Pre-lecture Activities in Undergraduate Science Courses

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Summary
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Pre-lecture activities facilitate student learning in three ways. First, students are introduced to core concepts before lecture to help identify misconceptions, activate prior knowledge and familiarize students with lecture material. Secondly, instructors can incorporate the pre-lecture questions into the lecture itself and provide student responses as discussion openers. Lastly, students are more likely to participate if they are familiar with the material and feel confident in their understanding. Therefore, pre-lecture activities help students prepare for lectures and provide a basis for interactive learning, without compromising the amount of content that can be taught during the lecture.

The purpose of this workshop is to prepare instructors to effectively incorporate pre-lecture activities into their courses. In addition to providing specific examples of pre-lecture activities, the workshop will also highlight how this teaching approach is supported by several learning theories, including constructivism, cognitive learning theory and Just-in-Time Teaching (JiTT) pedagogy. Lastly, the workshop will emphasize the adaptability of pre-lecture activities and how they can be incorporated into any science course. Workshop participants will have the opportunity to discuss different types of pre-lecture activities and different ways of implementing them into their courses.

Keywords
pre-lecture activities, just-in-time-teaching, Science, Undergraduate teaching

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Pre-lecture Activities in Undergraduate Science Courses
Laura Dindia, University of Waterloo

SUMMARY
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KEYWORDS: pre-lecture activities, just-in-time-teaching, Science, Undergraduate teaching

LEARNING OBJECTIVES
By the end of the workshop, participants will be able to:
• create pre-lecture activities (PLA) that adequately prepare students by introducing key concepts and activating prior knowledge;
• articulate the researched benefits of PLA on student performance & engagement;
• develop strategies that will motivate students to complete PLA; and
• provide appropriate feedback or assessment of PLA.
REFERENCE SUMMARIES

This study investigates the use of web-based multimedia modules, which are aimed at increasing student preparedness and understanding of fundamental concepts in an introductory physics course. The web-based modules were completed prior to lecture and included ‘preflight questions’ which were answered prior to lecture to assess student understanding of the material. This study concludes that pre-lecture activities significantly improve understanding of content addressed in the web-based learning modules. In addition, the study reveals that pre-lecture activities enhance learning of certain, but not all concepts, and is particularly valuable for concepts that are more abstract or require visualization. This emphasizes that pre-lecture activities should be designed thoughtfully, as the effectiveness not only depends on the type of PLA but also on the material being covered. Importantly, this study determines that pre-lecture activities enhance the performance of all students, irrespective of their ability level.


This article reviews the use of pre-lecture activities (PLAs) to improve student learning in engineering courses. The authors apply the constructivist view of learning and the importance of prior knowledge to explain the usefulness of pre-lecture activities in the learning process. This article also proposes that PLAs are an essential tool for reducing heterogeneity among students in their academic background, which is a common challenge for engineering instructors.

The review also details important considerations when designing PLA, emphasizing that PLAs should provide the necessary background so that students can incorporate new material into the constructs of their previous knowledge. Moreover, Kolari and Savander-Ranne (2007) provide student feedback on the use of PLAs indicating that students have a positive attitude towards their use and stated that the activities not only helped them prepare for lecture but also motivated them to research concepts on their own and look at the material from different perspectives. Overall the review concludes that PLAs increase student participation both in and outside of class which is demonstrated by increased time allocated to studying, which ultimately increase performance on evaluations.


The focus of this article is on the ability of PLAs to increase student participation and facilitate interactive learning during the lecture. This review article discusses PLA in the context of the Just-in-Time Teaching (JiTT) pedagogy, in which PLAs serve as the basis for this teaching and learning strategy. The article discusses how the JiTT method creates a
feedback loop where students receive feedback on their understanding during the lecture, as opposed to the traditional teaching strategy, which provides feedback during formal evaluation. The review provides actual examples of effective PLAs, including how to use activities to introduce students to real-life application of the discipline. The article also provides evidence that JITT teaching strategy improves study habits, increases class preparation, and most importantly improves student's cognitive abilities.


This research article addresses how pre-lecture activities can be used as a tool to increase active learning in large introductory biology courses without affecting the quantity or complexity of the material delivered. Overall the study found that implementing PLAs leads to active learning during lecture and significantly increase learning gains in a large introductory biology course. More importantly, the use of PLAs permits interactive learning during lecture without reducing content taught throughout the course. This was achieved by posting a portion (4-5 slides, took approximately 10 min to complete) of the material before the lecture, which was accompanied by a short quiz to encourage student completion. The study compared exam scores from different years which only differed in the presence or absence of these PLAs. The study demonstrated that students enrolled in the course with PLA answered more questions correctly on the final examination compared to students that took the course without PLAs. In addition to learning gains, the study reported that PLAs were well received by students with more than 90% of students completing the activities and most students felt that the PLAs aided in their understanding of course material.


Based on the cognitive load theory, Seer and Donnelly (2012) present a case study demonstrating how pre-lecture activities can be used to reduce cognitive load of chemistry lectures. This study investigated how pre-lecture resources paired with a pre-lecture quiz can assist the learning process by moving basic terminology outside of lecture so that more time can be devoted to more complex concepts. The authors outline the steps involved in designing pre-lecture activities which introduce core concepts and new terminology along with how to design pre-lecture quizzes in order to address misconceptions or misunderstandings. In addition to the intended positive effect on student learning and understanding the authors also describe several unintended outcomes in response to the PLAs. Specifically, these activities stimulated greater participation during the lecture and lead to increased discussion between class-mates. The students actively checked their understanding of the material with their peers and appeared more engaged. The authors also noted that despite the small grade associated with the PLAs, a great proportion of students routinely completed the activities and spent an unexpected amount of time interacting with the resources. The PLAs not only influenced student learning but also
impacted the lecturers such that greater care was taken when teaching difficult concepts as assessed by the PLA and more thought was given to the design of each lecture to address misconceptions.

CONTENT AND ORGANIZATION
Although this workshop has been designed for a 90 min session, it could be adapted for either a longer or shorter session depending on the number of participants.

<table>
<thead>
<tr>
<th>Duration (min)</th>
<th>Subject</th>
<th>Activity and Purpose</th>
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<tbody>
<tr>
<td>5</td>
<td>Introduction</td>
<td>Introduce participants to the concept of pre-lecture activities (i.e. what they are and the main purpose why they are used). Make sure to explain the use of PLAs in the context of the Just-in-time teaching (JITT) teaching strategy. Also emphasize that PLAs can be adapted for any course and are particularly beneficial for large introductory science courses. By mentioning this early in the workshop, participants will likely have a higher level of engagement. Make sure to ask the audience whether they have used PLAs activities and what their overall perception of their usefulness in preparing students. This will allow the workshop facilitator to effective gauge the audience familiarity with PLAs and their perception on their effectiveness.</td>
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<tr>
<td>15</td>
<td>Incorporating PLAs into the Classroom</td>
<td>Give participants a detailed overview how PLAs are incorporated into the teaching process, including: when they are provided to students, when they are to be completed, how to assess PLAs; and, finally, how to integrate PLAs into the lecture. After reviewing how PLAs are implemented into a course, lead a group discussion about potential challenges or concerns that the workshop participants might have regarding the incorporation of PLAs into their course such as time constraints, student's initiative to complete activity, and so forth.</td>
</tr>
<tr>
<td>15</td>
<td>Types of PLA</td>
<td>Lead a group discussion about the different possible types of PLAs that could be used in participants’ courses. After the group discussion, the workshop facilitator will show concrete examples of PLA used in science courses (see Appendix B for a sample handout).</td>
</tr>
<tr>
<td>15</td>
<td>Incentives for PLA Completion</td>
<td>Since a common concern regarding the use of PLAs is motivating students to complete them, split attendees into small groups and have participants discuss different ways to</td>
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</table>
provide students with incentives to complete PLAs. Ask for a volunteer from each group to share the ideas that their group came up with. The facilitator should write down these ideas on a black or white board to allow participants to take note of the examples given by the other groups.

If required, the facilitator can provide additional suggestions to encourage participation. This may include a short assessment such as a quiz, short answer or concept map that is typically worth a small percentage of the course grade. This assessment can be graded based on accuracy, effort or completion. Additionally, peer-reviewed activities or group discussions integrated into PLAs may also increase participation since they provide immediate feedback on students’ understanding of the material and promptly addresses misconceptions.

<table>
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<th>10</th>
<th>How PLAs Impact the Learning Process</th>
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<td></td>
<td>Discuss PLAs in the context of the key learning strategies. For instance, PLAs integrate several learning theories by activating prior knowledge, providing a base for constructive learning provides an opportunity for prompt feedback and is learner-centered.</td>
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<td>At this point, the facilitator should ask audience if they can foresee any additional benefits of PLA on the leaning process.</td>
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<th>5</th>
<th>Adapting PLAs</th>
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<td>Address limitations and possible challenges proposed during the group discussion. Highlight the flexibility of PLAs and discuss how they can be incorporated to differing degrees in order to meet the needs of any course.</td>
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<th>20</th>
<th>PLA Implementation</th>
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<td></td>
<td>Break participants into small groups to discuss the PLA implementation plan they created prior to coming to the workshop. Instruct participants to verbally share their plan with other members in the group indicating why they think PLAs would be particularly useful in the course they have chosen and the type of PLA activities they plan to use. Other members should share suggestions on how to overcome any potential challenges or concerns the participant might have about implementing PLAs into their course.</td>
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<td></td>
<td>Participants may be split into either discipline specific or interdisciplinary groups. Although dividing the attendees into discipline specific groups may facilitate sharing and constructive feedback, interdisciplinary groups may encourage participants to think more broadly about how they could incorporate PLA into their courses.</td>
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Note: The time allotted to this component will depend on the
number of participants in each group. To ensure that each attendee gets to participate, groups of three to four participants is ideal.

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<th>Conclusion</th>
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<td>5</td>
<td>End the workshop by providing a brief summary of the impact of PLAs on student learning.</td>
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**Total Time: 90 minutes**

### PRESENTATION STRATEGIES
Prior to the workshop, provide a handout (see Appendix A) that includes a brief summary of pre-lecture activities as a teaching approach. Ask participants to consider a course that they have taught (or have previously taken), which includes one or more of the following instructional challenges:

- misconceptions concerning core concepts
- differences in student prior knowledge
- lectures that impose large cognitive load (lots of new terminology, complex or abstract concepts, or quantity of material).

As part of this pre-workshop activity, instruct participants to select a key lecture or challenging concept that they would like to support using a pre-lecture activity. Ask participants to write a description of a sample pre-lecture activity that they would use to improve student understanding of the topic. Finally, ask participants to bring their description to the workshop to discuss in small groups as indicated in the workshop outline.

### ADDITIONAL REFERENCES


Seery, M. K., & Donnelly, R. (2012). The implementation of pre-lecture resources to reduce in-class cognitive load: A case study for higher education chemistry. *British Journal of Educational Technology,*
APPENDIX A: Pre-Workshop Activity

Pre-lecture activities (PLAs) are pre-assessment techniques that typically consist of a learning resource and short assessment and are completed by students prior to the lecture. The primary objectives of PLAs are to prepare students for lecture by introducing core concepts and identifying difficulties or common misconceptions.

_Directions to Participant_

Consider a course that you have taught (or have previously taken) that includes one or more of the following instructional challenges:

- Misconceptions concerning core concepts
- Differences in student prior knowledge
- Lectures that impose a large cognitive load such as lots of new terminology, complex or abstract concepts or a large quantity of material.

Choose a lecture or concept from this course that you feel a pre-lecture activity would improve student understanding of the topic.

Before attending the workshop, write a brief description of a sample PLA that would introduce students to this concept and/or identify commonly held misconceptions. Also provide the main objective of implementing the pre-lecture activity and how you would integrate the activity into the lecture.

Please bring the description of your sample PLA to the workshop.
**APPENDIX B: Examples of Pre-Lecture Activities Used in Science Courses**

**Example 1:** Pre-lecture activities can be as simple as posting a few animated slides that present new terminology or introduce students to complex concepts. The lecture slides can be accompanied by a short multiple-choice quiz to assess student understanding and provide incentive for student completion. See Seery and Donnelly (2011) for an example of a web-based lecture resource accompanied by an online quiz.

**Example 2:** Pre-lecture activities provide a great opportunity to extend beyond the lecture content and share recent advancements being made in a particular scientific field. These advancements are based on the fundamental concepts being taught at the undergraduate level, therefore, students will be able to apply what they are learning in lecture with real-life examples in their field. Marrs and Novak (2004) outline how this type PLA can easily be incorporated into biology courses, using an activity called “What is Biology Good for?”

**Example 3:** Providing some type of learning resource is a great idea for an introductory course, however upper year courses might benefit from student-centered PLAs, which involve the student researching independently to answer short-answer PLA questions. An example of this type of PLA is provided by Marrs and Novak (2004).