Promoting Reflective Physics Teaching Through the Use of Collaborative Learning Annotation System

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Effective physics teaching requires extensive knowledge of physics, relevant pedagogies, and modern educational technologies that can support student learning.[1,2] Acquiring this knowledge is a challenging task, considering how fast modern technologies and expectations of student learning outcomes and of teaching practices are changing[3,4] Therefore 21st-century physics teachers should be supported in developing a different way of thinking about technology-enhanced physics teaching and learning. We call it Deliberate Pedagogical Thinking with Technology,[5] and base it on the original Pedagogical Content Knowledge and Technological Pedagogical Content Knowledge frameworks.[1,6] However, unlike the two aforementioned frameworks, the Deliberate Pedagogical Thinking with Technology emphasizes not only teachers' knowledge, but also their attitudes and dispositions about using digital tools in order to support student learning.[5] This paper examines how an online system that allows an ongoing discussion of videos uploaded on it by the students can support reflection in physics teacher education. Examples of using such a system in physics teacher education and teacher-candidates' feedback on their experiences with it are also discussed.

In order to develop Deliberate Pedagogical Thinking with Technology and stay up-to-date with their teaching practice, teachers have to have an opportunity first to experience technology-enhanced physics learning as learners and second to reflect on their own experiences as future teachers.[7] Third, teachers have to be encouraged to reflect on their own teaching, rethink their current pedagogies, and continuously consider adapting and adopting new teaching practices. Yet reflection should not be limited to self-reflection, as teacher collaboration and mutual support are very powerful tools for improving practice.[8]

Reflection is an important contributing factor to effective teaching for both new and experienced educators as it requires an ability to analyze teaching, provide and receive constructive feedback, and evaluate pros and cons of various teaching approaches.[9-11] In recent years, teacher inquiry and reflective practices have been given more attention both in science education and in teaching in general.[12,13] Therefore, we suggest that reflection should become an integral part of physics teacher education in order to support beginning teachers in bridging the educational theories they are learning about with the teaching practices they implement during their practicum and post-graduation.[14] However, very often reflection in teacher education is being divorced from the subject-specific teaching practice.[15] This perpetuates the centuries-old theory-practice gap in physics teaching, where beginning teachers adopt the teacher-centered pedagogies they experienced as students, instead of creating student-centered learning environments promoted by their teacher education programs.[16] This paper describes the implementation of the Collaborative Learning Annotation System (CLAS)[17] developed at the University of British Columbia. We suggest how CLAS can aid teacher educators in promoting reflexive teaching practices and collaboration among physics teacher-candidates that will eventually result in the development of their Deliberate Pedagogical Thinking with Technology.

Collaborative Learning Annotation System in physics teacher education

CLAS is a freely available online media player and an online collaborative platform developed at the University of British Columbia.[17] CLAS allows uploading, sharing, and commenting on videos stored in the system, while making both time-specific and general comments (Fig. 1). The participants can respond to specific comments and create discussion threads focused on specific features of their videos. The instructor has full control of who has access to the videos; thus, they can be shared with the entire class or with a sub-set of students. The comments made by the instructor or by the students can be made either private or public. Most importantly, CLAS is compatible with the videos recorded using smartphones and other common devices, such as iPads or tablets, available today to many physics teacher-candidates. Thus, no additional special video-recording equipment is needed to use the system.

During the last three years, we have been using CLAS extensively in our secondary physics methods courses in the Teacher Education Program at the University of British Columbia. Usually these are small courses—with eight to 15 teacher-candidates, most of whom have already completed their BSc in physics (some of the teacher-candidates are enrolled in a concurrent teacher education program). As part of the course requirements, teacher-candidates are asked to teach at least four 10-minute mini-lessons to three or four of their peers and provide feedback to at least four mini-lessons taught by their peers. Unfortunately, the mini-lessons are so short, as the course is only a one-semester long three-credit course (36 hours in total); thus, we have very limited in-class time for student teaching. To use the time more efficiently, teacher-candidates are asked to teach their mini-lessons to three or four of their peers; thus, a number of mini-lessons can run simultaneously. Then the recordings of the mini-lessons are uploaded on CLAS and everybody is invited to watch and comment on them. A course instructor and a course teaching assistant provide detailed feedback for each one of these mini-lessons. This online feedback is especially important, as the course instructor and a teaching assistant cannot be physically present in all of the mini-lessons. The online feedback from the more experienced educators is aimed at supporting all teacher-candidates in their growth, as well as to model various constructivist feedback strategies. This is part of the cognitive apprenticeship approach implemented in many of our methods courses, in which instructors model teaching practices they want teacher-candidates to adopt in their own teaching.[7,11,18,19]

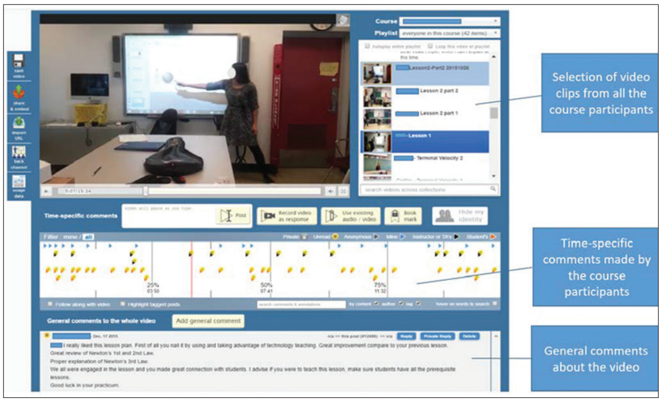

Fig. 1. Screenshot of CLAS interface. By clicking on different icons in the time-specific comments area, one can read and respond to all the comments pertinent to different parts of the video. To find more about the system visit http://ets.educ.ubc.ca/clas/.

There are five main reasons for incorporating CLAS in the physics methods course. First, CLAS assignments encouraged teacher-candidates to practice teaching specific physics concepts and reflect on their own teaching through watching the recordings of their mini-lessons. Being able to see the recording of your own teaching provides a powerful opportunity to challenge yourself and your teaching strategies. It also allows you to see what you are doing well and what your strengths are. This is important for teacher-candidates who are not native English speakers, as well as for the ones who speak English fluently. Surprisingly, despite the wide availability of smartphones or other recording devices, very few teacher-candidates have ever watched recordings of their own presentations or teaching for the purpose of reflection and self-improvement.

Second, teacher-candidates were asked to provide constructive feedback on the mini-lessons taught by their peers. This taught them to analyze the teaching done by others and to pay attention to various aspects of their own mini-lessons, such as adopted teaching strategies, student engagement, teacher-student interactions, scientific accuracy of the lesson, chosen materials, and demonstrations. By doing it,

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teacher-candidates also learn to come up with constructive suggestions for improvement. Since during the lessons some of them play the role of students, teacher-candidates have to think of potential student difficulties, prior knowledge, and student experiences during the lesson. Thus, teacher-candidates are learning to think about student experiences of their lessons, which is an important feature of a good teacher.

Third, CLAS activities taught teacher-candidates to accept and respond to constructive feedback. This is especially important as at the end of the physics methods courses they are required to participate in a 13-week long teaching practicum where they are being continuously observed by more experienced educators. As a result of this feedback, many teacher-candidates decided to reteach the same mini-lesson while using alternative teaching strategies. This was an additional benefit of incorporating CLAS in physics methods courses: teacher-candidates learned that good teaching is not about creating a "perfect" lesson from the get-go, but about working ceaselessly on improving oneself as a teacher through making every lesson a little bit better than the previous one. On multiple occasions, teacher-candidates decided to incorporate the comments they received and to reteach the same lesson. Since all the mini-lessons were recoded, teacher-candidates were able to reflect on their own progress and think of the areas for improvement.

Fourth, reflecting on their and their peers' mini-lessons through CLAS taught teacher-candidates the difference between Failure and failure. Winston Churchill once said, "Success is not final, failure is not fatal: it is the courage to continue that counts." Learning any new skill inevitably consists of many small failures. In order to prevent them from turning into a big Failure (giving up on learning), learners have to be supported in the process through continuous constructive feedback. The learners also have to be given time to master the skill and to be encouraged to try it multiple times. The same should apply to learning how to teach and learn physics, for that matter. Using CLAS encourages teacher-candidates to reflect on their teaching, receive constructive feedback, and try it again. It also models how they can support their future physics students when the students experience failures and disappointments in their own learning.

Fifth, the positive feedback on their teaching provided by their peers and the course instructor allowed teacher-candidates to identify their strengths, weaknesses, see their own progress, and eventually build their confidence and self-efficacy in physics teaching. As many teacher-candidates decided to reteach the same lessons, using CLAS helped them to see their teaching as a work in progress. Passionate but less experienced teachers are often their own worst critics, so receiving positive and constructive support from peers and from the instructors was a much needed boost for improving their self-esteem and confidence in their ability to become a successful teacher.

In the next section we describe how teacher-candidates used CLAS and share some of their feedback, as well as their comments on the mini-lessons by their peers.

Select teacher-candidates' feedback on the use of CLAS

At the end of the term, teacher-candidates, as all university students, are asked to provide anonymous feedback on their course experiences. The course evaluations for the physics methods courses consistently exceed the average course evaluations in the Faculty of Education (6.5+ out of 7 on a Likert scale). This is not surprising, as the course directly supports their future aspirations—becoming inspiring physics teachers. However, since the implementation of CLAS was a big part of the course, we can deduce that CLAS did not make a significant negative impact on the teacher-candidates (we do not have sufficient evidence for claiming that CLAS had a significant positive effect). We intentionally decided not to ask CLAS-specific questions in our end-of-term surveys, as we did not want to influence teacher-candidates in their course feedback. We wanted to see if they would choose to include their mini-teaching experience and their collaboration on teaching as one of the important learning opportunities in the course. The feedback we received clearly indicated that teacher-candidates viewed CLAS-enhanced mini-lessons as one of the course highlights and one of the most beneficial experiences in their entire program. Here are a few of their notes:

- ***Teacher-candidate A:*** "This course was the most interesting class which I have taken in this term. Teaching a concept in different ways, integrating technologies in teaching, feedback for improvement, challenges from peers, excellent and enthusiastic teaching examples, creating conceptual questions, etc. were some of my important learning experiences from this course."

- ***Teacher-candidate B:*** "I appreciated the instructor's candor when giving suggestions for how to improve our teaching style and technique, and that is what we are really here for after all. The instructor's ability to promote heated debate while maintaining respectful dialogue is something for us to aspire to as teachers."

We also looked at the quality of the feedback provided by teacher-candidates on CLAS. Here are a few of the excerpts provided in response to the time-specific elements of the videos (Fig. 1):

- ***Teacher-candidate C:*** "I really like this idea! I don't know if making solution keys would make sense for worksheet problems, but adding extra video content or resources would be sweet!"

- ***Teacher-candidate D:*** "[Y]ou did a great job in demonstrating the use of technology in class. Using the site Aurasma made the lesson very exciting. Students were engaged. This technology is very new for me. I am going to practice it in my spare time, so I can learn it 100 percent. Once I become confident, I will use it during my practicum. If I were to do it, I will provide a handout to explain how to use the website and the triggers. I looked at your previous lessons. You have improved a lot. As an observer, I noticed that you were not nervous. On the contrary, you showed that you had confidence."

- ***Teacher-candidate E:*** "I like the gesticulation and patience. Perhaps sometimes making an overtly incorrect interpretation of their comment, [sic] may be appropriate to make them correct you and engage more assertively."

- ***Teacher-candidate F:*** "I like how you've emphasized what you want the students to learn by the end of the lesson. Your enthusiasm is already evident, which is great!"

- ***Teacher-candidate D:*** "I really liked this lesson plan. First of all, you nailed it by using and taking advantage of technology teaching. Great improvement compared to your previous lesson. Great review of Newton's 1st and 2nd laws. Proper explanation of Newton's 3rd law. We all were engaged in the lesson and you made great connection with the students. I advise if you were to teach this lesson, make sure students have all the prerequisite lessons."

- ***Teacher-candidate G:*** "I really like how you draw a free body diagram here. Good visuals and clear explanation."

- ***Instructor:*** "If you go to a school and there is no Logger Pro there. [sic] You can have two dynamometers and if the students pull on them and they are connected, they will see that the forces have the same magnitude. So it would be a less visual, but still a valid option, for a low-tech classroom."

- ***Teaching assistant:*** "Great lesson! I think you had some great ideas here, although perhaps not enough time to do all of them properly. I think you spoke very confidently and clearly, although perhaps sometimes a bit too fast (with not enough time for pausing). I like how you used the smartboard efficiently, and also Logger Pro. I think you engaged the students well. Well done!"

This is select feedback on the use of CLAS in physics methods courses collected during the course of three years. While we were not able to conduct a rigorous study to ascertain the effect of CLAS implementation on teacher-candidates' learning, we can tell with certainty that teacher-candidates actively engaged with mini-teaching and CLAS feedback. Many of them also reported informally after the practicum that CLAS activities prepared them for accepting feedback from other teachers and to be much less nervous when they were being observed during their actual classroom teaching during the practicum.

Conclusions

Due to the small sample size of our courses (eight to 15 teacher-candidates per course) and the inability to design a controlled research study due to the ethical considerations, we cannot draw large-scale generalizations on the effectiveness of CLAS in physics teacher education. However, from the informal feedback provided by the teacher-candidates over the three years, their active engagement with mini-teaching, their general satisfaction with the course, and their clearly visible personal growth, we believe that CLAS can become an effective educational tool in physics teacher education. Our experiences with CLAS have shown that it is an effective tool to help physics teacher educators scaffold physics teacher-candidates in developing their Deliberate Pedagogical Thinking with Technology and gain confidence in their teaching ability. It is also a useful tool to create a community of practice that can last beyond their teacher education.

We invite our colleagues to try and use CLAS in their physics teacher education courses. We also believe that CLAS has a lot of potential for teacher professional development, as well as for secondary physics education.

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