In the present study, the following three knowledge building principles were used, "idea improvement", "epistemic agency", and "community knowledge" (see detail below in the Method section), and the present study intends to examine the proposed principled instructional design approach by answering the following questions: (1) How do the principle-based knowledge building activities affect participants' online performance and knowledge work (i.e., lesson design activities)? (2) How do the principle-based knowledge building activities affect participants' mathematics teaching practices?

Method

Study design, participants, and instructional context

This case study gathered on-site data embedded in a course context. The duration of the study was a year—i.e. two semesters, with each semester lasting about 16 weeks. Participants were nine teaching-education students. The participants were planning to become middle-school mathematics teachers in Taiwan after graduation, so took this university-level course entitled Middle School Mathematics Teaching. Major instructional activities throughout the academic year were described as follows:

(1) Lesson design ideas: Participants were guided to generate initial lesson ideas; then, they worked on the details such as setting instructive goals, preparing learning materials and worksheets, etc. One thing to note is that before this activity, students were also encouraged to reflect back on the teaching problems they have encountered previously in order for them to go beyond their best practice.

(2) Beyond best practice: Based on lesson design ideas, the participants performed their teaching practices in class, with the rest of the classmates serving as the audience and critical reviewers. On average, each teaching practice took about 25 minutes. All nine students in this course took turns to practice teaching. There were in total three lesson design cycles implemented in the whole school year.

(3) Peer feedback: The teaching performance was then under critical review by all other classmates who would individually comment on the practiced teaching by identifying issues, acknowledging strengths, and giving constructive feedback for improvement, etc.

(4) Co-design discussion: All participants were further guided to collaboratively discuss some design questions such as: "If you were to design this same lesson, how would you do differently to improve the teaching practices?"; "What is your main design idea?"; "Why is it useful?"; "How is it going to improve this particular teaching?" etc..

(5) Reflection: The student who practiced her teaching could further reflect on her video-taped teaching, and online peer-feedback and co-design discussion comments, etc., in order to summarize all comments and rise above previous lesson design ideas. Then, she will start to prepare for the next design cycle. In addition, the participants were also required to write reflection notes at the end of each practice and a reflection paper at the end of the course.

The lesson design activities were guided by a principled design approach, in particular, by using the following three knowledge building principles: (1) idea improvement, (2) epistemic agency, and (3) community knowledge. To elaborate, the principle of "idea improvement" highlights the importance of treating all lesson ideas as improvable and that "[p]articipants work continuously to improve the quality, coherence, and utility of ideas. For such work to prosper, the culture must be one of psychological safety, so that people feel safe in taking risks—revealing ignorance, voicing half-baked notions, giving and receiving criticism" (p. 79); the principle of 'epistemic agency' states that "[p]articipants set forth their ideas and negotiate a fit between personal ideas and ideas of others, using contrasts to spark and sustain knowledge advancement rather than depending on others to chart that course for them. They deal with problems of goals, motivation, evaluation, and long-range planning that are normally left to teachers or managers" (p. 79); and the principle of 'community knowledge' states that "[c]ontributions to shared, top-level goals of the organization are prized and rewarded as much as individual achievements. Team members produce ideas of value to others and share responsibility for the overall advancement of knowledge in the community" (p. 80). The above principles were purposefully selected because ideas (as building blocks of knowledge), agents (as knowledge workers), and community (as the context for knowledge interaction and advancement) represents three essential knowledge-building components. These principles were implicitly integrated into the lesson design activities, rather than explicitly taught in class. For example, to integrate the "idea improvement" principle into the lesson design activities, participants were encourage to *reflect* on the authentic teaching problems they previously encountered, to generate potential lesson design *ideas* for solving these problems, and to improve one another's lesson *ideas* during the *feedback* and *co-design discussion* activities; for the "epistemic agency" principle, students were encouraged to take charge of the entire lesson design process from producing initial lesson *ideas*, *practicing* their teaching, negotiating with peers about *feedback* and *co-design* activities, to becoming a critically *reflective* practitioners; for the "community knowledge" principle, students were encouraged to work collaboratively as a community by engaging in *idea* exchange, *feedback*, and *co-design discussion* activities. It is important to note that all the lesson design activities were only guided by the principles. Students were not required to practice according to any teaching scripts for acquiring certain pre-scribed core teaching knowledge.

Data source and analysis

The main datasets came from (a) participants' online lesson design activities, and (b) video-taped teaching practices. Moreover, students were required to write reflection notes after each teaching practice and a reflection paper at the end of the course. Using mixed-analysis approach, online collaborative activities were quantitatively analyzed, while online feedback/co-design/reflection comments, and teaching videos were content-analyzed. Using Chi's (1997) coding techniques, qualitative data were quantified for performing inferential statistics. The following provides more details.

First, online activity data recorded in the online database were analyzed focusing on two areas: (a) online activities (e.g., note creation and reading) and social dynamics (e.g., network density), and (b) the online feedback/co-design/reflection comments in the three lesson design cycles. Student online activities were analyzed by means of non-parametric Wilcoxon signed rank tests. This analysis was employed to measure the difference in terms of the amount of online activities between the two semesters. In addition, social network analysis was used to examine network density (which is defined as the sum of the values of all ties divided by the number of possible ties) (Wasserman & Faust, 1994); the higher the number of the density, the stronger the social dynamics of a community is suggested. In addition, feedback/co-design/reflection comments or suggestions to a possible course of improvement action were used as unit of analysis and they were parsed from a note if a note contained more than one specific comment/suggestion for a clear course of action for teaching improvement (e.g., suggesting to give students more response time when asking a question). Content analysis on participants' collaborative knowledge work based on the feedback/co-design/reflection comments was then performed. Zhang et al.'s (2007) concept of 'inquiry thread' was employed to trace participants' collective design improvement for teaching practice. Using an open coding process (Strauss & Corbin, 1990) to examine all 368 feedback/co-design/reflection comments recorded in the database, as a result, 12 different inquiry threads under two broad types of teaching practices were identified as follows: (1) efficiency-oriented (including "control over lesson plan", "control over teaching strategies", "control over class activity", "control over presentation skills", "control over what to teach", and "control over the use of teaching aids"; (2) innovation-oriented (including "adaptability in teaching design", "flexibility in teaching strategies", "interactive discussion in class", "open and engaging learning environments", "improvised learning activities", and "creative use of learning materials"). As an example, a student commented, "I realized that I should not spend too much time talking with students during my teaching practice so that I can more efficiently finish my planned teaching practice in time." (S6) and this comment was categorized under the "Control over lesson plan" thread theme. Two coders independently categorized all comments into different inquiry threads and a Kappa coefficient was calculated to be .72. Additionally, using the number of feedback/co-design/reflection comments contributed in one particular teaching practice or in a given inquiry thread, the number of collaborators who worked together in a teaching practice or in an inquiry thread, and the number of reads (i.e., the number of times online comments were read or referred or reflected by the participants in the database) as indicators, Wilcoxon signed rank tests were employed to illustrate whether there were any differences between efficiency-oriented and innovation-oriented teaching practices in terms of students' lesson design efforts.

Regarding teaching practices, data mainly came from video-taping of students' teaching practices. In addition, participants' reflection notes written after each teaching practice were used as complementary data. Using activity as unit of analysis, the videotaped teaching practices were parsed from the video and classified into various teaching activities. Next, classification of each activity during teaching practices was confirmed by the participants themselves. Then, the activities were content-analyzed based on a coding scheme highlighting three types of instructional activities (Collins, 1996): passive, active, and interactive learning. The passive mode highlighted instructional activities (mainly teacher-led) such as demonstration, direct instruction, lecture, asking factual questions, and the like. The active mode highlighted students' self--directed learning activities, such as hands-on exercises, independent work, quizzes, and the like. The interactive mode highlights team-based interactions (e.g., group discussion, group work, debate, or collaborative problem-solving). For the purpose of analysis, this study examined the percentage of time spent on each mode of activity for each of the four different teaching practices. Two coders independently coded each class activity into a mode. The inter-coder kappa was calculated to be 0.91.

Results and discussion

In this course, students were guided, under three knowledge-building principles, to work collaboratively as a community to help one another improve their lesson design and practice. To this end, they contributed design ideas online and collaboratively worked with, and reflected on, these design ideas. All the online design activities were documented in the online database. First, Table 1 shows overall online collaborative activities. Throughout the two semesters of a school year, participants contributed a total number of 160 notes (M=17.8 and SD=4.29) in the first semester and 242 notes (M=26.9 and SD=2.52) in the second semester. There was a significant increase from the first to the second semester for three main online collaborative activities, including number of notes created, number of notes read, and number of notes built-on.

Table 1. Summary of major online activities in Knowledge Forum (N=9)

Activity	First semester		Second semester		z value
	Mean	SD	Mean	SD	
No. of notes created	17.8	4.29	26.9	2.52	-2.55**
No. of notes read	140.2	32.94	205.9	56.07	-2.67***
No. of notes built-on	11.3	2.49	19.9	1.90	-2.68***

** *p<.01* *** *p<.001*

Second, content analysis on students' notes revealed that there are 12 emerging inquiry threads that were developed from a total of 368 feedback/co-design/reflect comments contributed in the online database throughout the school year. To explore the collaborative design processes among participants, analysis was performed to look into how collaborative design activity was sustained over time. Overall, there were more collaborative design efforts towards improving efficiency-oriented teaching practices than innovation-oriented teaching practices, as indicated by the number of comments (M=9.22, SD=3.45, for efficiency-oriented practices; M=4.41, SD=3.05, for innovation-oriented practices; z=-3.56, *p<.001*), the number of collaborators (M=6.26, SD=1.70, for efficiency-oriented practices; M=3.74, SD=2.46, for innovation-oriented practices; z=-3.16, *p<.01*), and the number of reads (M=67.41, SD=27.28, for efficiency-oriented practices; M=32.70, SD=23.25, for innovation-oriented practices; z=-3.48, *p<.001*). But when looking into each individual lesson design cycle over time, it was found that there was progressive change in collaborative design efforts towards less routinized teaching practices and more adaptive teaching practices from the 1st to the 3rd design cycle. Specifically, in the 1st cycle, collaborative design effort towards improving teaching practices was more routinized than adaptive, as indicated by the number of comments (M=11.67, SD=3.12, for efficiency-oriented practices; M=2.78, SD=2.39, for innovation-oriented practices; z=-2.68, *p<.01*), the number of collaborators (M=7.00, SD=0.87, for efficiency-oriented practices; M=2.67, SD=2.40, for innovation-oriented practices; z=-2.54, *p<.05*), and the number of reads (M=82.67, SD=27.17, for efficiency-oriented practices; M=19.67, SD=17.05, for innovation-oriented practices; z=-2.67, *p<.001*). In the 2nd design cycle, as compared with the 1st design cycle, there were relatively less collaborative design efforts towards routinized practices and more collaborative design efforts towards adaptive practices, but the outcomes still remained quite the same that collaborative design efforts was more routine than adaptive, as indicated by the number of comments (M=9.44, SD=2.51, for efficiency-oriented practices; M=5.22, SD=2.95, for innovation-oriented practices; z=-2.14, *p<.05*), the number of collaborators (M=6.67, SD=1.66, for efficiency-oriented practices; M=4.33, SD=2.50, for innovation-oriented practices; z=-1.90, p=.058), and the number of reads (M=73.89, SD=20.26, for efficiency-oriented practices; M=40.78, SD=23.04, for innovation-oriented practices; z=-2.07, *p<.05*). In the 3rd design cycle, however, the difference of collaborative design efforts between the routine and adaptive teaching practices became much smaller; all statistics comparisons were insignificant as evidenced by the number of comments (M=6.56, SD=2.79, for efficiency-oriented practices; M=5.22, SD=3.38, for innovation-oriented practices; z=-1.01, p=.313), the number of collaborators (M=5.11, SD=1.90, for efficiency-oriented practices; M=4.22, SD=2.39, for innovation-oriented practices; z=-.71, p=.48), and the number of reads (M=45.67, SD=20.73, for efficiency-oriented practices; M=37.67, SD=25.35, for innovation-oriented practices; z=-.83, p=.41). The results suggest that progressively the participants were developing a more adaptive disposition towards their teaching practices.

The content of participants' feedbacks/co-design/reflection comments were further examined to explore how collaborative design efforts for improving efficiency-oriented or innovation-oriented teaching practices was qualitatively sustained over time. In terms of collaborative design efforts towards the efficiency-oriented teaching practices, for instance, the first inquiry thread in the figure (with 27 comments) was concerned with "control over lesson plan". In the 1st design cycle, it was found that the participants were highly concerned about how to implement their lesson plans efficiently. For example, as some participants suggested, "I realized that I should not spend too much time talking with students during my teaching practice so that I can more efficiently finish my planned teaching practice in time" (S6 in P3 or the 3rd practice); and "Based on my teaching plan, my teaching pace was too fast, so I need to slow down to better help students acquire the knowledge I want to teach" (S8 in P6). In the 2nd design cycle, the participants still paid much attention to whether they were teaching according to their lesson initially planned, even though there were relatively few feedbacks contributed. For example, some participants commented, "I need to be more consistent in my class management as I was always behind my teaching schedule" (S4 in P13), and "I need to carefully follow my lesson plan step by step to avoid unexpected interruption so that I can practice my teaching more as I planned" (S3 in P18). Moving towards the 3rd design cycle, the number of comments contributed to the "control over lesson plan" thread was greatly reduced and the comments also became less harsh; for example, "You may want to make sure there is still room to include additional learning activities in your lesson plan" (S1 in P21); and "You still need to work on time management, although you have done a good job to cover all the materials you planed to teach" (S9 in P24). These excerpts indicated that participants' collaborative design efforts towards teaching practice became progressively less routine oriented.

In contrast, participants' collaborative design efforts towards more innovation-oriented teaching practices were also qualitative changed over time. For example, in the inquiry thread titled "adaptability in teaching design" (which received 29 comments), it was found that the participants did not generate any comments or ideas that were suggestive of more adaptable teaching practices in the 1st design cycle. Not until the 2nd design cycle, did they begin to produce and share comments related to adaptive teaching. For instance, some participants commented: "If you can flexibly provide more time for students to take over their learning path, they will have different learning experiences and you will also learn how to teach in a less rigid manner" (S9 in P10); and "In my teaching practice in the second design cycle, I did not completely follow my teaching plan/script, but I tried to adapt my teaching methods based on how students responded to my instruction at the moment" (S8 in P13). Entering into the 3rd design cycle, it can be seen that participants' disposition towards innovation-oriented practices was even more obvious. For example, some participants commented, "You have been dedicated to improving your teaching skills, but since every teacher has different personality traits, I suggest that you think about how to adapt your teaching strategies by making good use of your personality strengths" (S1 in P22); and "You need to think about how to empathize with students in order to improvise their learning; the question is not how to teach, but to help students learn by using appropriate method at the right moment" (S6 in P25). These excerpts indicated a shift in collaborative design disposition towards progressively more innovation-oriented teaching practices.

An intended goal of this course was to engage students in collaborative lesson design work for teaching improvement. Therefore, it was posited that students would progressively become more comfortable working collaboratively in the Knowledge Forum. Overall, the increased online activities and enhanced social dynamics suggested that this is the case. Additional content analysis on the online feedback/co-design/reflection comments also suggested that the participants were able to progressively develop a more adaptive disposition towards mathematics teaching practices.

Regarding class teaching practices, first, over a school year, each student performed three teaching practices within three design cycles. So, in total, nine students performed 27 teaching practices. All 27 practices were video-taped and then uploaded online for peer feedback, co-design discussion, and self-reflection. Video analysis was conducted to examine changes in teaching practices. It was found that there was a progressive decrease in trend in terms of the percentage of time used for passive learning activities, with the activity time spent in the three practices being 72.0% (SD=17.4%), 46.8% (SD=19.5%), and 38.4% (SD=17.1%). In contrast, there was a progressive increase in trend in terms of the percentage of time allocated to active learning activities, with the activity time spent in the practices being 17.0% (SD=12.9%), 36.4% (SD=18.6%), and 41.9% (SD=13.8%). Moreover, it was found that there was a progressive increase in the percentage of time allocated to interactive learning activities, with the activity time spent in the practices being 10.0% (SD=14.0%), 16.2% (SD=13.3%), and 23.8% (SD=12.2%).

Concluding remark

As 'deep constructivism' (Scardamalia, 2002, p. 4), knowledge-building attempts to guide classroom activities away from proceduralized tasks to innovative knowledge work (Zhang, Hong, Scardamalia, Teo, & Morley, 2011).), Previous studies ranging from the elementary-school classroom setting to university context provided convincing examples of what students can achieve in knowledge-building classrooms in the advancement of knowledge (e.g., see a special issue of the *Canadian Journal of Learning and Technology on knowledge-building*, Volume 36/1). In the present study, the findings further suggested that engaging teacher-education students in sustained knowledge-building in a teacher-education course could help the teacher-education students (a) learn to teach with progressively more adaptive manner, and (b) develop more adaptable practices. In conclusion, this study shows that the principle-based design approach was viable for guiding teacher-education students to develop more adaptive teaching practices.

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