CHECKPOINTS, CLOUD AND COLLABORATION (C^3): A Learning Framework to Improve Learning Outcomes for International Students in Computer Science

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Abstract

This paper describes the use of a learning framework called Checkpoints, Cloud and Collaboration (C^3) that fosters greater student engagement, active learning, and improved learning outcomes in an international student learning context. The framework was used to incentivize international students at a U.S. university to invest more actively in the learning process, adhere to Western-style educational standards, and provide "mentoring moments" for the instructor to help struggling students address gaps in understanding. A cadence of feedback and periodic reviews provided actionable feedback to students and the instructor earlier in the course offering, thereby allowing more time for appropriate interventions to improve the student learning experience and student performance.

INTRODUCTION

Many post-secondary Computer Science (CS) course offerings rely on lectures as the centerpiece of knowledge transfer to students. Although lectures can be an important component in a student's learning journey, the National Research Council [6] proposes that interaction, frequent feedback and application are essential to maximizing knowledge acquisition. A wealth of literature identifies the process of active learning as an effective approach to improving student engagement and education. In practice, however, many CS courses are designed with the lecture as the foundation of information exchange, and use lab and homework assignments to re-affirm concepts introduced during lectures.

The traditional "lecture as centerpiece" approach has a significant impact on multi-cultural and international learning environments where students may not have full mastery of the nuances of the host-country's language and idioms. Hayes and Irona [4] posit that international students entering Western higher education may have difficulty stating their own opinions, and may feel pressure to plagiarize or deviate from academic standards in order to avoid failure. Handa and Power [3] acknowledge that diverse cultural backgrounds of international students precipitate their need to learn Western academic conventions in order to be successful in their studies. Further, Pallela and Talari [7] focus specifically on East Indian students, and observe that many educational institutions in India utilize teaching modalities that focus on exam preparation and getting maximum scores (by whatever means necessary) at the expense of authentic knowledge acquisition.

The full scope of culture and international learning differences is far beyond the focus of this paper. However, it is clear from this brief survey of prior research that simply transplanting international students into a Western-style lecture-centric format will not be efficacious with respect to maximizing true learning. Therefore, the cultural components discussed here are important external factors that must be considered as part of any educational program seeking to engage international students. This paper

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describes the Checkpoints, Cloud and Collaboration (C^3) framework used to create learning communities within the classroom in order to foster greater student engagement, utilize active learning, and achieve better outcomes for an international student learning environment.

Background

There is a wealth of literature describing the benefits of active learning and this paper is not intended to cover the concepts investigated by researchers in that particular area. However, highlights from a number of researchers, including Vella, Yuan, and Kolb should be noted. Vella [8] posits that learners "learn best when they are actively engaged", and the key to successful knowledge transfer is getting students engaged in learning tasks so that the content "sticks" with them. Yuan [9] agrees with this concept and describes the importance of hands-on learning, particularly in Information Technology (IT) learning environments so as to move the learners from "theory" to practice. Kolb and Kolb [5] state that knowledge acquisition requires the combination of both understanding information and actively participating transforming experiences. Specifically, the Kolbs observe that "concrete experiences are the basis for observations and reflections. These reflections are assimilated and distilled into abstract concepts from which new implications for action can be drawn", and "To learn from their experience, teams must create a conversational space where members can reflect on and talk about their experience together"[5]. In support of these observations, early research by Bodie et al. [1] proposed the concept of "blended learning" where two or more approaches are used to teach the same material, and the idea of "chunking", or organizing small clusters of information into teachable units that can be easily conveyed as part of a lesson, and easily recalled by students as they build knowledge.

In addition to the conceptual framework of active learning, however, educators must be mindful of the learning context and environment. According to Drew and Mackie [2], the need to apply strategies that leverage the social context of learning, including open discussions, peer learning, and cooperative learning must be considered. Handa and Power [3] state "lecturers teaching international students also need to embrace the true spirit of internationalization by incorporating recognition of the prior cultural context of their students and instead of assuming homogeneity, should teach to the heterogeneity of their students' experience". In addressing the East Indian student experience, Pallela and Talari [7] describe the current Indian educational approach as a system that prepares students for centrally-administered board examinations, at the expense of imparting skills that help students develop into critical and independent thinkers. This philosophy and approach, of course, runs counter to the Western focus on independent thinking, critical analysis, and creativity. Successful engagement and education of international students requires recognition and attention to these nuances and differences in worldviews. Thus, with respect to this paper, the social context of learning extends beyond the traditional viewpoint of "the classroom", but also includes cultural contexts since the target audience for the learning environment was international students.

Project Goals

In 2014, a university in New Hampshire opened its doors to receive a large number of international students - primarily from the Indian Subcontinent - into the CS program. The school had a well-structured curriculum, with course offerings organized for smaller groups of students who were familiar with Western-style higher education. It was assumed that students would adhere to the University's guidelines regarding academic work and integrity in citing sources of information. Although there were a number of well-prepared and capable international students, there were also many who were

academically under-prepared and who struggled with the material. Within this group of struggling students, a subgroup showed little willingness to work within the academic guidelines, and opted to plagiarize assignments, or chose to employ academic dishonesty on projects.

An analysis of the early cohorts of international learners at the University led to one predictable outcome and one key observation. The outcome: some students were placed on academic probation due to their infractions. The observation: the structure of some of the CS courses allowed for easy "cheating" by students, either through recycling older projects or by plagiarizing content from the internet. It should be noted that the final project that was originally designed to help reinforce the course content and provide a measure of student proficiency in the subject matter. Therefore, neither the student nor the course instructor would benefit from the project unless there was active engagement by the student to fulfill the requirements and do the work. Unfortunately, lack of visibility into student progress with respect to the final project was often surfaced too late in the term to make significant adjustments.

The aforementioned factors provided the motivation for embarking on a modified approach with respect to teaching and engaging the University's international students enrolled in the CS program. Using a combination of active learning, topic chunking, and collaborative checkpoint reviews, the author of this paper redesigned the teaching framework for a specific foundational course - Object Oriented Design - with the purpose of addressing the challenges discussed earlier. As part of this transition, the author adopted a Cloud-based drawing environment to facilitate student-instructor and student-student collaboration for all class participants.

METHODOLOGY

Initial State

The initial design of the Object Oriented Design course consisted of three written homework assignments (due every other week) and one large team project due at the end of the course. Each homework assignment included a single question in reference to the final team project, but other than that, there was very little visibility into how the project teams were actually progressing towards a final work product. In addition, since the homework assignments were submitted as written documents (e.g. Word), it was quite easy for individuals to share information and concepts without actually grasping the material, or investing in learning the concepts presented.

On-premise software (ArgoUML) was used by the student teams to develop their designs, but some students sought out and acquired pre-existing model files from a variety of sources (previous students, online sites, etc.), or simply copy-and-pasted screen captures from example System Requirements Specification documents available on the internet.

It should be noted that not every student participated in displays of academic dishonesty, however, these behaviors were not isolated incidents either. Since the key goal for the author of this paper was improving the learning environment for international students rather than simply enforcing punishment for circumventing the current-state learning process, a redesign of the course approach was implemented.

Redesign

The modified approach to teaching Object Oriented Design featured process changes and migrating from on-premise software to a Cloud-based drawing environment (Lucidchart) that supported the

Unified Modeling Language. Suspending the use of ArgoUML prevented students from simply reusing existing UML models and passing them in as their own work. Further, Lucidchart provided an easy-to-use history feature that allowed the instructor to track the progression of work from each student on every modeling assignment. The process changes and switch to the Cloud were implemented concurrently, and reinforced a holistic approach to learning, collaboration and feedback.

The course material was decomposed into "chunks" covering the core topics of the systems development process. Rather than using written homework assignments as the key assessment tool for evaluating student comprehension of course content, the author instituted weekly "checkpoint reviews". These checkpoints were short (5-10 minute) informal student presentations - similar to design reviews used in industry - to gain line-of-sight visibility into how each student team was progressing, and to identify any gaps in students' understanding regarding the topic of focus for the checkpoint. During the checkpoint reviews, student teams were required to share their Cloud workspaces with the entire class so that they could learn from each other, and also learn from each team's interaction with the instructor.

In addition to the checkpoint reviews, two automated quizzes were also added to the curriculum. Practitioners in industry are rarely penalized for not memorizing every concept, so the quizzes were structured in a format that mimicked "on the job" situations.

The quizzes were open-book, open-notes and open-web, with the goal of both assessing student knowledge, and also incentivizing the students to attempt to find the required information if they did not immediately know the answer. Although the quizzes were a small percentage of the overall student grade, they provided another input into the continuous active learning cycle by allowing the students to connect course topics to working concepts in the context of a micro design problem.

The final project was retained as a major milestone in the course redesign. However, due to the intermediate checkpoint reviews, the task of preparing the final documentation shifted towards refinement of existing artifacts rather than creating entirely new assets.

RESULTS

The new teaching framework for Object Oriented Design was successful in two key areas. It: (a) incentivized students to invest in the learning process, and (b) created "mentoring moments" to help students course-correct and fill in their "gaps in understanding" earlier in the term rather than later. The combination of the Cloud-based environment and the weekly checkpoints enforced a culture of visibility and accountability. Everyone in the class was able to see the progression of each team's work. There was "no magic" - students knew that assets could not be inserted into their diagrams from other tools or previous student submissions, so everyone had to stay on task, and try their best to apply the knowledge gained from previous weeks to move their designs forward. The checkpoint reviews allowed the instructor to give direct feedback to each project team each week so that they could focus on correcting any mistakes and gain a better understanding of the course material. This "real-time" feedback also gave the instructor insight into topics that needed more coverage in future lectures, particularly if a number of teams had difficulty or common misunderstandings. Thus, the entire process helped the instructor to be more "agile" in content delivery and helped guide what learning elements to emphasize, deemphasize, and possibly re-emphasize on a per-week basis.

When participating in team projects, some students may be less active than others in the project work. The collaboration features of Lucidchart for the homework assignments allowed the instructor to have insight into particular strengths and weaknesses of individual students when considering knowledge acquisition. During the term, some of the students struggled with various topics, but opted not to request extra help from the instructor. Without further investigation and assessments, this author

cannot offer a determination as to why those students did not ask for help; perhaps they were too shy, or unable to properly formulate their questions, or possibly they were simply unwilling to approach the instructor and ask for help. Whatever the cause was for the lack of student-initiated interaction with the instructor, the homework assignments provided invaluable insights on an individual basis so that the instructor could intervene as appropriate. Lucidchart allowed for easy instructor-student interaction, and offered a mechanism for the instructor to make contextually-relevant comments in private so that the student could gain a better understanding of the topic, and improve their performance in subsequent weeks.

Two positive side-effects of the new approach of using checkpoints and the Cloud environment were also observed. First, the incidence of plagiarism and academic dishonesty decreased significantly. In essence, it was much more difficult to copy-and-paste existing material, and the effort to do so often outweighed the effort to simply create units of work from scratch. Second, since the Cloud solution was "ready-made", the zero-footprint installation meant that students no longer need to wrestle with installing software, and did not encounter software incompatibility issues. Through their web browsers, they were able to access the required software from any location, at any time.

CONCLUSIONS

In this paper, the author describes the use of a learning framework called Checkpoints, Cloud and Collaboration (C^3) that fosters greater student engagement, active learning, and better student outcomes. The redesign of the course for international students at the University has been successful on a number of levels. Student feedback and reviews have improved, and the incidence of plagiarism and academic dishonesty has decreased. Qualitatively, it appears that C^3 has proven beneficial in improving student outcomes in the Object Oriented Design course.

While progress has been made with respect to this teaching framework, the author recognizes that there is still room for future improvements. Future work includes conducting pre- and post-surveys of international students to gain a greater understanding of the reasons why some of them opt not to actively ask for help on topics in which they are struggling. At this point, it is not clear as to if culture is driving this behavior, or some other factor. Survey analysis may surface some of those complexities. Also, in the future, more inter-team collaboration may be facilitated through the use of peer reviews of student designs. In particular system-of-system design problems in which each student team is responsible for a small component of a larger whole can drive more student collaboration and group learning on a problem with a common learning objective.

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