Engineering of Teacher Learning in Online Mathematics Methods Course using Video-based Didactical Chess Technique

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Along with content development and content interactivity, promoting and facilitating effective content-focused communication is critically important to the success of an online course (Andresen, 2009; McCrory, Putnam, & Jansen, 2008; Tchoshanov, 2013). Well-designed and seamlessly implemented content interactivity and content communication significantly contribute to the effectiveness of learning environment in an online course (Testone, 2003; Trenholm, Alcock, & Robinson, 2016). In this proposal, we will discuss the 'Didactical Chess' technique to improve the effectiveness of teacher learning in online mathematics method course.

Keywords: engineering of learning; teacher learning; online mathematics methods course.

One of the central course assignments authors use in online mathematics method class for pre-service teachers is didactical problem solving, analysis, and reflection based on the selected video cases of middle school mathematics classroom. This assignment is a connected set of activities that addresses the learning objectives of the course and outlines the student learning pathway. It consists of the following steps: pre-video problem solving activity; during-video analysis of the didactical situations occurring in the video; post-video reflection; post-video discussion. The first step is to involve students in solving the problem that later they will watch in the video. Let us consider the following "Border problem" from one of the video episodes as an example. The instructor divides the class into small groups to work on the following activity: "Using the 10 by 10 grid, figure out without writing and without counting one by one, how many unit squares are in the border of the grid? Explain your method". The groups post their solutions and explanations on the discussion board. The whole class has a chance to comment on posted group solutions before the next online session where the instructor provides an access to the video case.

During-video activity phase includes an element of gamification. The game-based learning activity designed for this assignment we call "*Didactical Chess"*. Objective of the game is to watch the video case until the pause point purposefully selected by the instructor, analyze the situation, come up with the most effective didactical move, and justify why the selected move is most effective with regard to student learning. Below are the steps on implementation of the game. First, the designer/ instructor carefully selects didactical situation(s) in the video that has teachable moments such as student ways of problem solving, student misconceptions, student questions, to name a few. The designer includes the pause point in the video track. The students watch the video until that very point and during the pause they individually work on the "Engineering of a didactical move" chart which includes the following segments below.

- Analysing the situation: analysis of the content, the teacher action(s), the student action(s), and the classroom environment.
- Designing possible didactical moves: define the didactical task, identify main factors impacting potential move(s), and list possible didactical moves
- Selecting the move and constructing next didactical situation: select the most effective didactical move, justify why it is effective, and construct similar didactical situation.

The main purpose is to come up with a next most effective move if they were teachers in in the classroom situation presented on the video. The students can rewind the video back but they cannot continue watching the video until they submit the response. The most intriguing part for the students after completing the response is to watch the teacher's move in the video case. It usually happens that few students might come up exactly with the same move as in the video. The designer/ instructor usually selects one-two didactical situation per video case. The "Didactical Chess" activity involves teachers in zooming into details and dissecting the "molecular" didactical situations into "teaching atoms". After all, 'the devil is in the details'. Good teaching is about being able to conduct microscopic analysis of teaching craft and, based on this analysis, to understand how to effectively engineer student learning.

Post-video activity includes individual student reflection on the entire video case. The sequence of events in the video lesson included the following: the teacher collected "wrong" answers to the "Border Problem" and asked students reaction and thinking about the incorrect answers; the teacher collected different methods for thinking about the correct solution; the teacher gave a method from the previous day's class and asked students to make sense of it geometrically; discussion of the similarities and differences between methods; the teacher posed a question about shrinking the square to a 6x6 grid and there was some discussion of the proposed student answers.

The reflection is supported by following guiding questions subdivided into four main areas: the activity; the teacher; the students; and the classroom environment (Boaler & Humphreys, 2005). *The Activity* section includes the following questions for reflection: What were the mathematical tasks of the lesson? How did they follow from the main activity? What do you think about each of the events in the lesson? What do you think about the progression of the events? What mathematics means did each of them suggest? What were the decision points in the lesson that had changed the flow of the activity and when did they occur? Were there any didactical situations in the lesson you would have approached differently? What mathematical content and mathematical process did the lesson address? Where could this lesson go from here? What could students work on during in the next lesson?

The Teacher section of the reflection consists of the following questions: How did the teacher respond to student's different methods? How did the teacher capitalize upon student's diverse way of thinking? How did the teacher gather information from the students? What kinds of information did she gather? What would you have done differently if you were the teacher? At which didactical situations would you have made different decisions and why?

The Students section includes the following questions: What did students learn in this lesson? Do you think it was different for different students? How? Why? What were the various roles students played in the classroom? What different things were the students required doing? What questions did students ask? Which students were contributing or not contributing to the discussion?

Finally, *the Environment* area of the reflection includes the following set of questions: What classroom norms did you see in this class? What do you think the teacher had done to set up these norms? How was the classroom arranged? What materials were used and which role did they play? What in the classroom environment made the mathematics more visible?

After the students submit individual reflections, the instructor invites them to the post-video discussion. Through the invitation, the instructor encourages students to dig dipper into the important content-specific issues addressed in the video case. Unfortunately, some of the middle school teachers have a tendency to use general and descriptive way of reflecting on the video

cases. Some of them shy away from the content. The instructor's role is to engage the students into the content-focused discourse and sustain the focus throughout the discussion.

After the individual participation in the discussion, students work in groups on developing the lesson plan based on the same video case. When the draft of the lesson plan is ready, the group submits it to the instructor and requests a virtual office hour to conduct a pre-teaching conference. The instructor holds a synchronous conference with the group via chat room or Skype and provides a feedback on the lesson plan developed by the group. The second synchronous post-teaching conference is conducted after the group teaches the lesson and submits the videotape to the instructor. The post-teaching conference concludes the cycle of the connected teaching activity: teacher learning – lesson planning – teaching practice – student learning (figure 1).

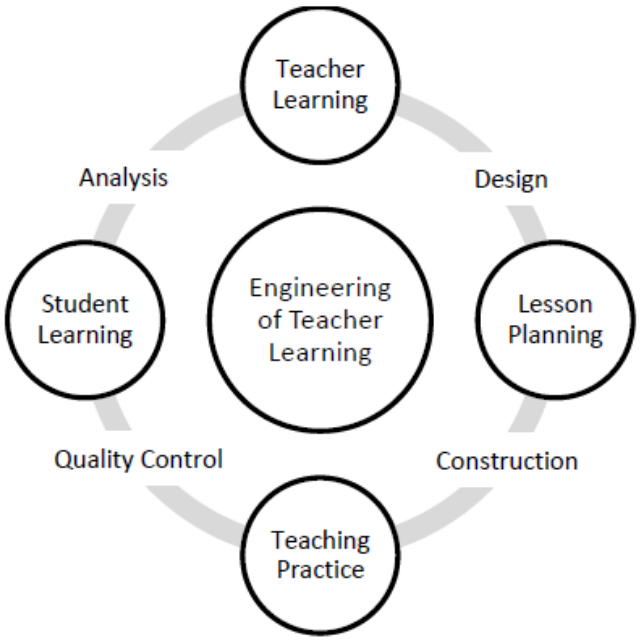

Fig. 1. Engineering of teacher learning cycle

At the end of the semester, students develop an e-folio, which consists of all the major assignments for the course including didactical problem solving, reflections, lesson plans, classroom videos as well as students' contribution to the class discussions. The students' course evaluations conducted at the end of the semester reflect the level of intellectual challenge as well as engagement the course offers for pre-service teachers enrolled in the class.

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