

# LEVERAGING TECHNOLOGY TO ENHANCE EVIDENCE-BASED PEDAGOGY: A CASE STUDY OF PEER INSTRUCTION IN NORWAY

**Christine Lindstrøm**

Associate Professor of Science

Oslo and Akershus University College of Applied Sciences

**Julie Schell**

Senior Educational Researcher

Harvard University

## Abstract

Peer Instruction (PI) is a research-based instructional strategy developed by Eric Mazur at Harvard University in the 1990s. Instructors across the disciplines, in every institutional type, and in classrooms throughout the world have adopted PI. The method relies on classroom response systems (CRSs) – or systems which allow instructors to collect student responses to questions. While PI can be and often is implemented using low-tech CRSs (e.g. flashcards), it is enhanced when paired with higher-tech tools (e.g. clickers). In this paper, we address the following research problem: Moving from flashcards to clickers in PI has advantages, however there is a lack of clarity about the practical aspects of this transition for individual instructors. We pose the following research questions: What is involved in the transition from a low-tech CRS (e.g. flashcards) to a high-tech CRS (e.g. clickers) for the instructor and students in a PI environment? What are student perceptions about the value of using clickers when they have previously used flashcards? What are the instructor perceptions of the value of using clickers when she has previously used flashcards? The purpose of this paper is to address the research problem and questions by presenting a case study of one instructor's transition from flashcards to clickers in one university classroom. The paper also provides recommendations for instructors wishing to implement clickers to improve ease of implementation. We found that the transition from flashcards to clickers involves primarily familiarizing the instructor and students with the new technology. We also found that both students and the instructor prefer clickers to flashcards. Most importantly, we found that of the pre-service teachers in our sample (N=21) who were taught using PI, 95% indicated that they intend to use PI, versus more traditional approaches, in their own teaching.

## Palabras clave

Peer Instruction, classroom response systems, clickers, flashcards, physics, pre-service teaching, technology.

## 1. Introduction

Peer Instruction (PI) is a research-based instructional strategy developed by Eric Mazur at Harvard University in the 1990s (Mazur, 1997). In a PI class, students receive first exposure<sup>1</sup> to content before class, through readings, videos, or other coverage activities. As such, instructors use PI within a flipped classroom approach. For example, in most traditional classrooms, students receive first exposure to material in class and then study that content further at home. PI flips the sequence of coverage: Instead of instructors covering the material in class and students applying concepts at home, students cover the material at home, and apply concepts in class with instructor guidance.

In Mazur's implementation of Peer Instruction, instructors motivate students to engage in out-of-class work using Just-in-Time Teaching (JiTT) (Novak, Patterson, Gavrin, & Christian, 1999). In JiTT, students complete a coverage activity and then respond to questions posed by the instructor. The Instructor then uses feedback from that first-exposure activity to identify student difficulties. Class time is spent doing ConcepTests – short conceptual questions that elicit, confront, and resolve student difficulty (see Heron, Paula, Shaffer, & McDermott, n.d.). The in-class cycle occurs as follows:

- Instructor provides brief mini-lecture on a concept or topic
- Instructor poses ConcepTest
- Students vote individually
- Students discuss their answers with a neighbor (emphasis is placed on finding a neighbor with a different answer and convincing them with your rationale)
- Students re-vote individually
- Instructor facilitates closure through an explanation of the answer

Research demonstrates that PI is related to a number of important learning outcomes, including improved performance on standardized tests of conceptual understanding, exam scores, problem solving, and retention in STEM courses and majors (Schell, Lukoff, & Mazur, 2013). However, PI implementation researchers also suggest that PI is used in classrooms in many different ways (Dancy & Henderson, 2010). One common variation pertains to how instructors facilitate voting.

## 2. Objectives

Voting on ConcepTests is an important process in PI. It facilitates student and instructor awareness of strengths and weaknesses (i.e. metacognition) and frequent self-monitoring of student learning states (Schell, Lukoff, & Mazur, 2013). There are a variety of classroom

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<sup>1</sup> The term "first exposure" was introduced to us in the book *Effective Grading*, 2009.

response systems (CRSs) available for collecting votes. Low-technology options include having students use their hands to vote (by holding up a finger to indicate answer choice 1, 2, 3, 4 or 5), and flashcards: pieces of paper with letters A,B,C,D that students can hold up to indicate their answer. Higher-technology versions include clickers, or small devices that record student responses and relay those responses to the instructor and more recently, cloud-based CRSs that allow students to use their cell phones or personal computers to vote (see Schell, Lukoff, & Mazur).

(Lasry, 2008) found in a study comparing the use of clickers (n=41) to flashcards (n=42) in introductory physics, where the instructor was held constant, there was no statistically significant difference on exam scores or in performance on a standardized test of conceptual understanding of physics. This finding indicates that in terms of learning, it is the pedagogy that is most important, not the technology.

However, there are advantages to using higher-tech versions of CRSs including more anonymity on the part of the student (they do not have to display their answer for everyone to see), the ability to archive response data, and the ability to engage students with response data, such as histograms and response counts.

In this paper, we address the following research problem: Moving from a low-tech to a high-tech CRS has clear advantages, however there is a lack of clarity about the practical aspects of this transition for individual instructors. We pose the following research questions: What is involved in transition from a low-tech CRS (e.g. flashcards) to a high-tech CRS (e.g. clickers) for the instructor and students? What are student perceptions about the value of using clickers when they have previously used flashcards? What are the instructor perceptions of the value of using clickers when she has previously used flashcards?

The purpose of this paper is to address the research problem by offering a case study of one transition from flashcards – clickers in one university classroom, which addresses the above research questions. The paper also provides recommendations for instructors wishing to implement clickers to improve ease of implementation.

### 3. Methodology

This study was conducted at Oslo and Akershus University College of Applied Sciences (HiOA), the largest educational institution for pre-service teachers in Norway. The full sample comprised (N=21) included 5 male and 16 female pre-service, primary education students in their second year of a four-year university degree. Students take the equivalent of one semester of science; however, this one semester is covered over two semesters in the second year of university. The science course constitutes the following subjects: Biology (32%), Physics (20%), Chemistry (20%), Science Education (15%), Geology and Weather (7%), and Technology and Design (T&D) (7%). The course is taught in sessions of 2 hours 45 minutes duration including two ten-minute breaks, with a total of 44 sessions in an academic year.

PI was used in T&D (three sessions in three weeks, autumn 2012) and Physics (eight sessions in four weeks, spring 2013), both taught by the second author. Classroom-response systems were used in both classes, but a low-technology version was used in the T&D class (flash cards, see figure 1). Clickers were used in the Physics course. Table 1 shows the course content in brief, and the number of Peer Instruction questions used.

**Table 1: Overview of course content and use of Peer Instruction**

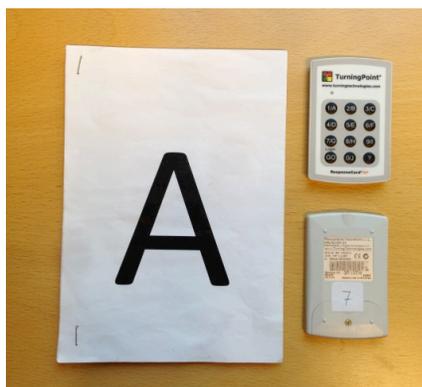
<b>Subject</b>	<b>Topic</b>	<b>Number of PI questions</b>
<b>T&amp;D #1</b>	<b>Intro to T&amp;D</b>	<b>2</b>
<b>T&amp;D #2</b>	<b>Bridges</b>	<b>4</b>
<b>T&amp;D #3</b>	<b>Project presentation</b>	<b>0</b>
<b>Physics #1</b>	<b>Thermal physics</b>	<b>5</b>
<b>Physics #2</b>	<b>Gravity and buoyancy</b>	<b>5</b>
<b>Physics #3</b>	<b>Mechanics</b>	<b>2</b>
<b>Physics #4</b>	<b>Sound</b>	<b>3</b>
<b>Physics #5</b>	<b>Light</b>	<b>4</b>
<b>Physics #6</b>	<b>Electricity</b>	<b>1</b>
<b>Physics #7</b>	<b>Astronomy</b>	<b>4</b>
<b>Physics #8</b>	<b>Group presentation</b>	<b>0</b>

Average course attendance in T&D was 2.4 of 3 sessions, and in Physics 6.7 of 8 sessions (one of which was compulsory in each course). None of the students had studied physics in the last two years of high school.

#### **4. Using low- and high-tech audience response systems with PI**

In T&D, the low-technology classroom response system was used. We used flash cards with the letters A-D. These were made by printing a capital letter onto a white A4 sheet (see Appendix A). Each sheet was subsequently folded and stapled at the corners to produce a relatively sturdy flash card (see Figure 1). At the beginning of each session, the pile of flash cards were handed out to the class, and each student picked a set of letters. The flash cards were collected at the end of the session and kept by the lecturer.

**Figure 1: The low- and high-tech versions of the audience response systems – flash card on the left, clickers on the right**



## 5. About the clickers and software

TurningPoint clickers and software by Turning Technologies were used in Physics. Students' clicker responses are collected via Turning Point software and a USB censor, which the instructor plugs into her laptop or classroom computer before each session. Turning Point offers three different ways of collecting data: PowerPoint Polling, Anywhere Polling, and Self-Paced Polling. We collected responses using Anywhere Polling: This is an option within the software that provides a floating, interactive toolbar over your screen display. You can easily hide or show the students the result of their polls using this toolbar. It also allows the instructor to compare pre- and post-discussion response graphs after the discussion, without revealing the responses prior to the discussion. At the end of each session, the responses to all questions were saved on the instructor's computer.

## 6. Results

Clickers were implemented on all eight days of the sessions related to physics.

### 6.1. Before the first session

The physics course was a repeat of a course the instructor had taught previously, so the majority of the PowerPoint slides and supporting material was already made. Some adjustments were made, however, before each session based on the feedback on the online tests the students did as part of their pre-work.

An introduction to the software and the clickers was given to the instructor via Skype by a research mentor in Australia. After the initial introduction to the use of clickers, the instructor tried them out in her own time in her office, originally by embedding the clicker software in the PowerPoint presentation, using PowerPoint Polling. This revealed, however, that she was unable to compare pre-post graphs using PowerPoint Polling. Thus, this trial raised some

questions that were resolved in a new Skype conversation with the research mentor, which resulted in a decision to use the Anywhere Polling function instead of the PowerPoint Polling due to its greater versatility.

Labels with the numbers 1-21 were attached to the back of 21 functioning clickers (see Figure 1). The class list was used to assign one clicker to each student, which was entered into the software prior to the commencement of the course. The instructor prepared the Turning Point software and class list on her office computer, expecting that it would be accessible from the classroom computer, as all computers in the building are networked.

## **6.2. First session**

In class, students picked up their clickers at the beginning of the session (at least before the Peer Instruction questions started) and returned them at the end.

The instructor expected to be able to pull the software from the office computer. However, she discovered that the software and list were not locally installed on the office computer. The Turning software therefore had to be installed during class, and there was not enough time to create a new participant list, so the system was used on 'auto', thus not registering individual clicker responses during the first session. Due to this unexpected stressor, she also forgot to specifically select to open polls with five alternatives and forgot how to hide the graph showing the results from the poll when it was closed. As the session progressed, however, and these mistakes were discovered, they were rectified.

In spite of a rather disastrous first session, some students verbally expressed to the instructor that they were very excited about using clickers.

## **6.3. Subsequent sessions**

In the second session, the clickers worked quite smoothly. The instructor discovered the benefit of displaying the polling pane during polling, which shows who has voted (see Figure 2). This both motivated the students to vote (it was fun for the students to see their response registered, as verbally indicated by them) and it made students aware of whether their vote had been registered (sometimes they had to press quite hard for the clickers to respond). During this session, a student also asked whether clickers are available for use in schools, illustrating the student's potential consideration of using the clicker as a learning tool as a teacher in his own classroom. At the end of the session the instructor accidentally failed to save the session, however, upon closing the software. As auto-save was not turned on, this resulted in loss of the data.

**Figure 2: The polling pane, hovering above the PowerPoint slide, showing who has voted (highlighted in green)**

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22			

From the third class, everything ran smoothly except for one glitch: one clicker stopped working after a few sessions. As the instructor had not prepared a couple of spare clickers to be used as substitutes in such cases, this student was left without a chance to vote. It is therefore recommended that a few clickers be assigned as spares, so that they can immediately be swapped in case of individual clicker failure and subsequently be assigned to the particular individual in the participant list (if individual response recording is of interest).

From the fourth session on, there were no implementation issues. The Turning software and clickers were easy to use; the only error made was that one session ended up not being saved for unknown reasons (presumably pressing 'Don't save' at the end of a hectic session).

From the perspective of the instructor, once the initial challenges were overcome, the clickers were much preferred over the flash cards. The primary reasons were the same as those given by the students: it made registration of student votes efficient and anonymous, and provided informative graphs. In addition, the data were saved such that the instructor did not have to count or record responses, which were susceptible to errors. The clickers were also more convenient than the flash cards, as the latter became worn and appear to need to be remade each year. In addition, the data the software saves on each individual is very valuable both for teaching purposes – especially to identify at-risk students – and for research purposes, as the instructor's classroom is one of her most important laboratories. The instructor will therefore continue to use CRSs, and will only keep flash cards as a back-up or as illustrations of how students can use a low-tech version in their classrooms if a digital alternative is not available.

## 7. Survey on Student Perception

Students (n=20) completed an anonymous Survey on Student Perception at the end of the last Physics session. For every Physics course taught by the instructor (four in total for the academic year), the students were given this survey. This was the first year the instructor taught physics to pre-service teachers, so she considered the survey an important tool to enable continuous improvement of her Physics courses. She developed the survey herself, including items she wanted feedback on for further course improvement and for use in research reports

and articles. The items requested feedback on how valuable various aspects of the course had been for learning physics, students' level of agreement with 12 different statements, students' perception of PI and the different audience response systems, students' perception of the curriculum and pre-work, and their overall evaluation of the course, with suggestions for improvement.

The instructor was not present when the survey was completed and the surveys were submitted in a box to ensure anonymity. Twenty of 21 students returned the survey, a response rate of 95%. Not all students responded to all questions; in cases where the response rate to a particular question was less than 20 students, the value of  $n$  is quoted.

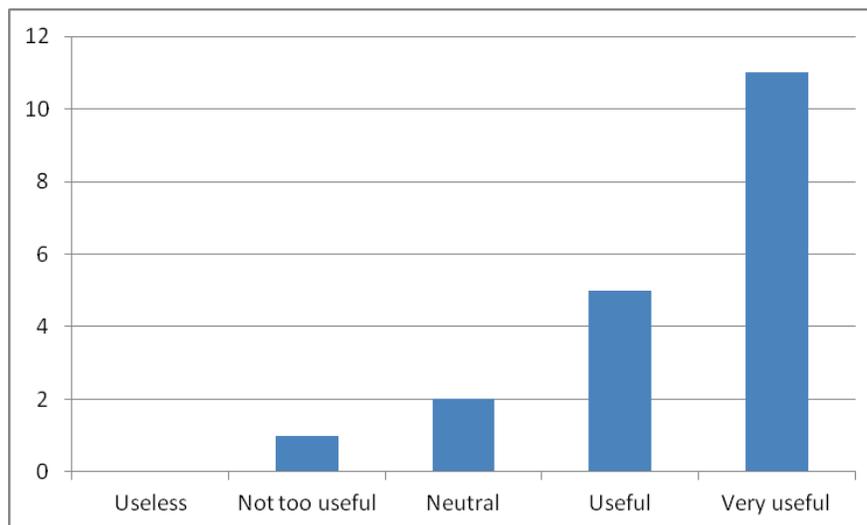
Students were first asked to indicate, on a scale from 1 to 5 (1 = worthless; 3 = OK; 5 = very valuable) how valuable they found ten different aspects of the physics course for learning physics. The results are shown in table 2.

**Table 2: Ranked list with average scores of the value of different aspects of the physics course for learning physics**

Rank	Learning method	Average
1.	Peer Instruction	4.40
2.	Watch videos (pre-work)	4.20
	Experiments	4.20
4.	Read textbook (pre-work)	4.15
5.	Lecture (based on online test)	4.10
6.	Group presentation	4.05
7.	Solutions to in-class exercises	3.94
8.	Exercises (in class)	3.78
9-10.	Online test (pre-work)	3.65
	Exercises (at home)	3.65

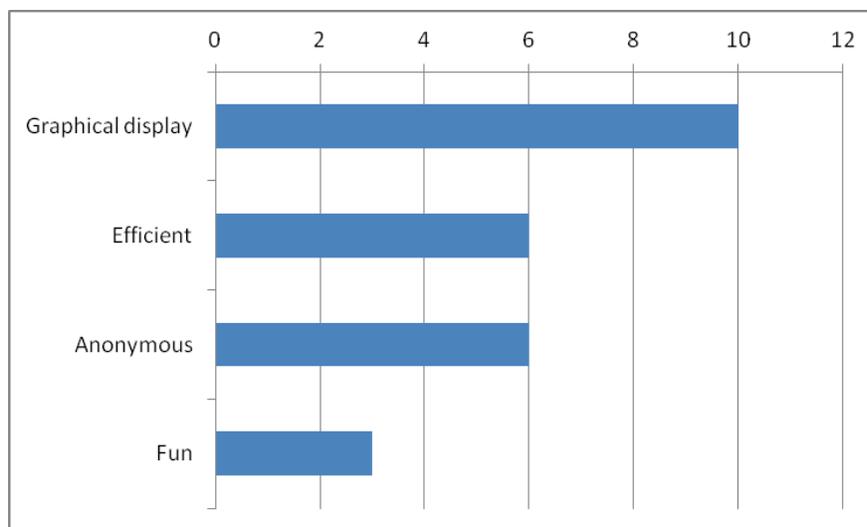
As is clear from table 2, Peer Instruction was considered the most valuable tool for learning physics. This was confirmed by a separate question, 'How useful did you find clickers (as used in Peer Instruction) as a learning tool?', where 11 students responded 'very useful', with an average score of 4.37 ( $n = 19$ ), the same score as in the first question (see Figure 3).

**Figure 3: Student responses to the survey item 'How useful did you find clickers (as used in Peer Instruction) as a learning tool?' (n = 19)**



Probing students' perception of Peer Instruction and the clickers further, it was found that none of the students ( $n = 19$ ) had used clickers before. One short answer question asked the students to compare flash cards with clickers – 'which system do you think was best and why?' Of 18 responses, fifteen students preferred clickers, whereas the remaining considered the two equivalent. Students' reasons for preferring clickers were the graphical display, efficiency, anonymity, and that it was fun (Figure 4).

**Figure 4: Frequency of reasons given by students as to why they preferred clickers to flash cards (n = 18)**



By the end of the course 18 ( $n = 19$ ) students responded that they thought they would try out Peer Instruction in their own teaching in primary school. In response to their plans for their own teaching ( $n = 18$ ), students focused on varied teaching methods (6) with active students (3), using experiments/demonstration (10) and Peer Instruction/discussion/questions (4). This supports the well-known reality that teachers teach in the way they were taught themselves. In this project, we see that if the students are taught using research-based methods, this is what they intend to use in their own teaching.

Students were also asked short answer questions about how the physics course was different from other courses students have had at the same institution ( $n = 19$ ), what worked particularly well in the course ( $n = 19$ ) and how it could be improved ( $n = 18$ ). In summary, students indicated that the course was very different from what they were used to. Explicit mentions of what made it different was Peer Instruction (8), varied teaching methods (4), practical work (4), and the pre-work (4); discussions, good course structure and an enthusiastic teacher were all mentioned three times each. What worked particularly well in the physics course were the teacher explanations (Just-in-time-teaching, 7), Peer Instruction (6) and experiments (5). To improve the course, the feedback overwhelmingly focused on having more time to learn physics (11). No other aspects were mentioned more than twice.

Questions that asked students to indicate on a scale from 1 (strongly disagree) to 5 (strongly agree) revealed that no one thought 'the physics course was boring' (mean = 1.50) nor did they agree that a traditional lecture course would have been better (mean = 1.75). The students also felt that 'the physics course helped me understand physics' (mean = 4.30). Overall, students were satisfied with the course (4.25), even though some thought there was a 'bit too much' content (mean = 3.65, where 3 = content ok, 4 = a bit too much content) and a bit too much pre-work (mean = 3.45, where 3 = amount of pre-work ok, 4 = a bit too much pre-work).

## 8. Discussion

The project reported had two separate aspects: the practical challenges associated with implementation of clickers in a physics course and the response by the students and instructor regarding the perceived value of the clickers as a learning tool for physics.

In terms of the practical implementation of the clickers, the main feature was the necessary preparation from the instructor. This involved receiving an initial introduction by an experienced clicker user, trying it out on her own to identify challenges, and then having a second discussion with the expert to get these particular issues sorted out. The Turning clickers and software were relatively easy to use, so this was sufficient training. Lessons learned resulted in the following recommendations:

- Begin with an introduction to the system by an expert, if possible.
- Try out the system to familiarize yourself with the software. Create a participant list in the software and check that all clickers function properly. Identify questions and challenges.

- Consult the expert with your particular questions and challenges.
- Try out the system in the room where you will use the clickers with your class. If possible, have a trial run with colleagues or a small group of students.
- In class, remember to register the session on the particular participant list you have created for your class.
- During polling, leave the matrix showing who has voted visible on the screen to allow students to check that their vote has been registered.
- Hide the graph for the first poll, before students have discussed the question. Only display the graph after the second poll, and then show both results on one comparison graph.
- This matters most when the question has a right answer, or when there is a large percentage of votes for one response. Showing the results to the students after the first vote may bias their second vote.
- Remember to save the session before closing the software.

## 9. Conclusions

For both instructors and students, moving from a low-tech CRS (e.g. flashcards) to a high-tech CRS (e.g. clickers) in a PI environment involves primarily getting familiar with the technology and its features. This is facilitated when there is an available consultant who is experienced in clicker use. In terms of perceptions among instructors and students who have previously used flashcards, though initially unfamiliar with clickers, both the instructor and the students took to them instantly and preferred them over flash cards due to the clear and informative graphical display of results, and the efficiency and anonymity they offer. In addition, the students thought the clickers were more fun, and the instructor appreciated the clickers' added benefit of storing the individual responses, which are useful both for teaching and research purposes.

Even though the course covered a large amount of material and a wide variety of topics in a short time, students were satisfied with the flipped classroom approach of the course and highlighted Peer Instruction as the most valuable aspect for learning physics. From the instructor's point of view, the flipped classroom structure removes the stress of having to 'cover' the entire course in class, whereas the Just-in-Time Teaching and Peer Instruction allows her to focus on what the students need her help with the most. This project has thus resulted in at least one converted instructor who will never go back to traditional teaching methods – or flash cards! We hope, in addition, that exposure to research-based instructional strategies will inspire pre-service teachers to implement innovative pedagogies in their own classrooms.

## Appendix A

Flashcards - <http://cloud.julieschell.com/0s1w1Q1p0O2Q>

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