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A Co-Design Approach to Engaging Colleagues in Active Learning Pedagogies

Dialogue between two Physics teachers:

Kevin:
Hey Rhys! Do you feel that today's activity was effective?

Rhys:
I think the students had fun during the activity, but the end fell flat. I do not think that they left the class with a clear "take-home" message. The previous activity felt better to me.

Kevin:
Well, we have about two weeks before the next activity. Let's re-think the script and focus on making the learning flow better. Keep the fun, but make the learning objective more visible. Do you want to keep the next activity photo-based?

Rhys:
Yes, that part works well.

Kevin:
I like it because it gets students thinking creatively at home, then they can come to class, share and learn some more.

Rhys:
But we need a better final group activity, in-class, to consolidate the learning.

Kevin:
OK, keep the photos, but maybe constrain the choices more so we can give a team quiz as feedback at the beginning of class. For the final activity, we have a bunch of clicker questions but let's use the really tough ones, and make it group response rather than individual… That design will get the team discussions going and introduce a bit of competition.

Rhys:
Sounds interesting; let's try it…

Introduction

Active learning is a pedagogical approach where students are engaged in classroom activities, as opposed to passively listening to lectures. In a more traditional style of teaching, the instructor does most of the talking, restricting opportunities for dialogue between instructors and students. In an active learning setting, the students are at the center of the activity. The instructor leads and scaffolds meaningful activities that facilitate student engagement with the subject matter and between the students themselves. There is accumulating evidence that active learning techniques, when implemented correctly, positively impact the learning and motivation of students as well as retention in STEM-based programs [1-7]. However, not all instructors embrace active learning. They may have misconceptions about active learning or see no real benefit to it. Without persistence or guidance, instructors get discouraged and return to a more traditional style of teaching. In this article, we report on how activity co-design can engage more instructors in active learning pedagogies.

Co-designing active learning pedagogies

Active learning pedagogies are meant to be engaging for students, but ultimately, instructors must assure that learning is achieved. Once a desired learning outcome is identified, pedagogy researchers and instructors collaborate on the design of a new active learning pedagogy. It is an iterative process that involves feedback, not only between the pedagogy researchers and instructors, but also with students via its implementation.

In the co-design process, the following three aspects need to be considered:

1. Discipline content: For example, designing an activity that will help students understand Newton's third law force pairs.

2. Resources available: What technologies do you have access to and/or wish to use? What type of classroom do you have? Will tutors be present in class? Etc.

3. Pedagogical design principles to implement: Will the activity include individual and/or team components? Will the activity extend to pre- and post-class? What knowledge and cognitive processes (Bloom's Taxonomy) are students to obtain and achieve? Etc.

To highlight the process, we will consider active learning pedagogies developed for a mechanics course held in a "versatile classroom." These strategies use web-based educational platforms and employ peer instruction and flipped classroom approaches.

In terms of discipline content, a recurring theme in classical mechanics is the analysis of forces. Students need to set up correct free body diagrams (a tool to analyze forces on objects) and to correctly analyze the forces acting on bodies. Many of the activities that we have designed therefore include a component where students must produce free body diagrams.

Our versatile classrooms are equipped with white boards along the perimeter of the room; one of these is in the front for instructor use and the rest are primarily for student use (e.g. to draw free body diagrams, brainstorming, problem solving, etc.). There is a projector and an interactive board (e.g. SMART Board) for audiovisual display, annotation and saving, 15-20 laptops for student use, and tables and chairs that can easily move and be reconfigured for student groups. Digital platforms such as Smart Amp (smartamp.com), Visual Classrooms (visualclassrooms.com), and Phet simulations (phet.colorado.edu) are employed. These resources allow activities to run outside the traditional spatial and temporal boundaries of a class; activities are designed to have pre-, during-, and post-class components. Furthermore, each stage of the activity can have individual, group (or team), and whole-class aspects. In addition, in-class tutors (second year students) are often available to assist the instructor, thus permitting flexibility with group size.

A script, displayed in figure 1, has been developed to aid in the design of activities. Each step of the activity is defined by 1) When and where does the task take place? 2) Who performs the task(s)? 3) What type of tasks are involved? 4) What cognitive process is to be used, as defined by Bloom's taxonomy?

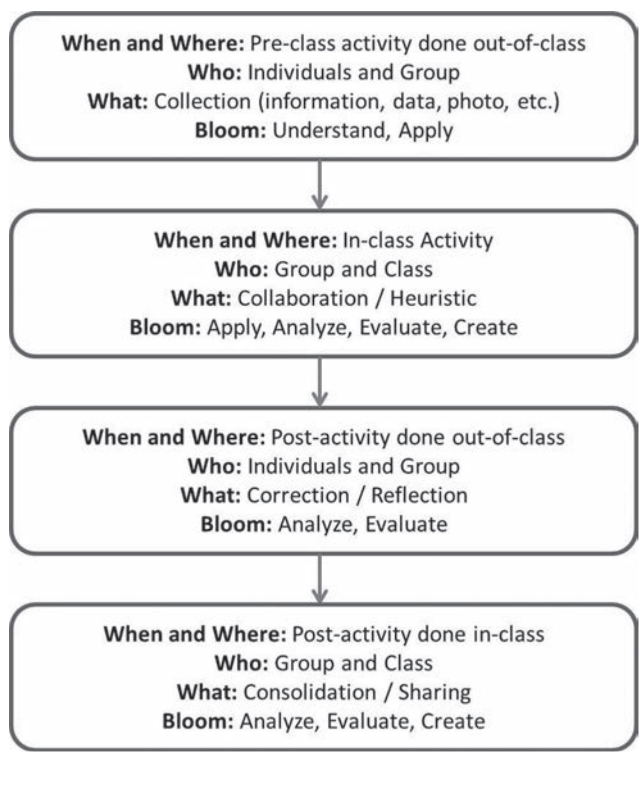


Figure 1: Script used to aid in the design of activities.

(a)

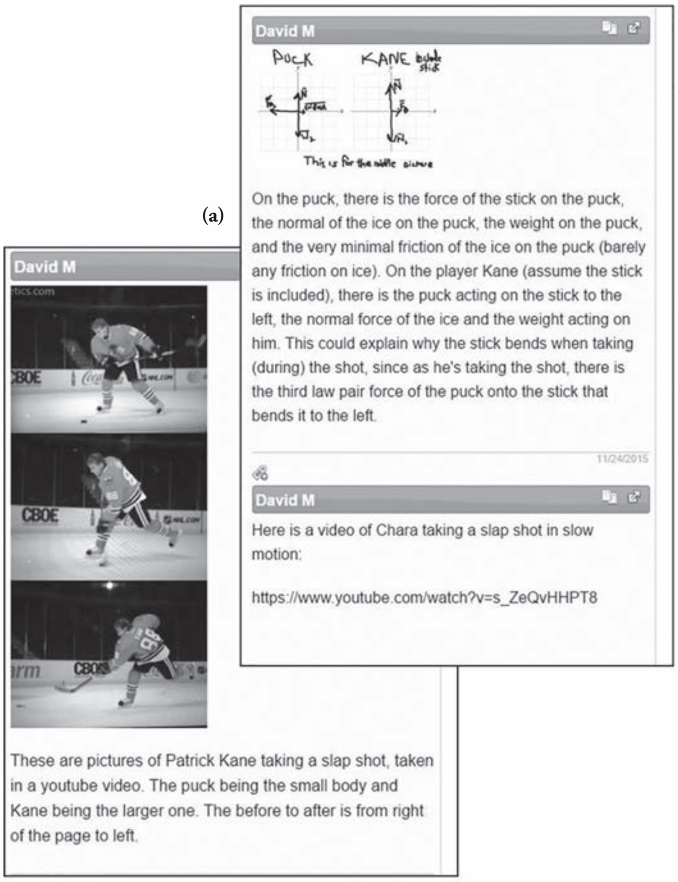
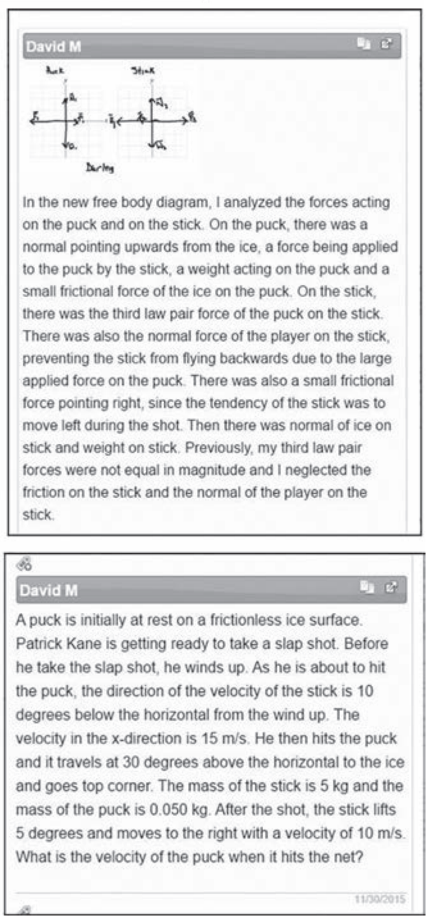


Figure 2: Example of a student's contribution (a) pre-class and (b) post-class for conservation of linear momentum activity.



(b)

All of the designed activities involve students analyzing photos of an "everyday" event. The students are encouraged to take their own photos, be in the photo, or use a photo they find interesting from the internet. For example, in one such activity for conservation of linear momentum, students must present a sequence of photos of two interacting objects before, during and after the interaction. Before coming to class, students need to upload their sequence of photos, prepare free body diagrams of the two interacting objects, and provide a rationale. Each student is assigned to a group, and each group has a digital group space (in Smart Amp or Visual Classrooms). The students can comment on each others' contributions prior to class. To help guide the students, the activity is constrained: in this case, each group has to showcase at least one example of each of the following features: 1) the mass of one of the objects is much greater than the other mass, 2) the change in total kinetic energy of the objects is small (approximating an elastic collision), 3) the change in total kinetic energy of the objects is large (approximating a totally inelastic collision), and 4) the initial velocity of both objects is zero. An example of a student entry is presented in figure 2 (a).

In-class, students work together in their groups in order to critique and correct their free body diagrams. The students are then to develop a heuristic for analyzing the free body diagrams of interacting objects (i.e. linking conservation of momentum of a system, impulse on an object, Newton's third law, etc.). They are then presented with a series of conceptual and quantitative questions to analyze and solve as a group using their heuristic. This activity lasts 1.5 – 2 hours.

Kevin:
Hey Rhys! I don't really know what a heuristic is, what does it mean in this context?

Rhys:
Oh, just a practical rule of thumb, how can students identify the important features, using their own words.

Post-class, the students upload their corrected free body diagrams, explain and reflect on what corrections were made, and finally, prepare a short question based on their photos. The students complete this in their assigned group space and comment on each other's final work until all students submit correct free body diagrams. The instructor has access to the group space; he/she can comment to a student or to the group and answer questions that students may still have. An example of a student final entry is provided in figure 2 (b).

Finally, there is a consolidation period in the following class where the instructor highlights the key learning objectives of the activity and shares the developed group heuristics.

Getting more instructors on board

Several activities have been developed using the script. These activities have been shared with the Physics department, and variations of each activity have been co-designed with instructors such that they have been adapted to their needs and available resources. As a consequence, instructors teaching in different classrooms (in traditional rooms or in rooms with up to six interactive boards) as well as those who wish to use less digital technology can still accomplish the activity. Furthermore, some instructors have experimented with team-teaching, thus providing the students with two instructors to discuss with. In total, about eight Physics instructors now use one or more of these activities in their mechanics classes.

Conclusions

We have now more instructors engaged in active learning pedagogies through activity co-design. The iterative co-designing process and the three aspects of activity design are illustrated. Active learning pedagogies developed for the mechanics course taught in versatile classrooms have been highlighted: the activities are multi-stage (pre-, during-, and post-class) and consist of both individual and group components. Variations of each activity have also been co-designed, thus allowing more instructors to employ them. Our goal is to build on this experience, that is, to co-design more active learning pedagogies for mechanics as well as other physics and science courses, and to allow more instructors to participate in the process. Ultimately, by engaging more instructors in active learning pedagogies, more students will engage with class content in meaningful ways, leading to a more positive experience for both instructors and students.

Kevin:
Hey Rhys! So, what's the learning objective from this article?

Rhys:
Well.… As teachers, we need to practice what we preach: be creative, ask questions and try out new things. Don't give up when things don't work out, but make them better.

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