Constructive Learning Using Flip-Flop Methodology: Learning by Making Quizzes Synchronized with Video Recording of Lectures

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Abstract. This article introduces the concept of Constructive Learning where students' comprehension is augmented by active creation of teaching materials. It highlights the potential of the Flip-Flop instructional methodology that involves students in creating quizzes synchronized with video recordings of lectures. The premise is that as students create questions, correct and incorrect answers, hints and hint links that lead to relevant resources, they get in depth understanding of the content presented in the video. Peer evaluation is also an integral part of the methodology. The collected data can be used for grading and as a resource pool for future quizzes. We describe the online tools that support the students and instructors. While this method was primarily developed for the use in flipped/inverted classroom settings, it can be applied do any MOOCs or other lecture screencasts or training that employs videos.

Keywords: Instructional methods · Constructive learning · Constructivist learning · Training videos · MOOC · Flipped classroom · Inverted classroom · Course design · Educational technology

1 Introduction

The maxim that 'Learning by teaching' is one of the best - if not the best - method of learning has been around for centuries. Search for his topics on Google Scholar shows 1,570 entries. Among these, numerous books and articles (e.g., [1–4], and Wikipedia summary and references [5]) are devoted to listing the advantages of various approaches to accomplish this maxim and present entire curricula development techniques based on the notion that students learn more and more profoundly if they need to present material to other students and challenge their understanding of the content.

Moreover, 'Active Learning' (see references in Wikipedia [6] and research survey in [7]) and 'Constructivist Learning' concepts – based on Piaget's theory and popularized by Vygotskii [8], also see Wikipedia [9] – have been widely accepted and

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integrated into the typical curricula. One of the tenets of these educational categories is that students should be involved in discovering and creating knowledge rather than simply absorbing lectures.

Search for the term 'flipped classroom' on Internet returns over 5 million entries. Search for 'MOOC' returns 8.5 million page finds. Undoubtedly these fairly recently introduced educational concepts and technologies are popular and gaining ground.

According to the top searches on Internet: 'The flipped classroom is a pedagogical model in which the typical lecture and homework elements of a course are reversed. Short video lectures are viewed by students at home before the class session, while in-class time is devoted to exercises, projects, or discussions.' For overview of flipped classroom approaches and how they fit in the landscape of educational categories see for instance [7, 10].

Typically, the flipped methodology relies on lectures that were recorded on as video. In particular, MOOC (massive open online course, see [11, 12] and Wikipedia [13] for discussion of proliferation and pros and cons of MOOCs) use video recordings of lectures to reach audiences often dispersed around the world. When flipped methodology is employed, the students view the video ahead of the class time and the instruction is devoted to exercises that practice the topics covered in the video lecture. While numerous educational institutions reported marked improvement of student outcomes on high school as well as on university level when flipped classroom is based on video recordings, there is a significant research literature as well as numerous popular journal articles that question their effectiveness (e.g., [14, 15]).

Our experience confirms the criticism, as we found that the most significant disadvantage of the flipped methodology is that here is no guarantee that the students have paid enough attention and understood the lecture while watching the video recording. Using the traditional instructional approach, learners digest a lecture in a controlled environment, mostly void of noise, artificial interruptions and other distractions. Since the flip classroom mandates that students view the lecture at home or in another environment of their choice, they may choose to do so in a noisy coffee shop or in a room shared with siblings who demand their attention. While cell phones are typically banned in a classroom setting, it is quite unlikely that a student will switch off his smart phone and not pick up he call when his girlfriend calls. In particular, it is very unlikely that the students will choose to view a video lecture or even its more difficult segments more than one time, even if they were insecure whether they understood enough of its topics. As a consequence, a substantial percentage of our students often come unprepared so that some of the class time needs to be devoted to reviewing the lecture material rather than to practice and exercises.

To alleviate in particular these disadvantages of flipped classroom and MOOC-based learning, we have developed a 'Flip-flop' method supported by extensive online technology means that involves students in 'constructive' learning by creating teaching materials tightly connected with lecture recordings.

2 Flip-Flop Basics

We propose to augment the inverted 'flip' methodology by an additional 'flop' element that ensures that the students not only review the video lecture, but - which is more important – makes it very likely that they get deeply involved with the topics presented in the screencast and attempt to understand the covered topics well at home before they come to the classroom.

The method is simple: the students construct quizzes that are synchronized with the video recording of a lecture. Moreover, they take quizzes that fellow students created. When they are then exposed to additional practical exercises in the classroom setting, we can expect that they digested the topics they viewed at home well enough that the instructor does not need to spend extra time explaining the subject in detail again and the classroom session can be devoted to the actual practical exercises.

While quiz-making as an educational technology is not new concept and even several commercial companies offer quiz making facilities based on video lectures – e.g., [16, 17], our methodology augments this concept in several important areas: Our quizzes feature feedbacks, hints and hint links and allow the author to choose from a variety of ways to synchronize tasks with the video – paused tasks stop the video while 'segment' tasks are displayed during the length of the corresponding video segment. Moreover, the author of a quiz can choose whether to show which answer is the correct one even when an incorrect answer was selected. Besides multiple-choice type of questions, we support poll tasks – which are important for peer evaluations – as well as 'pinboard tasks' where the author just pins text or an image without requiring the quiz-taker to respond. There is also a gamification element: Correctly answered questions increase the student's score for this quiz. It is up to the author of the quiz to determine the maximum points per task and whether the number of possible points decreases with time.

Since this tightly structured and systematic approach does not explicitly fit the well-documented and researched educational methodologies, we propose the term 'constructive education' for approaches and technologies that require the students to construct teaching materials based on and synchronized with recordings of educational lessons.

2.1 Quiz-Taking and Quiz-Making Technology

The quiz-taking tool plays the lecture screencast in the left pane while the right pane shows the corresponding task: In Fig. 1 the student has answered the question correctly and is rewarded by a smiley face and received 14 points. Notice that the feedback offers an additional information that explains why the chosen answer is indeed correct.

If the student selects the wrong answer, she receives no points and the feedback might indicate why the chosen answer is incorrect, preferably pointing out the likely misconception. This is depicted in Fig. 2.

Note that there is a "Hint" button in the top right corner. When clicked, dialog shows short text paragraph that may lead the student on the right path towards

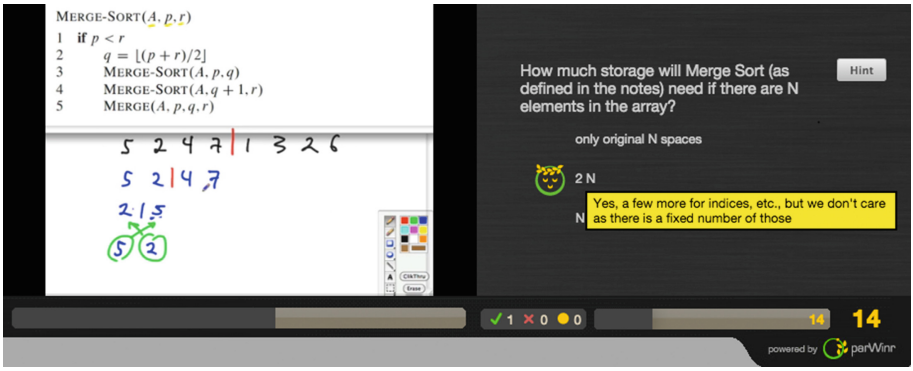

Fig. 1. Taking a quiz: selecting a correct choice displays a feedback that offers additional information.

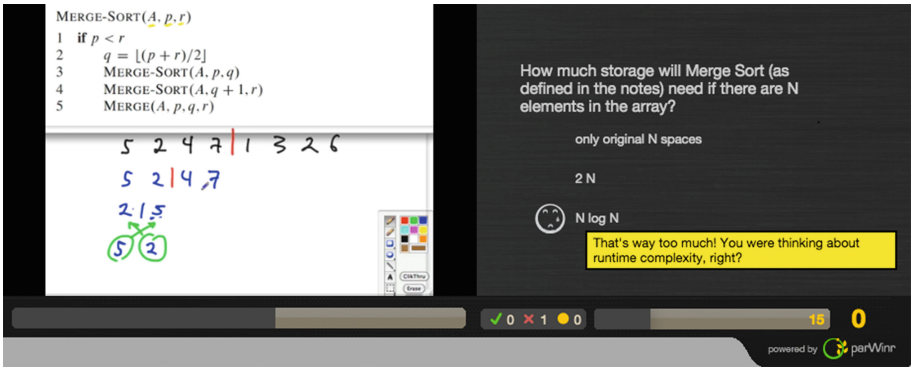

Fig. 2. Taking a quiz: selecting an incorrect choice displays a feedback that points out a possible misconception.

answering the question. As shown in Fig. 3, underneath the hint text is "Analysis of Merge Sort" button that when clicked opens an external webpage within another tab of the browser.

The most important aspect of the Flip-Flop method consists, however, in creating quizzes, not just taking them. Using our simple-to-use authoring tool, students split portions of the lecture video recording that has been posted on a common video platform (such as YouTube) into - typically three to five minutes long - consecutive segments, and add a task to each of the segments. While multiple-choice are the most commonly used tasks, we don't discourage students from using poll or pinboard tasks.

The screenshot in Fig. 4 shows the Flip-Flop authoring tool. The left side of the screen is devoted to the video and its segments. The current third segment is highlighted in green and the handles allow the author to determine the beginning and the end of the sentiment. The larger handles define the beginning and the end of the quiz.

Notice that this entire quiz covers approximately one fourth of the entire video. The right pane defines the task associated with the current segment. Here, the author has typed in the question, the hint, the answers and the feedbacks that where shown to the quiz-taker in Figs. 1, 2, and 3.

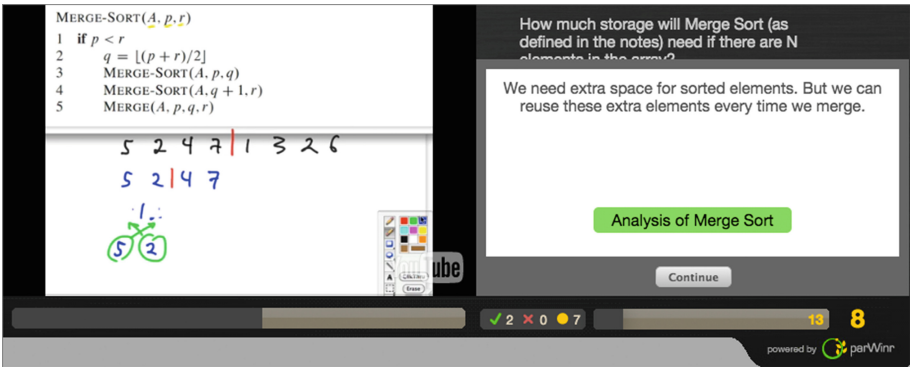

Fig. 3. Taking a quiz: hint with a link to a related resource page

To make the authoring tool initially easier to use for a beginner, the user can choose to display labels rather than icons for the buttons. Moreover, each button has a tooltip that is displayed when the cursor hovers over it for a while.

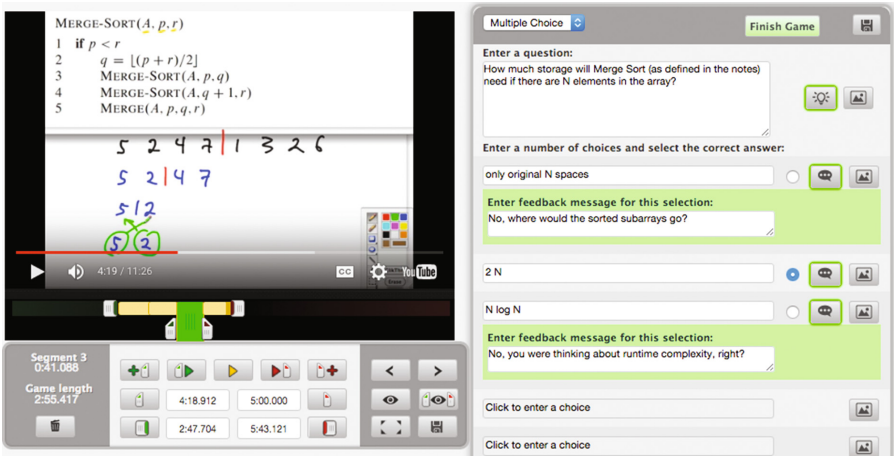

Fig. 4. Creating a quiz: multiple-choice task synchronized with a segment of video and entries for hint text, hint link label, hint link URL, and for choice feedback.

Once the quiz has been created, the author is provided with a simple embed string that when pasted into a page lets the peer students take the quiz. In the modern browsers, no additional web page elements (i.e. HTML code) are necessary.

2.2 Quiz-Making as Learning by Teaching

The Flip-Flop methodology has several advantages: In order to construct a meaningful quiz, the students need to understand the lecture and are likely to review the video recording one or more times until they do so.

In order to add a task, the students have to come up with a question that relates to the topic discussed in the specific lecture segment, with the correct answer, as well as with a few incorrect answers. They may well find that coming up with a relevant question is not always easy.

Moreover, while the correct answer is often quite obvious once the question is decided upon, formulating several incorrect, but not completely irrelevant choices is not a trivial matter: An incorrect answer cannot be partially correct and should not be obvious or easy to guess. And even when it is quite easy to formulate the first wrong answer, additional non-trivial incorrect answers are typically more and more difficult to come up with.

We encourage the students to accompany each of the answers with the feedback that will be displayed once an answer has been selected and emphasize that they should not just use the simple "Yes", "You got it!", "Wrong", or "Really?" feedbacks, but come up with more meaningful reasoning why the answer is good or not. In particular, a good strategy is to point out the misconception that is likely to be the reason behind choosing the incorrect answer.

Adding a hint requires additional skills: Since the length of the hint text is severely limited, students need to summarize their knowledge of the topic. They also need to formulate the hint so that it does not reveal the correct answer and only points towards the right direction.

When creating a hint button that leads to another web page, students practice another set of skills that are and will be increasingly in demand: searching for resources. In order to add a link button, the student has to look for web pages that relate to the question and decide which one of the found pages is the most appropriate, e.g., which explains the topic in more detail – or even better – then mentioned in the video lecture itself. Needless to say, the students are likely to deepen their understanding of the topic at hand from each of the resources they considered. Also, they need to judge the quality of these resources and their appropriateness for the level of course.

Last but not least, having to formulate all the components of a task is an exercise that may improve the students' writing skills.

Peer evaluation is another important component of the inverted classroom that is integrated in Flip-Flop methodology and supported by its tools. The student author has to add several predefined poll questions at the end of each quiz that allow the peers who take her quiz to judge the quality of all the quiz components: the questions, the correct answers, the incorrect answers, the feedbacks, the hint, and the hint links. Figure 5 shows one such poll task being entered within the authoring tool. Obviously, defining

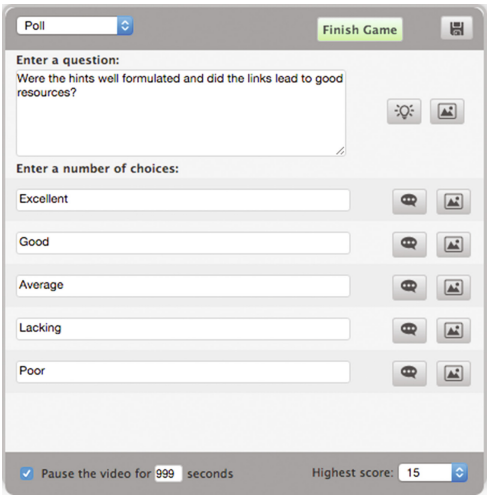

Fig. 5. Defining a peer evaluation task

all these default poll questions is a chore that cannot be automated and we will describe the tools that simplify these and other chores in the next section.

3 Flip-Flop Techniques and Technology

To support pilot experiment that is a currently underway we have expanded the system tools to make Flip-Flop more structured and easier to deploy. The students in a 300-level computer science course that has been previously inverted have been subdivided into randomly selected groups of four students. Each student had to construct a quiz and then also take the quizzes constructed by the other three students in the group. Thus the students are not only the authors of one quiz, but are confronted with several other quizzes related to the same lecture and necessarily have to compare their quiz with the work of their colleagues. Every quiz has to include a question that identifies the student taking the quiz followed by the aforementioned peer evaluation poll. Naturally, the instructor is encouraged to take the students' quizzes and submit her own evaluations.

The course encompasses more than 70 screencasts that are typically up to 20 min long. Each screencast has been subdivided into four approximately five minutes long. These subsections are assigned to every group member so that each student in the group creates a quiz from a different part of the screencast. Therefore every student either creates a quiz or takes a quiz from all the parts of the lecture video.

To facilitate the chores of assigning students to groups whose composition changes every week, subdividing the videos into quizzes, and creating segments and the corresponding tasks within each of the quizzes, we have developed an online scheduling tool depicted in Fig. 6. This tool lists all the screencasts, subdivides them row-wise into

subsections. Every group occupies a column where the blue name identifies the student who is in charge of creating the corresponding quiz.

The screencast titles, thumbnails and ids are links to the videos posted on YouTube. Notice that underneath each of these links is another link to the webpage that contains the topic notes. This feature makes it convenient for the students to consult the corresponding notes while watching a video. We even encourage the students to use the notes while constructing a quiz since even if they copy and paste text from the notes into a question and an answer, they will have to reformulate the text in most cases and they will rarely find there the alternative incorrect answers.

Hovering the cursor over the name of an author brings up the menu displayed in Fig. 7. As the tooltip indicates, the "Take Quiz" item serves two purposes: Since it is a link the quiz page, the group members can use it to take the quiz. For the author of the quiz it serves as check that her web page is functional, i.e., whether the corresponding file on the server is in the correct folder, and has the correct name and permissions.

The "Save Template" item greatly simplifies the author's menial and otherwise considerably time-consuming chores in defining the quiz segments, multiple-choice tasks and peer evaluation polls. After the author uploads such a template within the authoring tool, she is presented with a default quiz that has already all these components. For instance, the start and end points of the quiz and of each its segments shown in Fig. 4 have been created with such a template. Note that since the peer evaluation poll questions are the same for all quizzes, the template completely eliminates any effort in defining them.

But the template is not only a time-saving device – it allows the student author to fully concentrate on the creative aspect of constructing a quiz rather than being distracted by chores that do not foster her learning experience.

The template has another subliminal side-effect: Under the guise of providing all the features a task may incorporate, it equips every multiple-choice question with one correct and two incorrect answers, every answer with a default feedback, and every task with a hint and a hint link. Therefore the student needs to delete some of these components if she does not want to provide them. Not only is this an extra step, but we suspect that students will hesitate to delete proposed elements and step up to the challenge of creating the corresponding content even though we expressly mention that they will not be penalized for simplifying the default quiz.

The last two menu items further simplify the author's chores – they notifying the other members of her group via email that the quiz is ready.

To help the students to get familiar and confident in using the tools we have developed extensive tutorials that describe the individual tool features as well as strategies that may improve the quality of their quizzes.

Our Flip-Flop technology offers another tool that supports the instructor. The online Quiz Evaluation tool shown in Fig. 8 presents the students and their quizzes in a hierarchical fashion that allows the instructor to drill down the work of every student to the level of individual quiz components. She can not only view all the questions, answers and their correctness (according to the author), feedbacks and hints, she can also access the documents referenced by the hint links because each of these links this represented by buttons that leads to the corresponding web page. The number of questions answered correctly when a student took quizzes is currently only displayed in

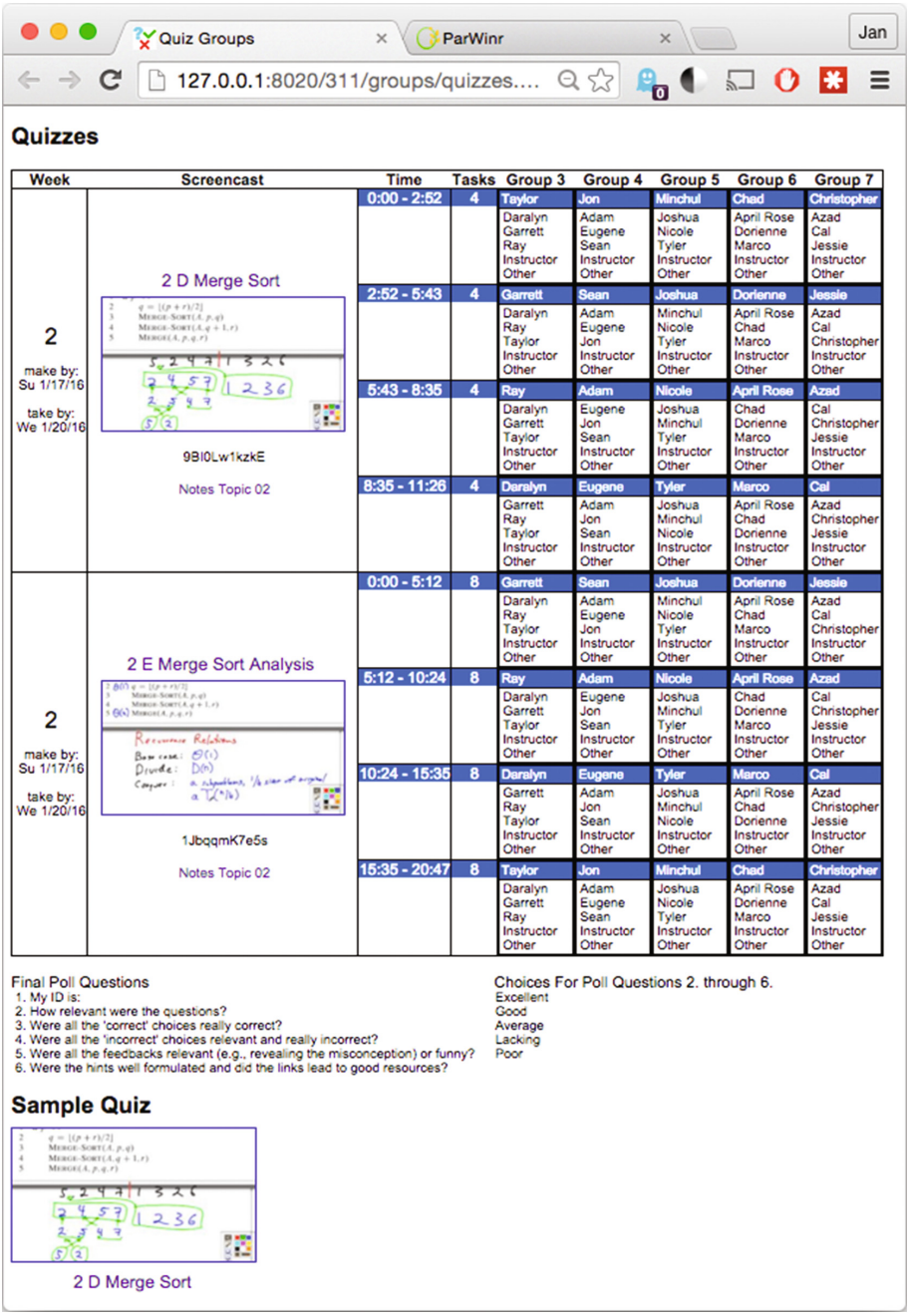

Fig. 6. Scheduling tool: subdivision into groups, screencast segments. Note links to screencasts on YouTube, web pages with topics notes, and splits of time segments for a quiz.

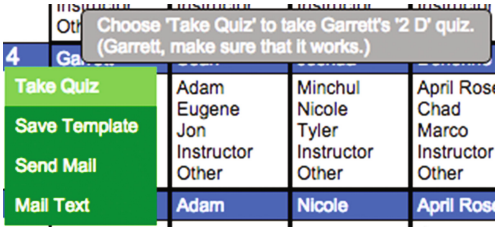

Fig. 7. Scheduling tool facilities: note tooltips and Save Template item that greatly simplifies quiz making chores.

summarily fashion, as the correctness would have to be first approved by an expert to be used as a reliable measure.

Notice that the peer evaluation scores are also displayed in brackets after the quiz titles. We intend to improve the visualization this peer evaluation, for instance in the form of the customary partially filled stars.

Another feature which is still under construction, is the instructor' evaluation of the students work. While currently the instructor can already provide the same scores as the student within the red pop-up dialogue, we intend to develop scoring for each of the individual test components as well as an easy way to correct and improve them. Moreover, we plan to incorporate additional grading facilities within our tools.

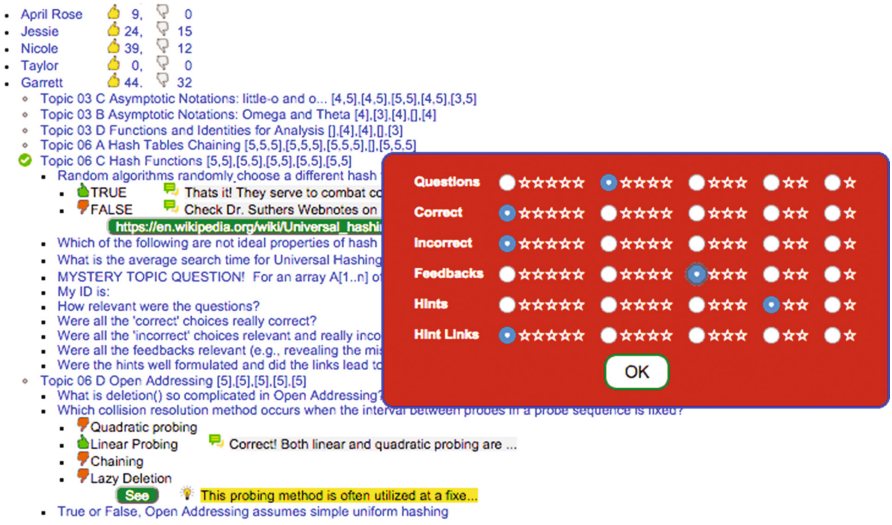

Fig. 8. Instructor's tool: drilling-down students' quizzes: note results achieved in all quizzes (thumbs-up and -down next to students' names), feedbacks in gray, buttons for hint links. Clicking the green check icon next to the quiz title displays a dialog where instructor can enter her own evaluation of the quiz.

4 Conclusions

The Flip-Flop methodology makes the concept of "learning by teaching" a well-defined and structured method supported by concrete technology. As students create and take each other's quizzes they practice skills that are essential to comprehension: asking questions, judging the correctness of answers, summarizing information and searching for resources.

The Flip-Flop tools support not only students while they create and take quizzes based on lecture screencasts, they facilitate peer evaluations, and provide the instructor with a wealth of data. This data can, for instance, make the task that most instructors like the least - the grading - less time consuming. Moreover, instructors can be reuse past quizzes in their future courses.

5 Future Plans

The Flip-Flop methodology will be investigated in detail during the Fall 2016 semester using surveys, data analysis as well as neuro-physiological methods [18].

The underlying technology can be further developed to simplify creating quizzes: For instance, video transcript and analysis of the audio track can help determine good beginning and end of segments within the video.

As the students develop expertise in creating quizzes and experience what makes a good quiz while taking the quizzes by their peers we expect that strategies emerge that can be reused in future courses. For instance, students are likely develop preference for paused questions as opposed to questions that appear while a segment plays or intersperse relaxing 'pinboards' and opinion polls in between difficult tasks.

Artificial intelligence will benefit the quiz authors as it can suggest questions based on the video content and transcript, correct answers, as well as documents to be used hint links. For instance, we are discussing with IBM whether IBM Watson [19] can be integrated into the Flip-Flop tools. On the other hand, artificial intelligence frameworks can benefit from the experts' knowledge while as they construct Flip-Flop quizzes. To use IBM Watson, a client must first 'ingest' documents and then 'train' Watson with questions and correct answers and that is exactly what hint links and quiz tasks provide.

Further interesting and enhancements would become possible once the database of tasks reaches substantial volume. For instance, it will become feasible to choose tasks randomly for a particular screencast or give precedence to tasks with higher evaluation scores.

References

1. Duran, D.: Learning-by-teaching. Evidence and implications as a pedagogical mechanism. In: Innovations in Education and Teaching International, pp. 1–9 (2016)
2. Hanke, U.: Learning by teaching. In: Seel, N.M. (ed.) Encyclopedia of the Sciences of Learning, pp. 1830–1832. Springer, Heidelberg (2012)

3. Goodlad, S., Hirst, B.: Peer Tutoring: A Guide to Learning by Teaching. Nichols Publishing, New York (1989)
4. Biswas, G., Segedy, J.R., Bunchongchit, K.: From design to implementation to practice a learning by teaching system: Betty's Brain. Int. J. Artif. Intell. Edu. pp. 1–5 (2015)
5. Wikipedia. https://en.wikipedia.org/wiki/Learning_by_teaching
6. Wikipedia. https://en.wikipedia.org/wiki/Active_learning
7. Bishop, J.L., Verleger, M.A.: The flipped classroom: a survey of the research. In: ASEE National Conference Proceedings, Atlanta, GA (2013)
8. Vygotskii, L.S.: Mind in Society: The Development of Higher Psychological Processes. Harvard University Press, Cambridge (1978)
9. Wikipedia. https://en.wikipedia.org/wiki/Constructivism_(philosophy_of_education)
10. Wikipedia. https://en.wikipedia.org/wiki/Flipped_classroom
11. Baggaley, J.: MOOC rampant. Distance Educ. **34**(3), 368–378 (2013)
12. Christensen, G., Steinmetz, A., Alcorn, B., Bennett, A., Woods, D., Emanuel, E.J.: The MOOC phenomenon: who takes massive open online courses and why? Available at SSRN 2350964. November 2013
13. Wikipedia. https://en.wikipedia.org/wiki/Massive_open_online_course
14. Vardi, M.Y.: Will MOOCs destroy academia? Commun. ACM **55**(11), 5–10 (2012)
15. San Jose State to Michael Sandel: Keep your MOOC off our campus. Boston Globe. 3 May 2013
16. Kahoot! https://getkahoot.com/ways-to-play
17. Zaption. https://www.zaption.com
18. Stelovsky, J., Minas, R.K., Stelovska, U., Wu, J.: Applying Augmented Cognition to Flip-Flop Methodology. Proceedings of HCII 2016 Conference. Springer, Toronto (2016)
19. Meet Watson. http://www.ibm.com/smarterplanet/us/en/ibmwatson/