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Adaptive Learning to Improve Student Success and Instructor Efficiency in Introductory Computing Course

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ABSTRACT

This paper describes Adaptive Teaching and Learning techniques and its application to an introductory computing course. The goal of utilizing Adaptive Learning was to increase student scores, pass rate and retention levels, and increase efficiency for both students and faculty. The adaptive learning technology was implemented in a large multi-section introductory Information Technology course over several academic semesters. Data was collected and the results are analyzed. The results show that there are significant improvements in the grade distributions, the pass/fail rate, and more efficient use of instructor time and effort.

Keywords: Adaptive Teaching and Learning, Agile Teaching and Learning, Student Pass Rate, Student Retention, Saving Course Preparation Time.

1. INTRODUCTION

Adaptive Learning (AL) is a method that uses software as an intelligent interactive teaching mechanism that combines the provision of resources according to the unique and essential learning requirements of each student (Jonsdottir, 2015). Given a set of well-defined course objectives, intelligent software disseminates the presentation of educational material tailored to each students' level, as indicated by their responses to questions, tasks, practices, and other skills. The ultimate purpose of AL is to transform the learner from passive receptor of information to collaborator (Khouri, 2014).

AL has proven to be an effective teaching technique for millennials. It has been somewhat driven by the recognition that using traditional, non-adaptive approaches cannot be achieved on a large-scale (Miner, 2017). AL owes its current popularity to the early days of the Artificial Intelligence undertaking which started in the 1970s. The basic premise was that the tool or system would be able to adjust to the student's learning method, which results in a better and more effective learning experience (Teasley, 2003).

In this study, AL techniques were implemented in Introduction to Computing (ITEC 1001), which is a 4-credit hour course that is required of every student at our institution, regardless of major. It focuses on conceptual topics that address system and application software, hardware, problem solving, the Internet, networking, security, ethical practices, and emerging technologies in various industries. In addition, it provides hands-on learning of word processing, spreadsheets, database, and presentation software.

It is a very large multi-section course, with an average of 90+ sections per semester with approximately 26 students per section, and approximately 45 instructors per semester. The course steering committee's decision to implement adaptive learning was largely attributed to the following issues:

1. Instructors were sometimes covering material that students may already firmly grasp, while not knowing areas where they needed more help.
2. Time was not efficiently utilized with the coverage of many topics already grasped by most students.
3. Some students lagged behind due to the complexity of some topics (ex: Database; Excel Pivot Tables, etc.). This could have been avoided if they were asked to perform less complex tasks they might have been acquainted with (Word, PowerPoint).

The course steering committee then determined the following goals that would address these issues (Committee, 2012):

1. Increase retention levels and student pass rate
2. Assure common content and assessment across all sections.
3. Reduce time spent preparing for lectures
4. Efficiently identify areas where students need more teaching support

2. BACKGROUND

The SCHOLAR system of geography of South America started the work on adaptive and intelligent learning systems that offered adaptive learning for such a topic. Shortly after, several other innovative systems appeared. The early work on AL systems can be found in the classic book "Intelligent Tutoring Systems" (Brusilovsky, 2004).

2.1 An Adaptive Learning Cycle

Reflective and responsive learning processes are an integral component of any institution with goals of integrated sustainability learning and adaptive management. To this end, AL plays a key role in maximizing the effects of reflective learning process (Schön, 1984). The practitioners of reflective learning in learning organization rely on each step of the cyclic and incremental processes of adaptive learning to provide the foundation for the next. In addition, the AL approach should be able to perceive changes that could affect the goals of the organization and provide answers regarding such variations (Senge, 2006).

Doing so requires vision, originality, facts, and the ability to integrate different measures of learning. Figure 1 illustrates the various roles of adaptive learning in all stages of responsive practice:

1. Individual – at the center of all learning
2. Organizational – networking and ideas generation in facilitating change ➔ dynamic system goals ➔ adaptive organizational goals ➔ adaptive strategies and activities, and ➔ reflecting on goals and strategies
3. Systemic – Disturbance ➔ Undesirable system state(s) ➔ Adaptation ➔ Desirable system state(s)

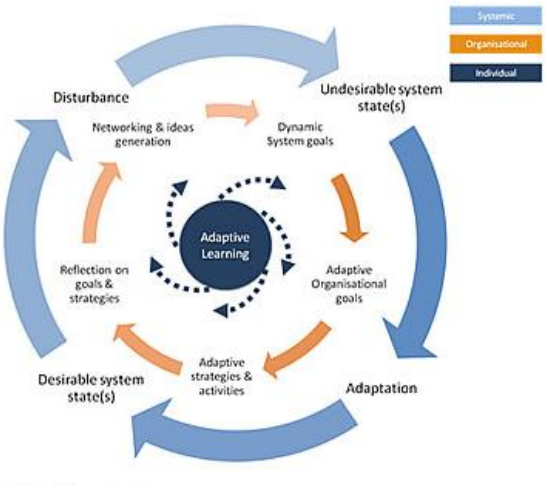

Figure 1: Adaptive Learning Cycle (Holling, 1978)

2.2 Toward A More Efficient Adaptive Learning Model

Many traditional adaptive platforms start with content such as e-textbooks and convert them into adaptive modules, by highlighting, in various colors, what the individual student already knows -- by answering a pre-test or practice questions correctly -- and what the student does not know -- chapter or module objectives that were not correctly answered. While this approach seems effective at the abstract granular level, it is not efficient at the detailed specification and technical levels (2017).

A more efficient approach would enable educators to customize and personalize each student learning instead of trying to apply a one-size-fits-all approach. (Nazeema Alli, 2016). Personalized and customized

teaching offers students an individualized approach that is specific to their preexisting knowledge, learning needs, and goals. Students learn best when their education is targeted and tailored to them (Bloom, 1984).

Examples of personalized learning activities that have been demonstrated to improve student outcomes include: 1) adapting the scope of instruction based on assessments of students' existing knowledge, skills, and gaps; 2) using personalized hints or prompts that support students during learning activities or assessment items; 3) prompting learners to generate explanations of how they have approached an activity (e.g., "show work"); 4) employing algorithms that adapt the presentation of content based on relevance to learners' goals; and 5) adapting the complexity or presentation of content based on a student's learning (Nazeema Alli, 2016).

Research shows that powerful new teaching, learning, and advising tools can help advisors and educators to personalize instruction and advise students (Roschelle, 2010). A personalized learning approach and environment can engage students and provide timely feedback and robust student support. This higher quality teaching and advising can result in greater retention and in higher rates of program completion (Jonsdottir, 2015).

To implement personalized learning, educators would need to create granulated knowledge maps for the adaptive course, and then outline every skill and every pre-requisite a student needs to learn to master the course objectives and outcome assessments. Each mastery requirement, set by the instructor, will have a set of information (tidbits, video clips, images, etc.) that assesses the level of knowledge the student has attained relative to that skill. In doing so, the educator becomes more of a facilitator and less of a lecturer, thereby giving the students the power to control what they learn, once they reach their desired mastery (Tseng, 2008). Figure 2 illustrates the assessment approach of a personalized adaptive learning experience. The adaptive platform starts with a medium difficulty level question, and drives into either a harder or an easier question based in the student response. Furthermore, the adaptive system presents the student with various learning aids (graphics, audiovisual, text, etc.) to determine their style of learning.

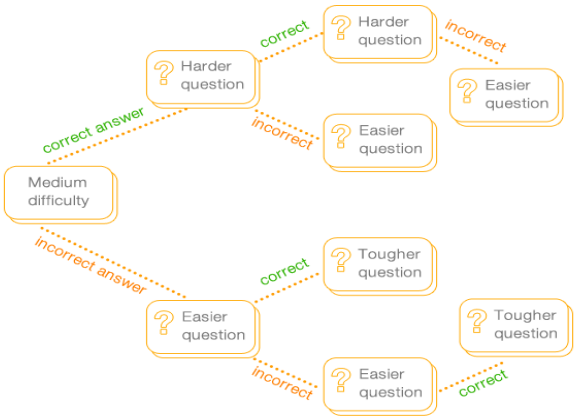

Figure 2: Basic Adaptive Learning Assessment Approach

Using the assessment approach in Figure 2, the adaptive system learns the student's personal style of learning (graphics, audiovisual, text, etc.), and unique learning needs, then presents the material in a manner that makes the student feel properly rewarded for retaining the learned knowledge (Nazeema Alli, 2016).

3. ADAPTIVE INTEGRATED LEARNING TOOLS

There is no shortage of technology-based adaptive learning tools on the market today. While many of them share a common underlying approach to adaptive learning, a few tools stand above the rest in terms of student retention and pass rate metrics. This study utilized two adaptive learning tools from McGraw Hill Higher Education: SimNet™ and Connect™. In addition, Brightspace D2L was also incorporated as the Learning Management System (LMS).

3.1 SimNet, Connect, and D2L

SimNet™ is a learning and assessment tool for Microsoft Office skills that help instructors monitor student progress on learning outcomes in a virtual Microsoft Office environment.

Connect ™ is an adaptive digital teaching and learning environment that saves students and instructors time while improving performance over a variety of critical outcomes. Connect provides opportunities for both formative and summative assessment. This adaptive technology provides students with a safe place to make mistakes encouraging deliberate practice and enabling them to move one step closer to mastery (MHE-Education, 2017).

With SimNet, instructors employ the adaptive learning feature, SimPaths, for MS Office applications and the adaptive interactive reading experience, SmartBook in Connect, for concepts.

Both programs help in reducing lecture time and grading, and the students appreciate this method of learning (GGC S. , 2017). As a result, instructors are able to cover much more in a shorter time, and the students accelerate their learning experience by *not* having to relearn what they already know.

Connect and SimNet are powerful and feature-rich tools. Investing instructor time in learning these capabilities (beyond the basic use) could be of great value to instructors and students alike. Additionally, providing a single access point to all course resources (Brightspace D2L, SimNet, and Connect) by using the McGraw-Hill Campus API deep integration techniques, students experience a smooth and productive learning experience where they can check all their grades (in D2L) and due dates (in the D2L Calendar).

Figure 3 illustrates a sample Learning Analytics Levels in Adaptive Learning using MHE Connect and SimNet. It demonstrates that as the student discovers how s/he is doing (their insight level), they will be able to determine how they will be able to improve on it (predictive matching).

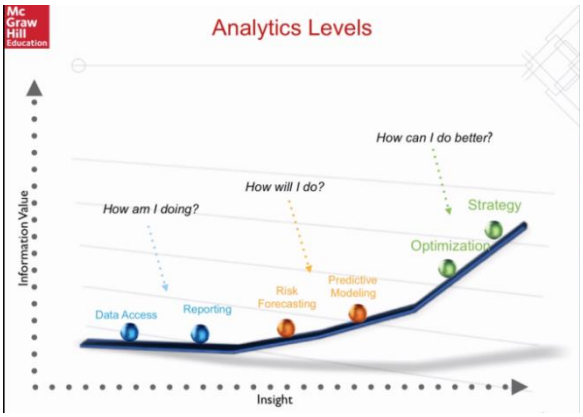

Figure 3: Sample Learning Analytics Levels in Adaptive Learning

Finally, the student will be in a position to optimize their performance and develop a learning strategy that best fits their learning style and objectives.

3.2Adaptive Assignments

Assignments vary each week based on what concepts or skills are covered during that week. A typical week for IT conceptual topics includes a SmartBook assignment (in Connect) covering one chapter from the SmartBook and SmartLearn e-Book due before class, and completing practice questions to determine the level of knowledge students have regarding various "concept" topics related to the chapter. This is typically followed by a quiz to measure the variance between what the student knew and what they needed to learn.

The weekly SimPath assignments consist of a pre-test in the Microsoft Office simulated environment, an adaptive customized lesson based on the pre-test results, and then a post-test, also simulated, which is adaptive as well. The customized lesson includes the reading from Microsoft Office 2016: In Practice, a video, and the opportunity to practice in the simulated Microsoft Office environment. This is followed by an "independent" project using the actual

native MS Office products (Word, Excel, PPT, and Access). Independent projects do not allow for any additional help to the student (hints, suggestions, etc.)

A typical week for office applications includes completing an adaptive simulation, using as SimPath (pre-test, customized lesson, post-test), and completing a Project working with native Microsoft Office applications.

3. THE STUDY AND RESULTS

Over a three-year period (SimNet starting in May 2014 and then added Connect in August 2015 – both to May 2017), data regarding student and instructor outcomes were collected for three ITEC 1001 sections. Student data was provided by our intuitional research, and the instructor data was obtained through a survey that was administered to all participating faculty.

We sought to determine the effect of AL on the following student and instructor outcomes:

- Exam Scores (these are averages summarized across multiple sections into one data set)
- Student Pass Rate (data summarized across multiple sections into one data set)
- Grade Distribution (indicated via number of students *or* percentage of students summarized data across multiple sections)
- Impact on Lecture Time (indicates minutes vs. hours and daily vs. weekly)

3.1 Results of the Study

The analysis of the collected data yielded the following:

- Exam Scores

  Figure 4 shows that scores rose about 10 percentage points across exams (including midterm and final), in all three sections that were evaluated.

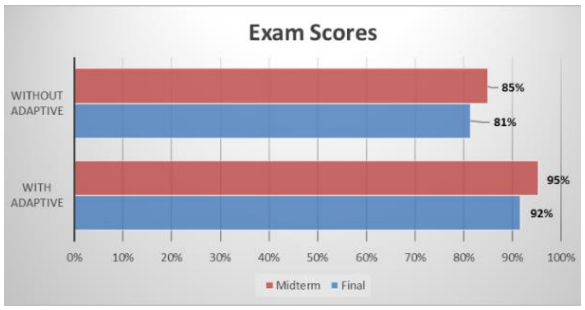

Figure 4: Exam Scores

- Student Pass Rates

Student pass rate also rose significantly with AL by almost 10 percentage points, which can be seen in Figure 5.

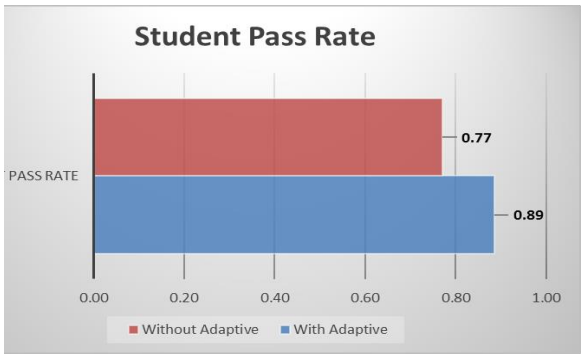

Figure 5: Student Pass Rate

- Grade Distribution

The rate of A's and B's increased with the use of AL, while D's and F's declined (Figure 6).

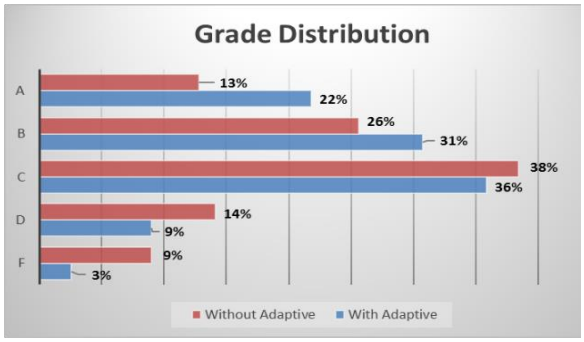

Figure 6: Grade Distribution

- Instructor Time

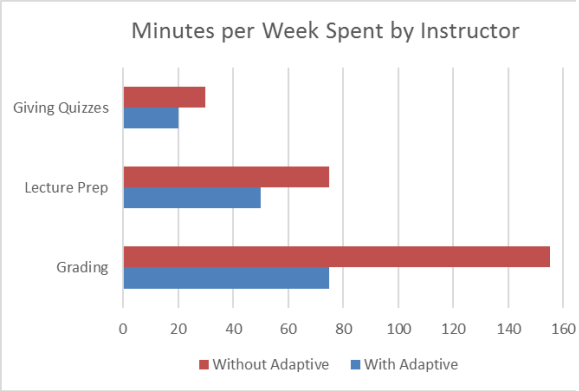

Figure 7: Minutes per Week Spent by Instructor

Time spent giving quizzes, preparing for lecture and grading have all decreased with the use of Connect and SimNet (Figure 7).

3. CONCLUSIONS

Adaptive Learning provides an effective way to quickly view assignment results before class and tailor lectures and class activities accordingly. This is beneficial for both instructor and students in that they are not wasting time covering material they already understand, while drilling into the material where they are still challenged.

By implementing the appropriate tools with adequate adaptive content and objectives, both for computer concepts and Microsoft Office skills, student exam scores, pass rate, and grade distribution improved. It was demonstrated that Instructor efficiency also improved. Students report that using adaptive simulation is an effective approach to gaining office applications skills.

When Adaptive Learning is implemented correctly, it could yield efficiency improvements that benefit both students and faculty and maximize the most efficient use of time. In addition, adopting the right software tools, helps faculty define specific metrics that they can work toward achieving in the future. Adaptive Learning has the potential to make teaching and learning massive amounts of content as well as advanced office software skills manageable within limited time and resources.

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