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## **AC 2011-607: AN EVALUATION OF THE "JUST IN TIME TEACHING" METHOD ACROSS DISCIPLINES**

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The implemented method aims at adjusting teaching content “just in time” (JiTT), shortly before class, based on students’ understanding and feedback on the concepts learned. Student reading is stimulated by online questions on topics to be taught. Questions are to be answered before the class begins. The instructor can see student answers in a spreadsheet format in real time. Upon scrolling over student answers, the instructor can quickly adjust lecture content to topics signaled by the students as being more unclear or more difficult to understand. JiTT involves more student work, as students are guided to read anticipated lecture content in advance and to answer questions. In order to assess the appropriateness of JiTT at different class levels and across disciplines, the method was implemented in two physics, one software engineering/computer science, and one composition classes. A common questionnaire was given to all students for comparing results and student perception. The majority of the survey respondents felt that the online assignments helped them very much with keeping up with lecture material, while they activated students likely to be passive in the groups. Most of the respondents were indeed interested or even excited when their answers were discussed in class, which is in tune with the fact that students became more curious about the material and their work after completing the online questionnaire. Factors perceived by the students to be motivating them to prepare for class are identified, with the online questionnaire on top for all four courses taught by different instructors. It is interesting to note that although the implementation of JiTT was somehow different, depending on each instructor’s style, and although class levels and disciplines were different, significantly similar positive perceptions were recorded for different criteria.

### **I. INTRODUCTION**

Many instructors have difficulties making students read outside the class [1]. We use online quizzes for obtaining feedback on the students’ comprehension of topics not yet taught in the classroom. Variations of the method were originally developed in 1996 at IUPUI and the US Force Academy; the term “Just in Time Teaching” or JiTT was coined. In this approach, students complete online assignments/quizzes [2] by a certain deadline. Instructors adjust lectures “Just in time” not only to cover the curriculum but also to respond to student needs [3] so that the feedback loop is closed. The end result is a student-centered strategy even in large lecture classes [4]. Likely, the most important success factor is using “good” questions in the quizzes [3]. In addition, JiTT allows for keeping the students engaged and for increasing the likelihood of them reading the assignments [1]. The method was applied to different fields of studies, such as physics [5], biology [6], geosciences [7], economics [8], astronomy [9], environmental engineering [10] or photography [11]; from introductory, general education classes to upper level ones, for small or large classes [11]. More information can be found in [13]. We experimented

with a version of this method in three different classes and two disciplines. The focus of our research was mainly guided by the following questions:

1. *What are the gains* associated with this method?
2. Given that the three courses have different levels of difficulty, are taught by different instructors, in different disciplines, and have different specifics regarding the implementation of the method, *what are the common characteristics observed (if any) in student learning, learning patterns, and teaching efficiency?*
3. *What would be the appropriate range for the weight of online quizzes* when grading them (not unduly pressuring students while at the same time giving them "credit" for participation)?
4. *Is the method more beneficial in introductory courses* than in advanced ones?

## 2. METHODOLOGY

Students were explained that online questions/quizzes will be uploaded approximately on a weekly basis. We aimed at adjusting teaching content “just in time,” shortly before class, based on the students’ understanding and feedback. The method requires that students read in advance topics to be taught in class and answer a few questions before class begins. Depending on the course, the answers were requested a few hours before the class started. The weight of the online quizzes was 0% for PHY111, 3% for PHY112, and 10% for CSC322. This variable weight was assigned in the hope of identifying the balanced weight to be assigned in the future, so that students should be motivated enough to answer the questionnaire but not overloaded by this grade component.

For the implementation of the method Google Docs Forms were employed for PHY111; this requires a Gmail account and the creation of forms that include the questions the instructor considers important for assessment of student understanding of concepts. Once the form is created, it can be emailed to the class (student emails are needed). The email contains a link that takes the student to the created survey form, where students input their answers. The instructor can see student answers in a spreadsheet format in real time. Upon scrolling over student answers, the instructor can quickly adjust lecture content towards topics signaled by the students as being more unclear or more difficult to understand – all “just in time”. The Angel system was used for CSC322 and PHY112; it allows the course editor to create surveys in the form of quizzes. It is possible to add questions to a survey in free-form text with basic formatting, which was sufficient for the purposes of the course.

The CSC322 - Systems Programming is cross-listed for computer science and software engineering students. The instructor teaching this course is a software engineering faculty. This appears as a difficult course to teach, as it requires students to learn programming with assembly language and machine instructions as well as to tackle various issues at this fundamental level. PHY111 - College Physics I is an algebra-based introductory physics course. The instructor teaching this course is an ECE faculty temporarily based in Physics. PHY112 - General University Physics is a calculus-based course. The instructor teaching this course is a Physics faculty.

In order to assess the impact of the method, a questionnaire (Table 1) common to all three courses was given at the end of the semester. The survey was given online and it was anonymous.

Table1. Feedback questions about the online quizzes methodology.

Q1. On days when there was an online preparation assignment, I was more likely to do the reading assignment?
Q2. After an online preparation assignment, I looked forward to the discussion we would have in class about it.
Q3. I found that the online preparation assignments and the discussions we had in class about them helped me learn the course material better.
Q4. When an answer I submitted was discussed by the class I felt: excited, embarrassed, apprehensive, interested, I don't think my answers were presented to the class
Q5. In your opinion, which of these options would motivate students to prepare for class by doing the reading assignments? A. Daily quizzes over the reading B. Pop quizzes over the reading C. Online preparation assignments (as done in this course) D. Nothing, just assign the reading E. Class discussion about the reading that assumes the reading was done prior to class F. Other
Q6. About how much time per week did you spend outside of class working on this course? A. less than 1 h/week B. 1-4 h/week C. more than 4 h/week
Q7. Please check all that are true about your learning behavior this semester in this course. A. I almost always read the book before quizzes. B. I almost always came to class and was there before class started. C. I often worked with classmates on the homework. D. When I got stuck on a problem, I sought help from the textbook E. When I got stuck on a problem, I visited the professor's office hours. F. I completed and turned in all homework assignments. G. I participated in all online quizzes. H. I made sure I understood the material before each exam.
Q8. Please provide any other comments or suggestions about the quizzes. Thank you for your input.

In CSC322 there was approximately one online quiz per week. The quiz was prepared two days in advance and it was posted on the course web page within Angel. Students had the strict deadline of 1:00 p.m. to answer the quiz and solve the problems in it. A quiz typically contained *three or four questions*. Anonymous student answers to each question were shown on the screen. The class first pinpointed the correct answer to the question, and then discussed why it was correct and the potential errors made by the students who submitted incorrect answers. Due to the anonymity of student responses, there was no fear of ridicule, and students were able to gain the necessary knowledge without peer pressure.

Here is a sample quiz:

*Suppose we are given the task of generating code to multiply integer variable  $x$  by various different constant factors  $K$ . To be efficient, we want to use only the operations  $+$ ,  $-$ , and  $\ll$ . For the following  $K$ , write expressions in  $C$  to perform the multiplication using only the above operations.*

- A.  $K = 17$
- B.  $K = -7$
- C.  $K = 60$
- D.  $K = -112$

**PHY111 and PHY112** The teaching strategy in this course was accompanied by presentations, board discussions, problem solving, and exams.

The following are sample questions from quizzes in PHY111:

- *Can you make a vector out of scalars?*
- *The speed of a car increases the following way: within the first 4 seconds the speed increases from 0 to 4 m/s; the next 4 seconds the speed increases to 12 m/s.*
- *What was the average speed of the car?*
- *How would you describe the linear motion of an object that has negative velocity and positive acceleration?*
- *What are the parameters that limit your speed while driving on a curve?*

Typically, there were one or two questions posted.

### 3. RESULTS AND ANALYSIS

The first three questions in Table 1 were evaluated on a Likert-like scale: strongly agree (SA), agree (A), neutral (N), disagree (D), and strongly disagree (SD).

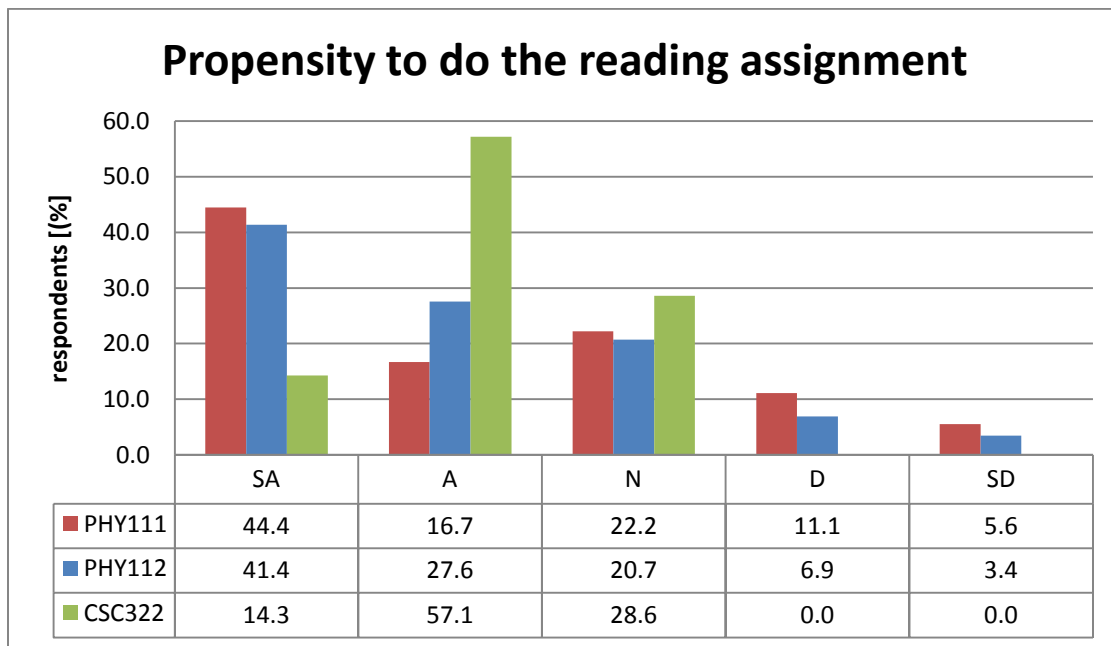


Fig. 1 Responses to question 1: *On days when there was an online preparation assignment, I was more likely to do the reading assignment?*

Fig. 1 shows student responses to question 1. The online assignment really stimulated (A and SA) most respondents (about 61% to 71%) to do the reading assignments. Yet, a few were little influenced, if at all (D and SD). Although the results are consistent overall for all three courses, there are specifics for each course. For instance, CSC322 students were stimulated by the

assignment/quiz (A 57%) but not overly stimulated (SA 14%). At the same time, for PHY111 and PHY112 many respondents were overly stimulated (SA over 40%). The patterns for the Physics course are fairly similar and different from those for CSC322. Although there are differences in response patterns, it is true for all courses that students were more likely to do the reading assignment. *That means in fact that they would take the textbook and read in advance, browse and try to understand concepts on their own in order to complete the online quiz. This habit generated by means of the online quizzes is in addition to the regular homework arising from the topics discussed in class.* Reading in advance, done by most respondents (except for those who disagreed - D and SD), developed additional skills and built confidence that students can work on their own and understand new concepts. Such skills are extremely valuable in the long run and they are transferrable to other disciplines.

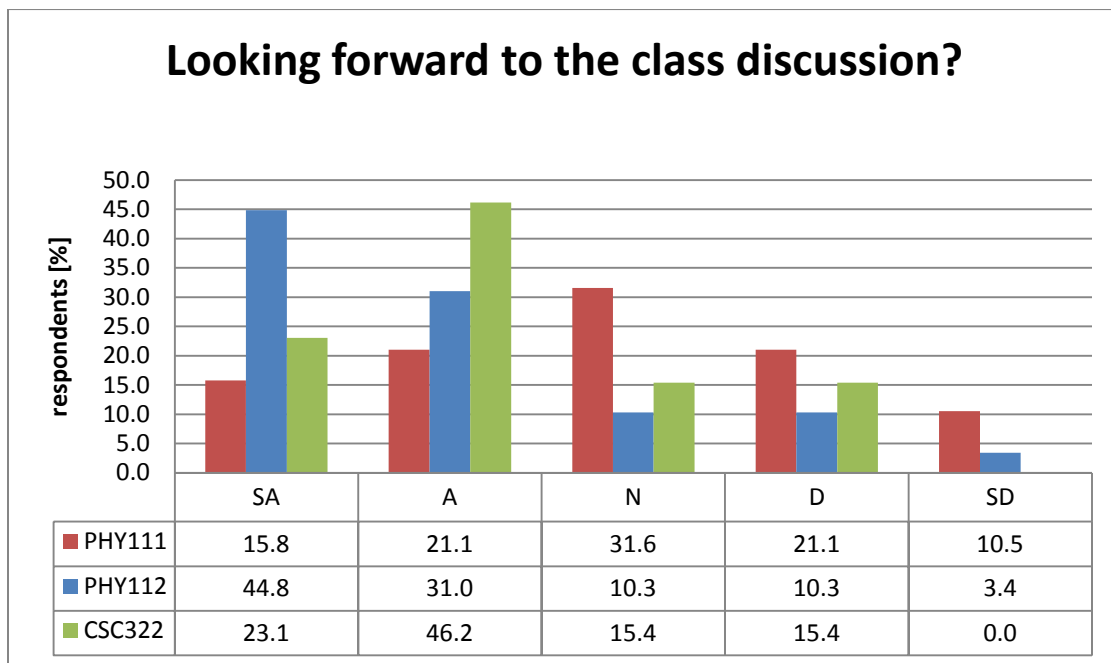


Fig. 2 Responses to question 2: *After a quiz I looked forward to the discussion we would have in class about it?*

Fig.2 shows the responses to question 2. Most students were happy and curious about the class discussions based on online quizzes. It appears that the most excited were students in PHY112 (75.8% SA and A), followed by those in CSC322 (69.3% SA and A) and those in PHY111 (36.9% SA and A). PHY111 had a fairly balanced response to this question with more than 30% of responses being neutral and a similar fraction for those who were not excited about the discussions. Certainly, each instructor has a different teaching style and there are specifics for each course that may influence results. In addition, the lower excitement in PHY111 may be related to the students' lower motivation for independent work (no weight assigned to online quizzes) and accordingly less effort channeled towards extra-study and less enthusiasm about class discussions.

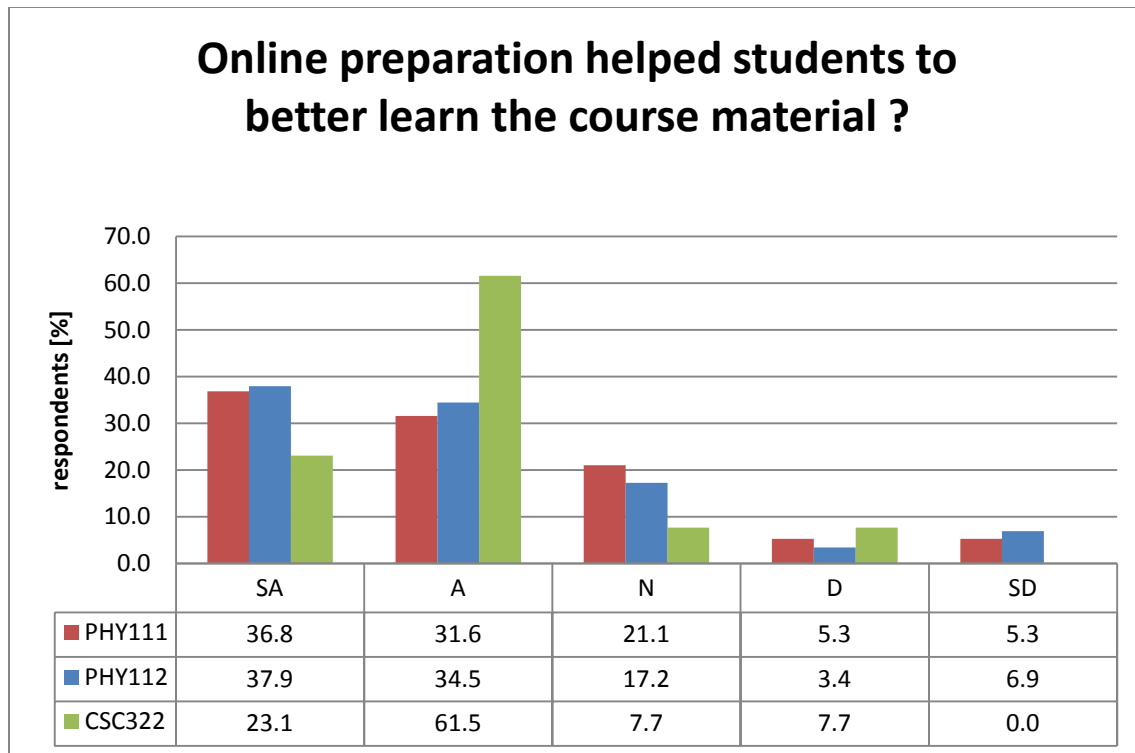


Fig. 3 Responses to question 3: *I found that the online quizzes and the discussions we had in class about them helped me learn the course material better.*

Student opinion about the influence of online quizzes (Fig. 3) is overwhelmingly positive. Only up to about 10% (D and SD) of the responses in any of the three courses disagreed about the fact that quizzes and related class discussions helped them better learn the course material. A majority of 84.6% (A and SA) of the responses were positive for CSC322, 72.4% for PHY112, and 68.4% for PHY111. The fraction of those remaining neutral (virtually feeling that were not affected by the method used) is close to 20% for Physics courses and 7.7 % for CSC322. This difference may be correlated again with the weight associated with the quizzes for each course. CSC322 had a 10% weight and questions used in quizzes were more difficult and required more time to prepare; accordingly, the learning process was likely to be intensified relative to simpler questions for the introductory physics courses. Nevertheless, for all courses most respondents felt that the method helped them learn better. This is interesting, as these results came with one or two quiz questions for Physics courses and three questions for CSC322. It appears that the number of questions does not matter much, as long as students are motivated to read and search for the relevant information through the textbook before class, which again seems to be the greatest gain.

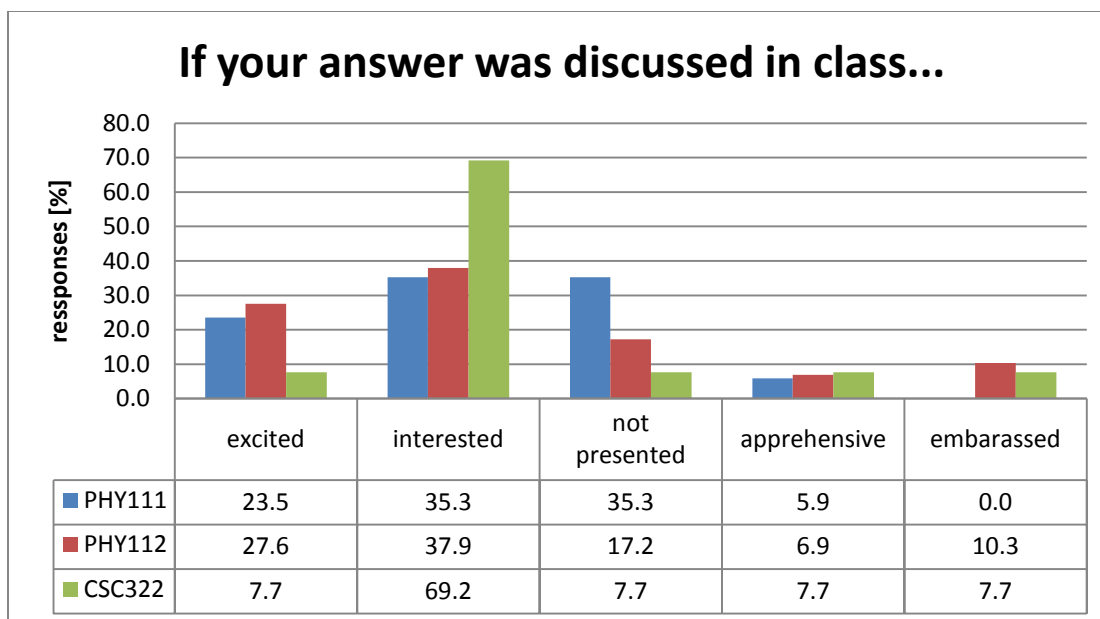


Fig. 4 Responses to question 4: *When an answer I submitted was discussed by the class I felt...*

Another measure for student perception of this method is given by responses to question 4 (Fig.4). Students in CSC322 were very interested in class discussions (almost 70%) generated by their answers but hardly anybody was excited (7.7%). At the same time about 25% of the respondents in the Physics courses were excited, while close to 36% were interested in class discussions. This difference may result from the fact that CSC322 is an advanced course (vs. introductory Physics courses) and students are more mature and have a more balanced sense of what they want to learn and of the effort needed for learning. It is also noticeable that almost all students in CSC322 had seen their answers discussed in class. This may be correlated to class size, significantly smaller than the two Physics classes examined. On the other hand, very few students were actually apprehensive or embarrassed by class discussion around their quiz responses, irrespective of the course. That indicates that in general students feel good about their answers being discussed in class, possibly because this is perceived as more individualized education.

Question 5 attempts to identify the relative importance of motivation factors. Preparation for online questions stands out as the main motivator, irrespective of the course. It is also noticeable that for CSC322 this factor is present in more than 50% of the responses (about 10% more than in the Physics courses). Daily quizzes come as the next important factor for Physics courses but reading discussion comes second for CSC322. Pop quizzes have little relevance as a motivational factor for all courses while the reading assignment alone has virtually no relevance (only small relevance for PHY112). Reading discussion has good relevance for CSC322, some for PHY112 and minimal for PHY111.



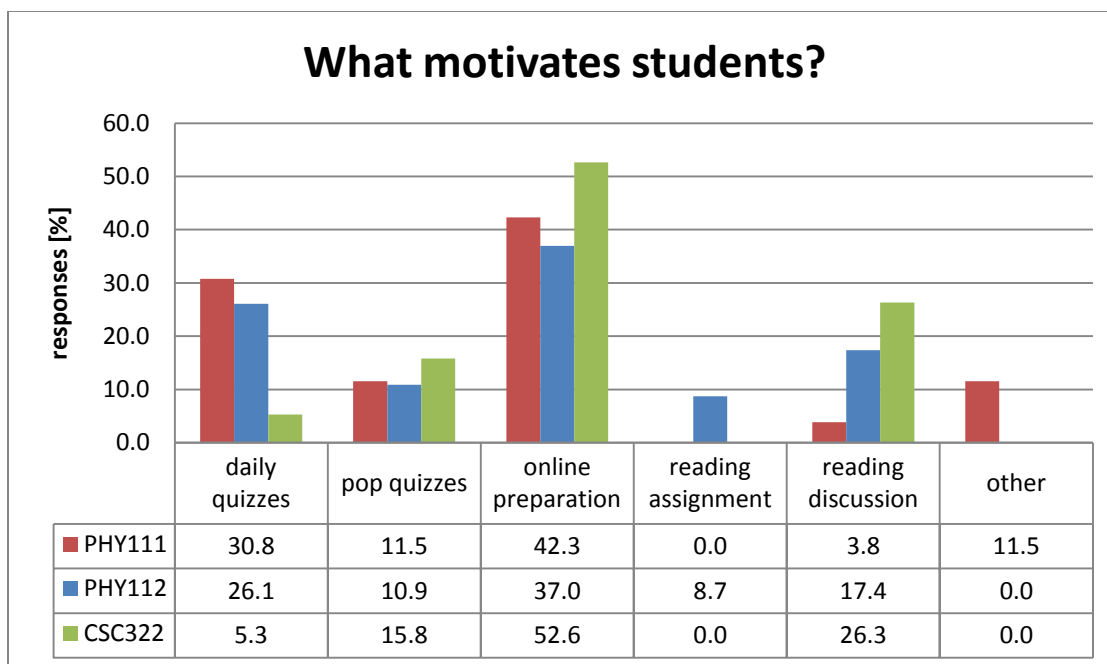


Fig. 5 Responses to question 5: *In your opinion, which of these options would motivate students to prepare for class by reading the book? Check all that apply...*

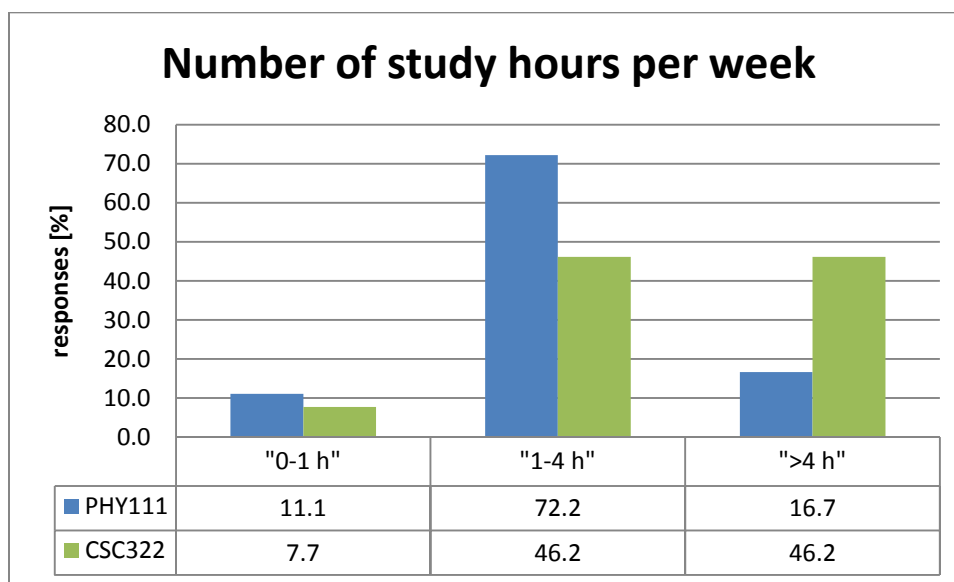


Fig. 6 Responses to question 6: *About how much time per week did you spend outside of class working on this course?*

Responses to question 6 (Fig. 6) were unitary only partially, so a comparison can be done only between CSC322 and PHY111. About the same fraction of responses indicates that in both courses students studied up to one hour per week. However, more than 70% studied between one and four hours in PHY111, while for CSC322 the fraction represents only 46%. A significantly

larger fraction of the students in CSC322 than in PHY111 studied more than four hours. This conclusion correlates well with the courses' levels (CSC is an advanced course).

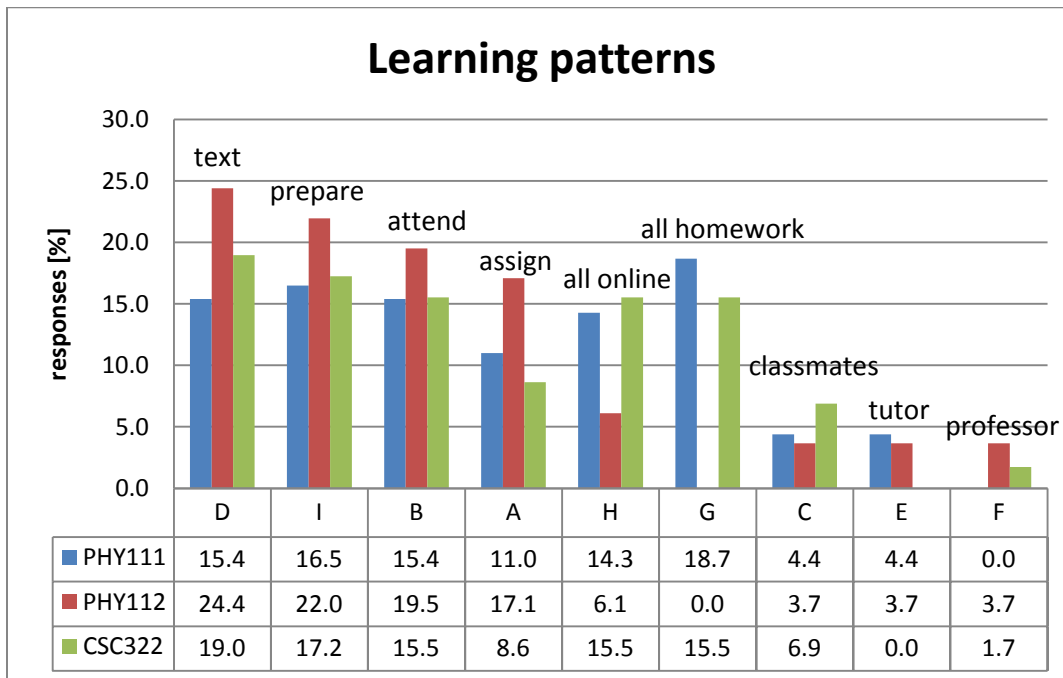


Fig. 7 Responses to question 7: Please check all that are true about your learning behavior this semester in this course... (see Table 1).

Question 7 attempted to identify learning patterns related to the course (Fig. 7). For all courses, a prominent learning pattern is the use of the textbook when encountering a problem (D). It appears that students are more conscientious in preparation for exams (I). Also, among the respondents, class attendance (B) appears as an important pattern. Reading assignments (A) were done particularly by students in PHY112. However, a significantly smaller fraction of responses were related to all online quizzes being completed (H). None of the respondents in PHY112 turned in all homework assignments (G). A relatively small fraction of respondents in each class actually worked in groups with their classmates on the homework (C). There is a strong indication for all classes that students do not ask for their instructor's help (F) but rather use other ways (particularly the textbook and sometimes a tutor (E)) to find solutions to problems. To a certain extent, this can indicate increased student self-confidence in solving problems using their own ability. It is interesting that none of the respondents in PHY111 came to see the instructor, although they were always encouraged to do so. On a different note, teaching evaluation forms typically ask students if the instructor was available during office hours. Given the low use of the instructor's office hours, answers to this question come to relate to other subjective factors or students may just choose "neuter".

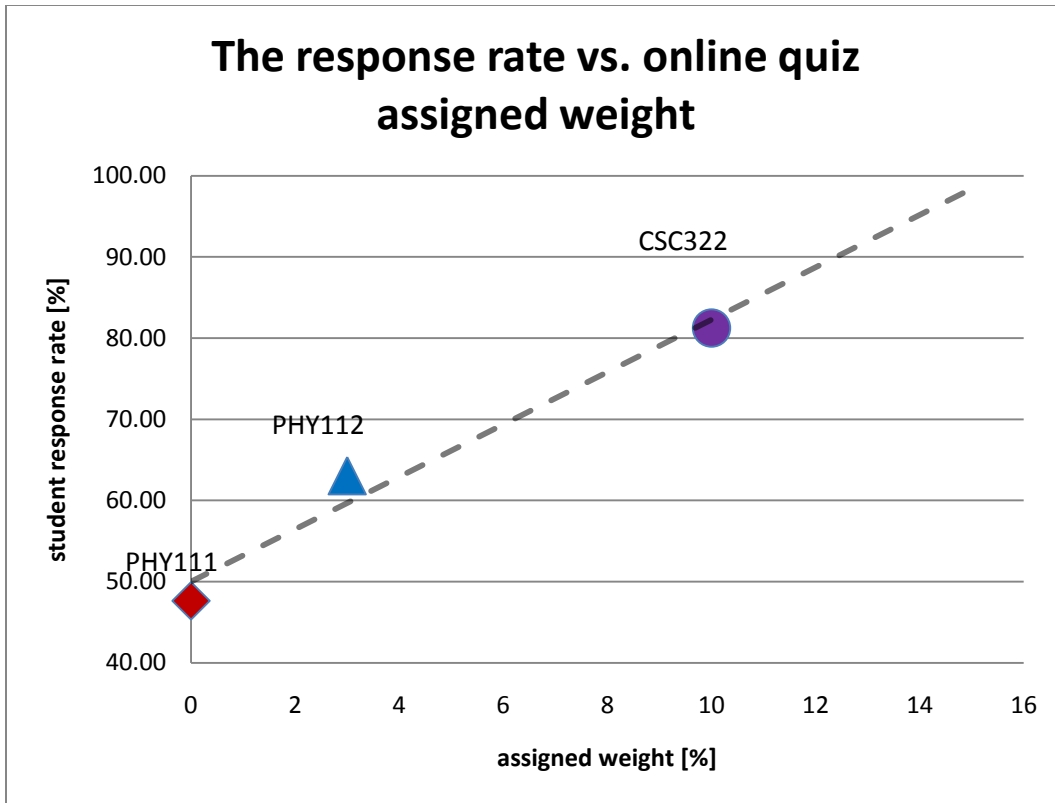


Fig. 9. Percentage of student response rate versus assigned weight.

There were 40 students in PHY111 and 20 responses, 46 students in PHY112 and 29 responses, and 16 students in CSC322 and 13 responses. The percentage of student response for each course is given in Fig. 9. The chart was obtained by plotting the student response rate against the percentage weight assigned for online quizzes. PHY111 had a 0% weight assigned and the obtained response rate was close to 50% while CSC322 had a 10% weight assigned with a response rate higher than 80%. A linear regression line is also plotted in Fig. 9, which meets the 100% response rate for an assigned weight close to 15%. Although the response rate may not vary linearly with the assigned weight (particularly at response rates larger than 80%) it provides a good estimate for what the assigned weight should not be. It appears from our data that assigning weights larger than 15% is essentially pushing for close to 100% student participation in online quizzes. The maximum gain in participation for weights larger than 10% appears to be limited to maximum 20% (for whatever weight increase). Therefore, we were satisfied with an assigned weight of about 10%, which may stimulate students to respond at a good rate, likely without being under the impression that online quizzes are absolutely vital and thus possibly becoming annoyed by this requirement. It is also interesting to remark that a worth of 10% appears to produce an increase in response rate of over 30%. The estimates we could derive from our data should be further verified in other similar studies. Nevertheless, the results appear

consistent and seem to give an interesting insight about the process of calibrating the weight of online quizzes.

### **Sample comments from students with respect to online quizzes/assignments:**

#### **CSC322**

- *The quizzes were a strong point of the class this semester. It was helpful to see that other people were having a hard time with certain topics as well.*
- *The book is a complicated read, but I actually read chapters from it so it was cool.*
- *If the quiz is online, you can also ask more obscure questions and expect the student to have to track down the answers in the book.*

#### **PHY111**

- *I liked them a lot, actually. They made me actually open the book and at least skim if not read the chapters, helping my understanding of the class increase a lot! Keep them up!*
- *I liked the assignments; they helped me a lot. It would be easier if they were scheduled to come at a certain time each week.*
- *They got started you off in the right track which helped a lot.*

#### **PHY112**

- *I liked this class very much - with the quizzes, and the online assignments.*
- *I liked the online questions, but also the weekly quizzes and the group work.*
- *I did not like them.*
- *You are my favorite professor and I enjoy your methods.*

Most of the comments are favorable with regard to online quizzes and students acknowledged their benefits.

## **4. CONCLUSIONS**

Online quizzes/assignments stimulated most respondents to read in advance. This is also proven by their comments, acknowledging that they were beneficial. They gained long-term skills due to the use of online quizzes. In addition, most students were happy and curious about class discussions based on their responses. Although online quizzes did not contain many questions, they appear effective in motivating students to read through the textbook and find adequate answers that prepare them for deeper understanding of the concepts to be taught in class. Most students look forward to class discussions; the highest interest in this activity was noticed in the advanced class. We identified that students do believe that the highest motivational factor in learning and preparing for the course was generated by online quizzes correlated with class activity in all three courses. Possibly, study time patterns were also influenced, but we could not identify the extent to which this happened. Nevertheless, in all courses using the textbook in

finding solutions to problems was identified as a major learning pattern. The weight assigned to online preparation was important. We found out from our analysis that weights larger than 15% are unnecessary as they will not significantly increase student response rates. Likely, a 10% weight sufficiently motivates most of the students to engage in online preparation. The method was experimented in both introductory and advanced courses. In both cases most respondents felt that online preparation helped them (more so for the advanced courses, although not in all respects). However, we cannot identify if this is due to instructor and/or method implementation or due to the advanced level that may allow for more substantial learning. The more intense interaction with students and the time taken for preparation of online quizzes render this method quite demanding for the instructor. From our experience, a sequential application of the method for one course is more likely to be successful than its simultaneous application in two courses, for instance. The method appears to particularly increase student ability to work independently, creating sound and transferable learning skills in the long run. We are hopeful that our experience and analysis can be useful to other new and established instructors ready to try online teaching methods.

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