Just-In-Time Teaching: A web-based method of integrating classroom assessment and instruction

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“Good classroom assessments are not only measures of learning but genuine episodes of learning themselves.” (Brookhart, 1993, p. 7).

Recent literature on assessment suggests that classroom assessment exercises should not be isolated events within a course, such as often occurs with the episodic administration of a mid-semester or final examination, which typically fail to produce the desired effect on student learning. Rather, in order to facilitate student understanding of material, ideal classroom assessments should not only provide information on whether students are learning, but also be exercises from which students can learn (Wolf, 1993). This blurring of the line between assessment and learning is often most obvious in complex assignments involving performance assessment. However, smaller, more frequent assignments can also be used as ways to both track the progress of students’ understanding as well as be potential learning experiences for students. In these types of exercises, the question of whether the assignment is one of assessment or teaching becomes unanswerable. Rather, these assignments intertwine the aspects of student learning and assessment.

In recent years, a barrage of classroom assessment techniques (CATs) has been made available to classroom teachers. The numerous CATs described by Angelo and Cross (1993) can be used to both provide feedback to students on their learning and to provide feedback to instructors on what changes need to be made in the classroom in order to maximize student learning. The range to which CATs can be well integrated into the classroom environment varies and is often dependent upon the instructional style of the teacher. Many of the CATs listed by Angelo and Cross have not yet been full investigated regarding impact on student learning. The purpose of this paper is to describe a new type of exercise called Just-in-Time Teaching (JiTT), which integrates assessment with student learning in through an online environment and in-class discussion. Students’ perceptions of the JiTT exercises are described and discussed.
Dynamic Assessment

The term dynamic assessment has been used to distinguish the integrated process of learning assessment from the traditional static assessment (Pohner & Lantolf, 2003). In static assessment, the only feedback students receive is in the form of the test score. In the college classroom, midterms and final exams tend to be examples of static assessment. Students receive the numeric score on these tests, typically without any additional information about their performance. Dynamic assessment, in contrast, refers to the more embedded nature of assessment in which instruction is more closely united.

Dynamic assessment is based on the theories of psychologist L.S. Vygotsky, whose theories have impacted the fields of both child development and educational psychology. “According to Vygotsky, what the child is able to do independently represents a view of the child’s past development, but what the child is able to achieve with mediation, provides insight into the child’s future development” (Lantolf & Poehner, 2004). While Vygotsky focused more on child development, his theories can be generalized to the college learner. According to Sternberg and Grigorenko (2002) as summarized by Pohner and Lantolf (2003), dynamic assessment can be distinguished from traditional assessment in three ways. First, dynamic assessment focuses on the students’ future development in understanding the material rather than on understanding of past performance. Second, the instructor or examiner has a more intimate rather than neutral relationship with the student. Finally, the authors suggest that instruction occurs during the assessment process itself through individualized, mediated assistance.

Dynamic assessment may take a variety of approaches as described by Lantolf & Poehner (2004). For example, on tests and quizzes, standardized hints and prompts can be provided to the student in order for him or her to gradually reach the correct answer. In a classroom setting, dynamic assessment may be more difficult, as the instructor does not often have the opportunity to work in an individualized setting. However, some elements of dynamic assessment can potentially take place in a group environment, perhaps facilitated by technology. As Lantolf and Poehner (2004) state, “One area of interest concerns the use of interactive procedures with groups of learners rather than individuals. Mediation can be provided to several students at once as they jointly engage in completing a task with instructional recommendations highlighting each person’s contributions and how best to maximize their performances. Another particularly exciting area of research focuses on integrating computer technologies with DA procedures” (p. 7). Whether or not dynamic assessment can take place at the classroom level has not been investigated.

Just-in-Time Teaching Exercises

Just-in-Time Teaching (JiTT) exercises were developed in the field of physics by faculty at Indiana University-Purdue University at Indianapolis, the United States Air Force Academy, and Davidson College in the early 1990s (Novak, 1999; Novak, Patterson, Gavrin, & Christian, 1999). Since their introduction, a small community of researchers across the country in various disciplines has begun to utilize JiTT in their college level courses. Initially, many of the courses using JiTT exercises have been from the sciences (i.e. Grove, 2002; Marrs, Blake, & Gavrin, 2003; Guertin, 2005; Linneman
& Plake), although the application towards various disciplines is apparent and is being pursued (i.e. Howard, 2004; Cookman, 2004).

The web-based exercises consist of a series of either multiple-choice or short-answer problems or questions placed in an online format. Students are asked to submit their responses within a pre-defined time period with the due date several hours before class, enabling students to work at their own pace and schedule. The instructor then customizes the following class period based on the student responses. The method utilizes technology in order to efficiently gather the responses of the students, yet also utilizes a low-tech method of tailoring a class session to best meet student needs (Marrs, et al, 2003). A review of the questions and responses is completed at the beginning of the lecture period with a follow-up in-class exercise and extension of the discussion. Examples of students’ responses are anonymously displayed in order to encourage discussion.

The JiTT exercises could be a potential way of performing dynamic assessment within the group classroom setting. As noted above, the college instructor does not often have the time to mediate individual students’ learning. However, by utilizing JiTT, the instructor can check students’ understanding of the material and correct any misconceptions. Instructors can quickly realize whether their students are on the right track with learning the material. Responses that are particularly interesting or relevant can be shared with the class as can those common misconceptions in the material that repeatedly emerge in students’ responses. As Marrs and her coauthors describe the class discussion period, “[T]he professor concentrates not only on the content discussed that day but also on addressing students’ prior knowledge and misconceptions” (p. 42). The classroom setting following the JiTT exercises submissions is tailored to the students’ level of understanding. As this is done in a group setting with anonymous postings of example responses, students can learn from the responses from their fellow students without feeling threatened.

The JiTT exercises have other benefits as well. The exercises actively engage students in the material before class discussion, which encourages class participation and preparedness. The ultimate goal of the JiTT is to have students get beyond just memorization and become actively involved in the learning process. As Pascarella and Terenzini (1991) state, “Simply put, the greater the student’s involvement or engagement in academic work or in the academic experience of college, the greater his or her level of knowledge acquisition and general cognitive development” (p. 616). Similar to background knowledge probes, instructors can ask questions in such a way that require students to access their own experiences and relate them to the material. JiTT exercises are learning exercises in that they encourage students to become actively involved with the material by providing frequent activities in which they are forced to be prepared, do necessary readings, and integrate material from lectures, readings, and prior knowledge. Research in educational psychology has shown that individuals understand new information in light of their prior knowledge of a concept (see for example, Anderson & Pearson, 1984). JiTT exercises can help students to create links between their background and conceptual understanding to the new material. In this manner, the JiTT exercises provide a valuable opportunity for students to better comprehend the material.
An Application of JiTT

A geoscience professor at Penn State Delaware County implemented JiTT exercises in Fall, 2005 in an introductory course entitled “Dinosaur Extinction and Other Controversies.” The instructor termed the exercises DinoBytes. Students were required to submit the DinoByte exercises online through a course management system by a deadline two hours before a specified class time. Before class, the instructor reviewed all the responses to look for common errors, misconceptions, and particularly interesting submissions to share with the class. The assignments were graded using a rubric based on the amount of effort and correctness of the items. Individual feedback was given to each student electronically through the course management system. The JiTT assignments were used in combination with several course projects to determine final grades in the course. No examinations were administered. As mentioned above, during the class, the instructor lead a classroom discussion based on example responses, which are anonymously projected onto a screen.

The weekly exercises are designed to encourage higher-order thinking skills in students, requiring synthesis, evaluation, and analysis. The questions asked students to solve problems, hypothesize theories, or synthesize information from various readings. Appendix A provides examples of the DinoByte exercises used during the semester.

Methods of gathering student perceptions

Data was collected from three sections of Earth 105 during the Fall, 2005 semester. Student perceptions of the course and the DinoByte exercises were gathered using three online surveys, administered at the start, middle, and end of the term. At the start of the semester, students were asked to identify any preconceptions that they held about the course and the anticipated DinoByte exercises. The mid-semester survey was used to gather data from the students about what needs to be improved in the class as well as to gather some basic perceptions of the course to date. The end-of-semester survey was used as a more summative assessment to gather final perceptions of the course. An incentive of extra credit was given to students who chose to complete the surveys.

A total of 69 students were enrolled in the three sections. The response rate for each of the surveys was quite high, ranging from 72% to 89% participation on each of the surveys. A total of 62 (89%) students completed the pre-course survey, 53 (77%) completed the mid-semester survey, and 49 (71%) completed the end-of-semester survey.

Each survey consisted of a combination of item types including Likert-type, Yes/No, and open-ended questions. Students were able to explain their responses to the Likert-type and Yes/No items in a comment box. The open-ended questions and student comments were analyzed using content analysis to identify salient themes. N-Vivo software was utilized to facilitate the open coding process. Frequency data was obtained for the Likert-type scale items using SPSS statistical software.
Results

Pre-Course Perceptions

On the pre-course survey, students expressed that the JiTT exercises were new to them. A total of 78.7% stated that they had not been required to complete similar exercises in their other courses. The majority of the students (60.7%) stated that they were looking forward to completing the exercises. In general, the students were looking forward to completing the exercises. Some reasons listed for their positive perception of the exercises included an increased learning of the material, an outlet to express their own thoughts and opinions, and the ability to see the responses of other students. Several expressed that they would rather have smaller assignments rather than traditional static assessments. As one student noted, “I enjoy learning through assignments much better than tests or quizzes. When you take a quiz or test, you just memorize information and forget it when the test is over, but assignments are more laid back and you can actually learn while you are completing them.”

Students were also asked their pre-course perceptions of having the DinoByte responses posted anonymously in class. The majority of the student responses were overwhelmingly positive. The most frequently stated opinions of the anonymous postings included the “sense of security” provided by anonymous posting and the ability to better understand the nature of a good versus a poor answer. The following are examples of their statements:

- I like the anonymous posting of results because certain students may not want to share with the class their responses. Therefore, posting responses anonymously can give the students a sense of security.
- Better, because if one of my answers is used as a poor response, it’s less embarrassing.
- It’ll show me what a good response is and what a bad one is.
- I like it because it gives me something to compare my work to…
- It shows possibly a different outlook on the material or maybe answers some questions that a student who does not understand could follow from another student.
- It helps me know the real answers behind every question.

Students felt that the discussion of these anonymous responses will help their understanding. As some students noted:

- Discussion will help clear up any uncertainties anyone may have with the topic.
- The class gets a notion on what questions their fellow students have and can help answer them without pointing fingers at anyone.
- It will help all of the students because it will give them the chance to see what others are thinking in general. Students can compare their answers with the ones being posted and discussed to see if they are on the right track of thinking. Also, if a student was confused on one of the questions,
sometimes it is better to hear it from a peer perspective because it will be in easier terms to understand.

- I think that it is beneficial to view and discuss postings of other students’ assignments because it gives others something to compare themselves and their individual work to kind of gauge themselves and see where they stand compared to their fellow students.

**Mid-semester Perceptions**

The questions on the mid-semester survey were utilized as a way of providing feedback to the instructor on what aspects of the class. Appendix B provides the data from a series of 15 Likert-type scale items relating to the DinoBytes. At this point halfway through the semester, students were able to provide anonymous feedback on the DinoBytes. Students were asked general questions of the DinoByte activities and then specific questions regarding the process of completing the DinoBytes and questions regarding the process of discussing the DinoBytes.

In the general questions of the DinoByte activities, students agreed or strongly agreed that the exercises helped increase feelings of being involved (55.8%), increase feelings of communication with the instructor (52%), identify areas of confusion (50%), keep up with reading and coursework (71.1%), and improve critical thinking skills (67.3%).

Students were asked their perceptions of completing the DinoBytes. The majority of students agreed or strongly agreed that the DinoBytes helped to have a better understanding of the course material (66%), helped understanding beyond memorization (67.3%), helped to see what was not understood in the course material (58.4%), and increased the sense of responsibility for classroom success (69.2%). Fewer students felt that the JiTT activities helped to create links between personal experiences or background.

Students were also asked to rate their perceptions of the classroom discussions of the DinoByte activities. The majority of students agreed or strongly agreed that discussing the DinoByte responses helped to better understand the course material (71.7%), helped to see what was not understood (64.1%), increased confidence (69.8%), and helped to see where mistakes were made in responding (77.4%). When asked to comment on their responses, many students felt that the classroom discussions helped to solidify their understanding of the material. For example, the following are examples of students’ quotations:

- I like that we discuss the DinoBytes after they are completed to tell me where I may have gone wrong and where there is room for improvement.
- Discussing the DinoBytes is a great idea. It helps us to understand what we did right or wrong and also shows us some other ways to look at the questions.
- Having a comment posted in class definitely help me to understand everything better. Having a comment posted anonymously also helps me to feel more confident, because I can feel more free to talk about it in class
and not feel like I answered something wrong and have the whole class know about it.

- Being able to see my DinoByte response in class is a definitely a confidence booster, and I’m always able to understand where I went wrong in understanding a question after class.
- [The professor] takes a lot of time discussing the DinoBytes so I am usually able to find where I went wrong answering some of the questions.
- Sometimes I don’t understand completely what the DinoByte was asking, but by going over the responses my questions are cleared up.

At midsemester, students also commented on individual feedback received through the course management system. The results were slightly more mixed regarding the students perceptions’ of the individual feedback. Some students felt that this individual feedback helped to better understand the material. As one student stated, “Completing DinoBytes gives me a little help in understanding the material, but when we receive our feedback, it helps me to do better on the next one.” In contrast, some students felt that the neither classroom discussion nor the individual comments provided enough feedback regarding their completion of the DinoByte activities. As one student noted, “The feedback on assignments is usually given over the internet and isn’t very personable. It’s hard to relate to this.” Another student noted, “There isn’t much feedback on the graded assignments. I never know which answers I got wrong to know how to correct them.

Final Survey Perceptions

On the final survey, a total of 89.8% of the students felt that the DinoBytes helped to increase their critical thinking skills. A total of 87.8% of the students felt that the learning gained from completing the DinoBytes made them worth the amount of work that they required. In addition, a total of 69.4% of the students felt that they learned and remembered more from a course having DinoBytes than other courses that did not have similar exercises.

As a result of the midsemester data, the instructor had made an effort to provide more individualized feedback. Additional questions were asked on the final survey to ask about the students’ perceptions of the individualized feedback. A total of 71.4% of the students said that they went back to review the instructor’s comments. Some students just wanted to know why they lost points. Others used the information to learn from their mistakes and to understand how to approach the material in the future, as suggested by the following comments:

- I liked to see what I did wrong. I was able to learn from my mistakes.
- I like to know what I did wrong or right to make my future DinoBytes easier.
- If I get points taken off, it is nice to know where I went wrong so I can learn from my mistake, or misinformation.
- It’s important to know if you didn’t completely answer a question so that you better understand the content.
Other students focused primarily on the grades and did not bother to review the instructor’s comments. One student explained he or she did not review “[b]ecause what’s done is done. I can’t change anything.”

Discussion

In general, the students in our study seemed to have a positive perception of the DinoByte exercises and potential learning benefits. Students felt that the in-class discussions of the exercises provided a benchmark to compare their own responses. With the individualized feedback that most students utilized, the students responses supports that the JiTT exercises provide a unique type of setting for students to receive feedback on their progress in the course.

One limitation of our study is the lack of a comparison group. Because students have the opportunity to attend any class section, the decision was made to use the JiTT exercises in all three sections of the course. Therefore, no comparisons of learning can be made to determine if JiTT would be more effective than traditional teaching and assessment techniques. Another problem with having a control or comparison group in the classroom is the question of what would be used as the alternative treatment. Would the comparison group be asked to only have a mid-semester and final exam, as in traditional classrooms? What will be the criteria for success in order to compare student learning between the JiTT and the comparison groups? What would the time that is used for classroom discussion of JiTT exercises be used for in the comparison group? These questions need to be answered and explored in order to better understand the impact of JiTT.

An additional research question concerns the relationship between the individual feedback and the group feedback. In order for JiTT exercises to be affective in dynamic assessment, perhaps individualized, written feedback needs to be included with the group feedback exercises. If the sole source of feedback in the classroom is within the whole course, students may still lack the ability to understand how and why their responses were not ideal. The individual feedback is necessary for students to know how they individually performed. The group discussion of JiTT allows for students to see examples of ideal responses, to see alternative interpretations of questions, and to discuss examples which may contain misinterpretations or errors.

The JiTT technique has potential applications for a variety of fields. Modifications to the types of questions asked can be made in order to make JiTT more appropriate for a particular discipline. However, some instructors may have more difficult implementing the technique in their classroom. In large enrollment courses, instructors who wish to use JiTT as dynamic assessment would have to modify the strategies used, such as utilizing a select sample of students’ responses to tailor the classroom discussion period.

Just-in-Time Teaching is a potentially beneficial classroom assessment technique that can be used to integrate the processes of both assessment and classroom instruction. JiTT is dynamic assessment in that an instructor can use the results to determine the level of understanding for students in the classroom through the individual submissions. Individual feedback can be easily provided to students with the aid of classroom management systems. Feedback is given to the entire group of students in a tailored
classroom discussion setting. Students then have the opportunity to learn from the responses of others what constitutes a good versus poor response to the questions.
References


DinoByte: Dinosaur Blood and Tools of Paleontology

1) In your opinion, what type(s) of metabolism(s) did dinosaurs have? Defend your answer.
2) After finding a bone bed in Cretaceous rocks, you set about mapping the area containing the exposed bones. The area measures 13.5 x 22.5 m and contains about 1,250 bones. What is the approximate bone density of this bed (in m²)? What are some factors that might cause variations in this average?
3) Why do paleontologists frequently look for fossils in desert areas, as opposed to forests or jungles?

DinoByte: Who Owns Dinosaur Fossils?

1) What if a fossil is found on private land? Should a paleontologist be expected to pay the landowner the market value for that fossil before it can be studied?
2) Does an amateur collector who originally found a fossil get co-authorship on a scientific report of the fossil? Does the professional paleontologist acknowledge the collector or does the paleontologist deserve sole authorship because of his or her advanced educational background?
3) What happens when one paleontologist performs research on certain fossils knowing full well that another researcher is already studying them? What if the first paleontologist scoops the second, by submitting the results to a journal first, leading to the second researcher's work being rejected: "Sorry, that's already been done"? Is this just an example of how science, like other aspects of capitalistic and goal-oriented society, is a competitive venture?

DinoByte: Are Dinosaurs Birds? Are Birds Dinosaurs?

1) Feathers in birds today have different (but often overlapping) purposes, such as insulation, display, and flight. In the case of flightless coelurosaurs such as Caudipteryx, which of these functions was most likely and why?
2) You are doing fieldwork in the southwestern United States on an excavation of Upper Triassic rocks when you discover what seems to be a bird skeleton. Which hypothesis of bird origins - theropod or thecodont - would your discovery support and why? Would it necessarily only support one of the hypotheses? Why or why not?
3) If all birds went extinct tomorrow, how would the world be different? What environments might be affected the most and in what ways?
## APPENDIX B

Questions regarding DinoBytes – Fall 2005 Semester Midsemester Survey

<table>
<thead>
<tr>
<th>General perceptions of DinoBytes</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly agree</th>
<th>N</th>
<th>Avg. (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The DinoByte activities make me feel more involved in this class as compared to my other classes.</td>
<td>1.9%</td>
<td>15.4%</td>
<td>26.9%</td>
<td>42.3%</td>
<td>13.5%</td>
<td>52</td>
<td>3.50 (.980)</td>
</tr>
<tr>
<td>The DinoBytes make me feel that I communicate more with the instructor of this course than other courses</td>
<td>5.8%</td>
<td>11.5%</td>
<td>30.8%</td>
<td>38.5%</td>
<td>13.5%</td>
<td>52</td>
<td>3.42 (1.05)</td>
</tr>
<tr>
<td>I am more likely to understand the material rather than just memorize.</td>
<td>3.8%</td>
<td>7.7%</td>
<td>21.2%</td>
<td>44.2%</td>
<td>23.1%</td>
<td>52</td>
<td>3.75 (1.03)</td>
</tr>
<tr>
<td>The DinoBytes help me to find areas where I’m confused.</td>
<td>3.8%</td>
<td>9.6%</td>
<td>36.5%</td>
<td>42.3%</td>
<td>7.7%</td>
<td>52</td>
<td>3.40 (1.04)</td>
</tr>
<tr>
<td>The DinoBytes help me to keep up with the reading and work in this class.</td>
<td>1.9%</td>
<td>9.6%</td>
<td>17.3%</td>
<td>44.2%</td>
<td>26.9%</td>
<td>52</td>
<td>3.85 (1.08)</td>
</tr>
<tr>
<td>The DinoBytes helped to improve my critical thinking skills.</td>
<td>5.8%</td>
<td>5.8%</td>
<td>21.2%</td>
<td>42.3%</td>
<td>25.0%</td>
<td>52</td>
<td>3.75 (1.08)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Perceptions of Completing the DinoBytes</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly agree</th>
<th>N</th>
<th>Avg. (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completing the DinoBytes helps me to better understand the course material.</td>
<td>3.8%</td>
<td>7.5%</td>
<td>22.6%</td>
<td>39.6%</td>
<td>26.4%</td>
<td>53</td>
<td>3.77 (1.05)</td>
</tr>
<tr>
<td>Completing the DinoByte helps me see what I don’t understand about the course material.</td>
<td>5.7%</td>
<td>7.5%</td>
<td>28.3%</td>
<td>39.6%</td>
<td>18.9%</td>
<td>53</td>
<td>3.58 (1.06)</td>
</tr>
<tr>
<td>Completing DinoBytes makes me feel more responsible for my success in class.</td>
<td>7.7%</td>
<td>3.8%</td>
<td>19.2%</td>
<td>32.7%</td>
<td>36.5%</td>
<td>52</td>
<td>3.87 (1.19)</td>
</tr>
<tr>
<td>I often try to relate my own personal experiences when answering the questions.</td>
<td>1.9%</td>
<td>9.4%</td>
<td>56.6%</td>
<td>22.6%</td>
<td>9.4%</td>
<td>53</td>
<td>3.28 (.841)</td>
</tr>
<tr>
<td>The DinoBytes help me to make links between my own background and the class material.</td>
<td>5.8%</td>
<td>7.7%</td>
<td>53.8%</td>
<td>23.1%</td>
<td>9.6%</td>
<td>52</td>
<td>3.23 (.942)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Perceptions of Discussing the DinoBytes</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly agree</th>
<th>N</th>
<th>Avg. (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discussing the DinoBytes helps me to better understand the course material</td>
<td>5.7%</td>
<td>1.9%</td>
<td>20.8%</td>
<td>37.7%</td>
<td>34.0%</td>
<td>53</td>
<td>3.92 (1.07)</td>
</tr>
<tr>
<td>Discussing the DinoBytes helps me to see what I don’t understand about the course material</td>
<td>7.5%</td>
<td>3.8%</td>
<td>24.5%</td>
<td>35.8%</td>
<td>28.3%</td>
<td>53</td>
<td>3.74 (1.15)</td>
</tr>
<tr>
<td>Being able to see my DinoByte response posted anonymously in class makes me feel more confident.</td>
<td>3.8%</td>
<td>3.8%</td>
<td>22.6%</td>
<td>34.0%</td>
<td>35.8%</td>
<td>53</td>
<td>3.94 (1.04)</td>
</tr>
<tr>
<td>After class discussions, I am usually able to find where I went wrong answering the DinoByte questions.</td>
<td>5.7%</td>
<td>3.8%</td>
<td>13.2%</td>
<td>43.4%</td>
<td>34.0%</td>
<td>53</td>
<td>3.96 (1.07)</td>
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