Adaptive Learning Practice for Online Learning and Assessment

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ABSTRACT

Adaptive Learning (AL) is a personalized learning technology. It can customize learning based on pre-determined knowledge state on a particular subject or topic. This assessment driven approach not only allows students to have their own learning path with individual learning nodes or steps, but also provides various formative and summative assessments the students' learning performance. With the appropriate mapping between course learning outcomes and program outcomes, the program outcomes can be assessed through the assessment results of AL in selected courses. Colorado Technical University (CTU) has been using AL technology in their Web-based Learning Management System (LMS) since October of 2012. CTU's AL approach is both assessment driven and facilitator/faculty driven. In this paper, we will share our experience and findings on using AL in Online Computer Science (CS) and Information Technology (IT) courses to enhance student learning and assess the program outcomes for continuous improvement and programmatic accreditation.

CCS Concepts

• **Applied computing** ➞ **Computer-assisted instruction**

Keywords

Adaptive Learning; Assessment; Accreditation; Intellipath; Learning Path; Online Education.

1. INTRODUCTION

Over recent decades, more and more U.S. colleges and universities have recognized that a one-size-fits-all learning approach is not working in many instances, and adaptive learning technology has been utilized as the solution which has been showing positive results in a number of large pilots [1]. Adaptive learning systems use individual differences as a basis of the system's adaption to provide unique instructional manipulation to meet individual needs [2]. As a personalized learning technology, adaptive learning is becoming the next big thing in education,

especially online education [3], and has been holding a great promise for enhancing student learning and success [4].

For the past several years, adaptive learning advocates have promoted its potential for transforming higher education [5]. A number of funding possibilities have been creating the potential for investigation into the use of adaptive learning in higher education. In fall 2015, bolstered by a $4.6 million-dollar grant from the Bill and Melinda Gates Foundation, a competitive grant opportunity was offered by the Association of Public and Land-grant Universities (APLU) for its 237 member colleges or universities that want to enhance personalized learning, utilize technology for proactive advising, and accelerate degree completion rates [6]. Dziuban et al. discussed about the history of adaptive learning research and various adaptive learning tools or systems [7]. They also introduced the adaptive learning implementation in two universities [8]. One of them is CTU.

CTU started piloting adaptive learning for online courses in the beginning of 2012. The Realizeit [7] adaptive learning system was selected and integrated into CTU's own learning management system. This customized adaptive learning system was branded as Intellipath [4]. All materials related to adaptive learning at CTU as well as platform icons are consistently referred to as Intellipath. As the only institution of higher education engaged in the full-scale implementation of adaptive learning across the curriculum at that time, CTU was accepted as an active participant in the Bill and Melinda Gates Foundation's Adaptive Learning Market Acceleration Program (ALMAP) in 2016.

CTU's initial pilots in adaptive learning included pilots in Math and English courses, offering three courses to approximately 100 students. Each year the number of Intellipath courses was significantly increased. By 2015, CTU had launched 63 courses, offered a total of 107 courses, and had just over 32,000 users (Table 1).

Table 1. CTU adaptive learning demographics

Year	Courses Launched	Total Offered	Unique Users*	Population Adoption**
2012	3	3	358	1.5%
2013	16	19	16,075	55%
2014	25	44	29,634	78%
2015	63	107	32,319	79%

* "Unique Users" indicates the number of individual Intellipath users by year.
** "Population Adoption" refers to the percentage of CTU's population using Intellipath each year. All data is as of December 14, 2015.

CTU's College of Computer Science and Technology (CST) started a pilot of Intellipath in one technology course (IT106) at the end of 2014. Starting from 2015, the college of CST has launched 20 Intellipath courses with over 5,000 unique students.

2. ADAPTIVE LEARNING AT CTU

2.1 Adaptive learning process

Adaptive learning is implemented through the Intellipath platform at CTU. A typical CTU online Intellipath course is broken down into multiple units or objectives in terms of content. Each objective is broken down into lessons that are arranged in a learning path or map. Intellipath determines the learning path for each student based on various assessments on the student's current knowledge state or performance. Therefore, a student may have his or her own learning path which is different from other students'. As Intellipath continues to collect data on student performance and outcomes, the learning path or map may be modified to ensure that both content and sequencing are enabling student success.

The class instructor has a full view of students' learning paths, progress, performance and assessment results. Based on the review, the instructor can make various decisions to adjust the learning paths, communicate with the students to provide assistance, and grade through Intellipath. The instructor is also involved in the continuous assessment and improvement of each content node, which includes a review of the performance metrics collected while students were using the module as well as student performance in related subsequent coursework. The general process of Intellipath courses is shown in Figure 1.
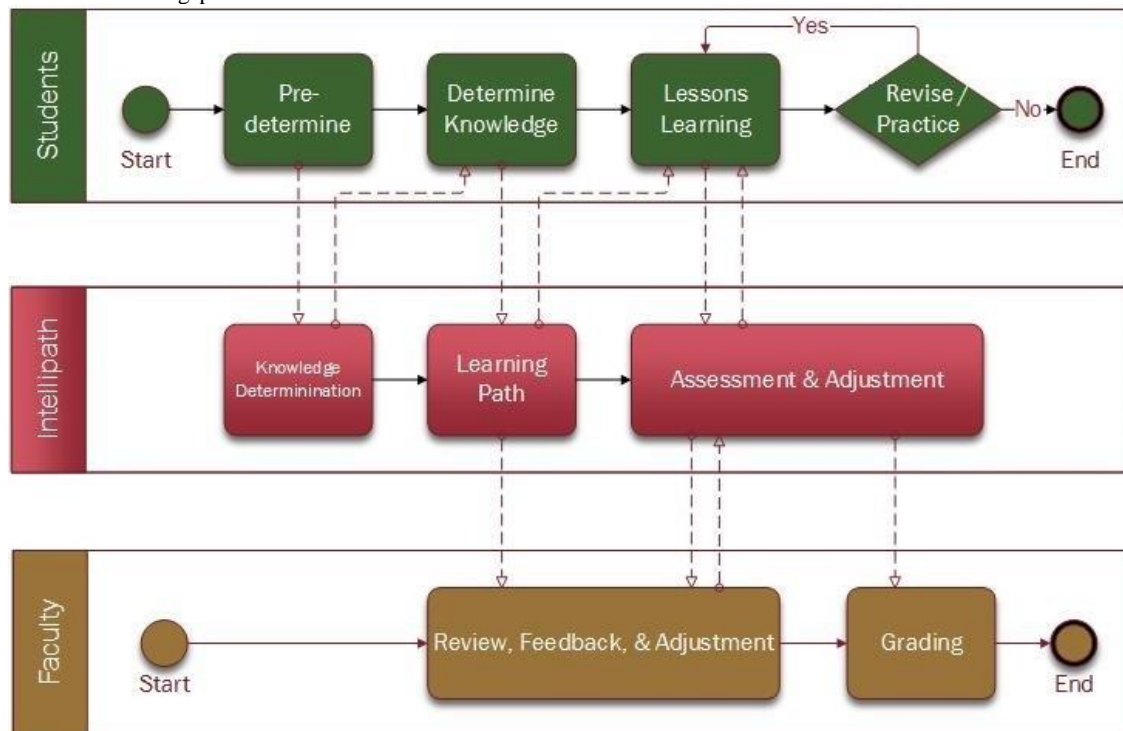

Figure 1. Intellipath courses process.

2.2 Learning activities in Intellipath

The following student learning activities are defined in an Intellipath course:

- *Determine Knowledge*: A diagnostic exam that creates the student's personalized learning path or map through each objective. This feature will determine a student's knowledge across a number of lessons. Determine knowledge will ask students 2 – 3 questions from each lesson that it selects dynamically, depending on how the student is performing.

- *Learn*: Command used by a student to start a lesson.

- *Resume*: Command used by a student to resume at the point where he or she left the lesson, provided they chose the option to save their progress when the exited the lesson previously.

- *Revise*: Command used by a student to re-do a lesson providing an option to improve his or her knowledge for the lesson.

- *Practice/Questions*: Command used by a student to practice a lesson. This provides the question block that is contained in the Questions section of the lesson.

- *Practice Objective*: Command used by a student to practice all completed lessons within the objective.

- *Submission*: If a submission is required, students can upload the following submission types: Text type will display a Text field; URL type will display URL field; file reference type will display a Choose file button. The instructor will have the ability to add feedback and score for each submission, which will become visible to the students.

- *Try*: Command used by a student if they wish to attempt the questions for a lesson that is not yet available to them (locked lesson).

When students start a class unit, they need to complete Determine Knowledge first. The Intellipath system will ask their comfort level for the unit topics. A series of random questions from that unit's lessons will be generated based on the identified comfort

level. After students complete the questions, Intellipath will determine the individual learning path for each student based on his or her answers to the questions. A learning path example is shown in Figure 2.
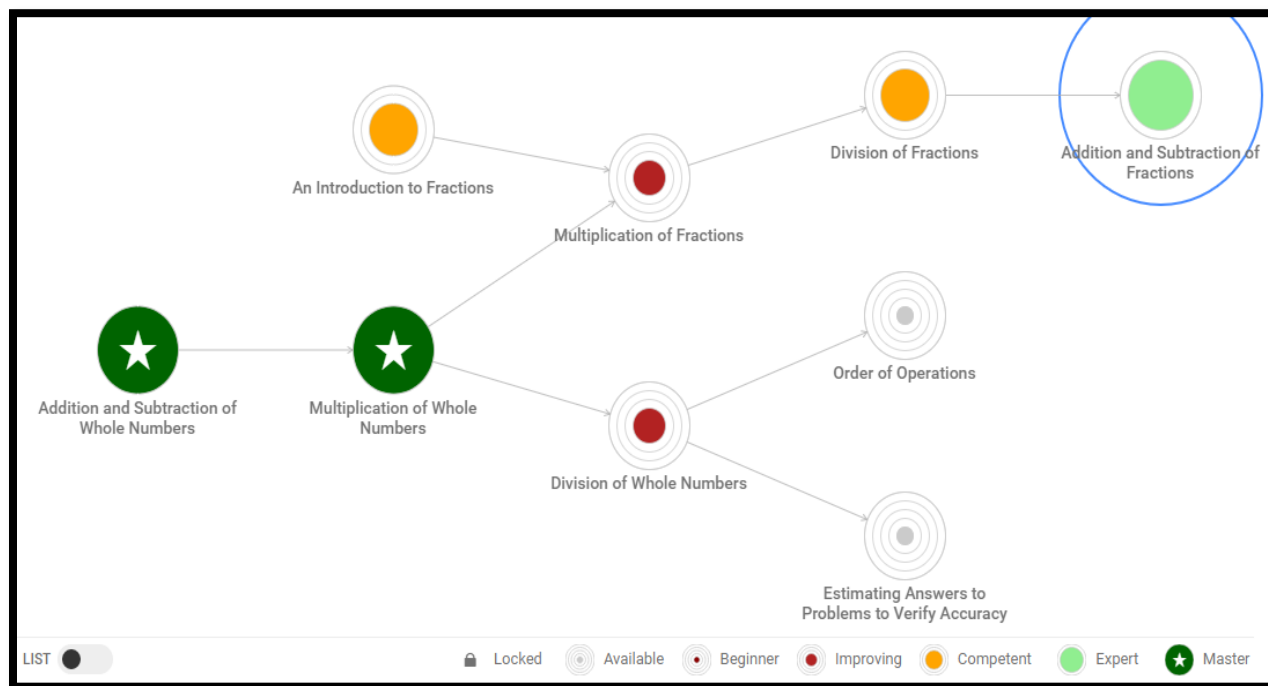

Figure 2. A typical learning path in Intellipath.

Each node in the learning path represents a lesson. Students usually need to complete the lessons in order through the learning path. However, the instructor can control it by unlocking a locked lesson if the student uses the Try command. The learning path is color-coded with Mastery bands to indicate the level of ability for key concepts in a lesson.

Students start learning a lesson by clicking on it. A lesson has five components: Introduction, Learning, Interactive Example, Questions, and Summary.

Introduction is a brief introduction to the topics covered in the lesson. Learning is the learning materials such as text instruction, audios, videos, and optional references.

After completing the lesson materials, students can practice or test what they have learned in Interactive Example which contains practice examples or questions. The Interactive Example result will not be counted for the student's performance on the lesson. Students may review the lesson materials and do the Interactive Example again.

When students feel ready, they can go to the next step which is Questions. Questions contain a series of random questions selected by Intellipath based on the topics of the lesson. The difference from Interactive Example is the result of Questions will be counted for the student's performance. A student can redo Questions through Revise or Practice for improvement but the specific questions may be different from the last time. Even the same question may have different correct answers.

Another type of Questions is Submission, which is usually used for a project or paper that the instructor needs to grade manually. If a submission is required, students can upload the required submission work to the Intellipath system. The instructor can provide feedback and add a score for each submission, which will become visible to the students.

2.3 Grading and faculty engagement

Except Submissions, student learning in a lesson or unit is assessed and graded by Intellipath automatically. Intellipath grading criteria are based on student learning progress, mastery and improvement (Figure 3).

Progress is the points earned for lessons completed. If all lessons are completed, full points will be earned. Mastery is the points earned for comprehension of lesson content. Improvement Score is the points earned for completing revisions and practices.

Students can improve their performance in two ways: 1) To improve the Progress score, complete all of the lessons if the student has not done so. 2) Use Revise and/or Practice commands (see the definitions on Page 2). This may improve the Mastery level and also the Improvement Score points.

Intellipath provides various tools to the instructor to review each student's learning activities, progress, and performance. Based on the review, the instructor can make data-driven decisions about lecture content, classroom activities, student assignments and individual student-instructor interactions that supplement or are offered as an adjuvant to the Intellipath curriculum. The typical activities for an instructor include:

Figure 3. Intellipath grading criteria.

Send messages to individual students or entire class.

- Answer students' questions through messages or emails.
- Provide a chat or tutoring services.
- Assign Revise and Practice to individual students.
- Add extra lessons or learning materials to individual students or entire class.
- Grade submissions and add feedback.
- Adjust and submit the final grade for each student.

3. WHAT WE HAVE LEARNED

3.1 Student performance improvement

Intellipath has been improving student performance overall at the college of CST. Within the 20 Intellipath courses offered in our college, 16 courses were converted from the regular version. Compared to their regular version, 15 of the 16 Intellipath courses have better performance and higher Pass rates. For instance, we had piloted IT190 (Introduction to IT) in Intellipath for three terms. There were 10 IT190 classes each term. We used 5 of them in Intellipath pilot for each term. Figure 4 shows the comparison of the two versions (IT190X is the Intellipath version).

We investigated the only course that was not improved after moving to Intellipath and found when the course was converted to an Intellipath course, the individual projects were changed as well. The new projects were more difficult and the average grades were lower compared to the old projects. This is why the overall course performance remained the same.

Another thing we have learned is that students are more engaged in Intellipath. Students have indicated they like Intellipath in the end of course student surveys. We have also found the Intellipath completion rate is usually higher than the completion rate of non-Intellipath activities such as individual projects. In some units of IT106 (Introduction to Programming Logic), the Intellipath completion rate can be up to 25% higher than the individual projects.
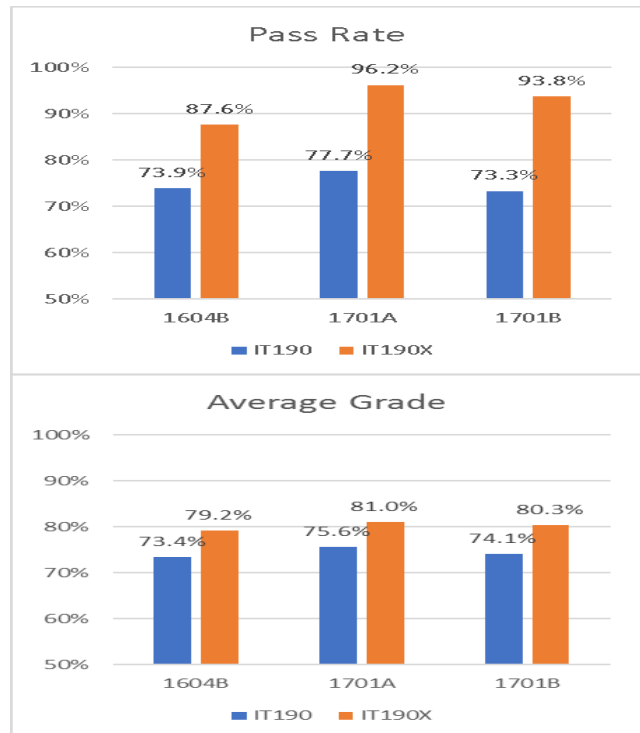
Figure 4. IT190 Regular vs. Intellipath.

When the submission feature became available in 2016, we started a pilot to change an Intellipath course (IT106) which had individual projects outside the Intellipath system. We moved those projects into the Intellipath lessons as submissions. Therefore, the projects became a part of the work in Intellipath. The performance was improved after the change. Figure 5 shows the improvement in IT106. After this pilot, we have made the same change for all our Intellipath courses. It will be the standard design for all new Intellipath in the future.

PASS RATE

Legend: Regular | Pilot | Full Launch | Submission

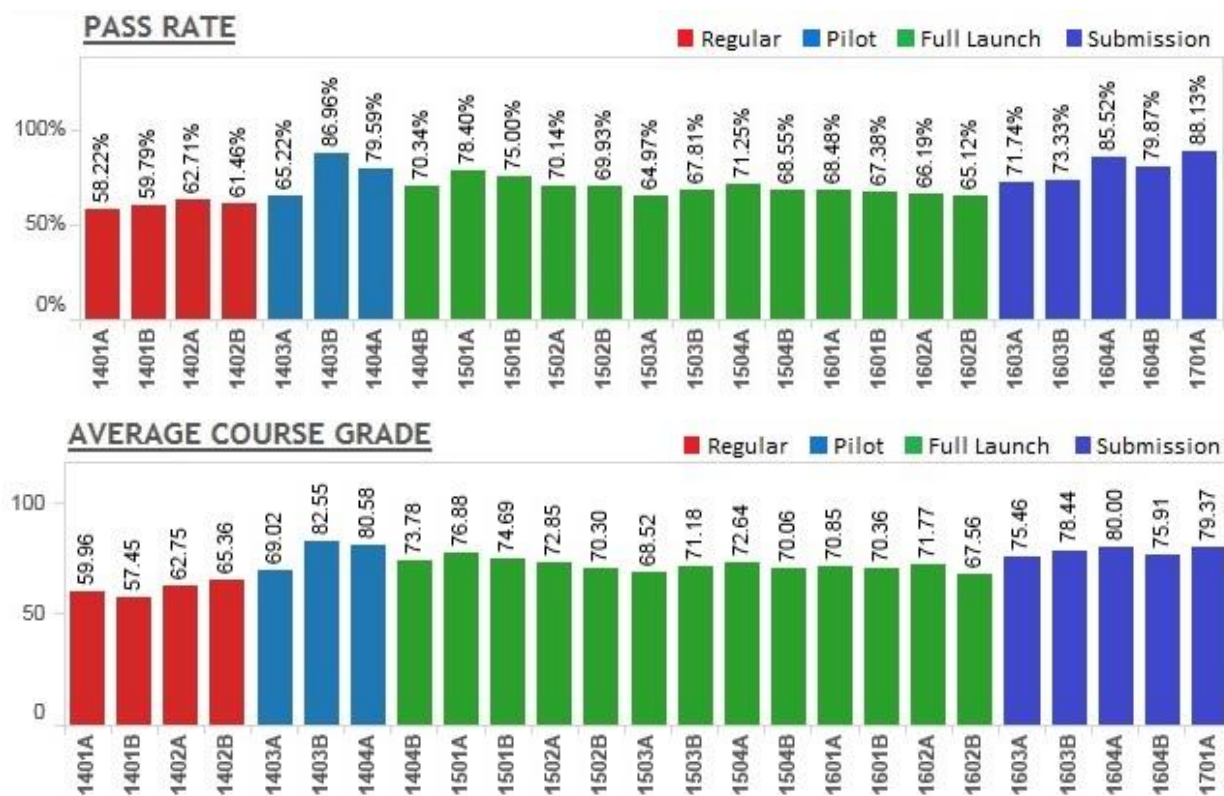| Course	Pass Rate
1401A	58.22%
1401B	59.79%
1402A	62.71%
1402B	61.46%
1403A	65.22%
1403B	86.96%
1404A	79.59%
1404B	70.34%
1501A	78.40%
1501B	75.00%
1502A	70.14%
1502B	69.93%
1503A	64.97%
1503B	67.81%
1504A	71.25%
1504B	68.55%
1601A	68.48%
1601B	67.38%
1602A	66.19%
1602B	65.12%
1603A	71.74%
1603B	73.33%
1604A	85.52%
1604B	79.87%
1701A	88.13%

AVERAGE COURSE GRADE

Legend: Regular | Pilot | Full Launch | Submission

Course	Average Course Grade
1401A	59.96
1401B	57.45
1402A	62.75
1402B	65.36
1403A	69.02
1403B	82.55
1404A	80.58
1404B	73.78
1501A	76.88
1501B	74.69
1502A	72.85
1502B	70.30
1503A	68.52
1503B	71.18
1504A	72.64
1504B	70.06
1601A	70.85
1601B	70.36
1602A	71.77
1602B	67.56
1603A	75.46
1603B	78.44
1604A	80.00
1604B	75.91
1701A	79.37

Figure 5. IT106 performance changes.

3.2 Components to create success

Each course may have its own properties or specialties. Therefore, adaptive learning design and implementation for each course may be unique based on the course's properties or specialties. Some courses may not even be appropriate for implementing adaptive learning. For instance, courses with linear content are easiest to adapt. If units and lessons of a course are totally separate from one another, no learning paths can be created.

Another component to succeed is curriculum integration. An advantage of the curriculum-wide approach is that learning paths connect learning lessons across entire degree programs. Students are automatically directed back and forth between learning paths if, for example, they require a refresher of foundational concepts when completing higher level courses or if they are a highly accomplished student and need to be challenged by more advanced applications or problems.

The success of adaptive learning also needs faculty engagement. The automated, assessment driven component of our Intellipath platform informs the facilitator/faculty driven element of our adaptive learning courses. The results of the assessment driven activities populate sophisticated faculty dashboards so that our instructors can make data driven decisions about lesson content, classroom activities, student assignments and individual student-instructor interactions. Without active faculty engagement, the advantage of Intellipath cannot be applied fully. Some students may even get lost and become frustrated without faculty assistance.

## 3.3 Application to program assessment and accreditation

Program assessment is a key for continuous improvement. It is also required for programmatic accreditations which are designed for specialized programs, departments, or schools within a university or institution. For instance, the Accreditation Board for Engineering and Technology (ABET) is a well-known one for post-secondary education programs in Applied and Natural Science, Computing, Engineering, and Engineering Technology. ABET evaluates programs utilizing outcomes-based assessment methods [9]. They expect programs to clearly define program learning outcomes and objectives, establish an assessment process to determine the extent to which these outcomes and objectives are achieved by graduates, and use the data thus collected to improve the program [10].

Program assessment requires data collection and analysis which usually takes a lot of time and effort, especially, for a large program. Because adaptive learning is assessment driven, it can support the program level assessment based on its student learning assessment at course level. To do so, an appropriate mapping between program outcomes and course learning outcomes needs to be established. In the college of CST, all program outcomes have been mapped to one or more selected courses within the program. The associated units in the courses are also selected to be used for the assessment. Table 2 shows a mapping example in the BSIT program.

Table 2. Program outcome mapping for assessment

Program Outcome	Course Objective	Course	Unit
(2) Apply database concepts and capabilities through the creation, organization and maintenance of modern database systems	Design and implement tables, relationships, forms and reports	CS251	2, 3, 4
	Create and manage tables	CS362	4, 5
	Apply standard techniques to sort, restrict, and manipulate data	CS362	3, 4, 5

From the Intellipath system, the performance on the Mastery criteria for all the associated units can be pulled out and utilized as the data for the particular program outcome assessment. In case the benchmark (e.g., the green bar in Figure 6) for the outcome is not met, we can trace down to particular course(s) and unit(s), and make some changes for improvement if necessary.
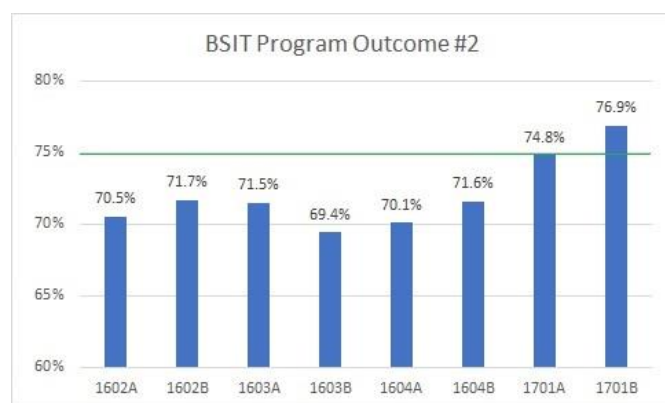
Figure 6. A program outcome assessment example.

4. CONCLUSION AND FUTURE WORK

Adaptive Learning has been very successful through the Intellipath platform at CTU. The results have shown the improvement on student performance and engagement. It has a significant impact to assessment as well. For further improvement, the following are some tasks for the future work:

- *Full curriculum integration*: Adaptive Learning curriculum integration is partially done in the programs at CTU currently. Students may still be automatically directed back and forth between learning maps through some courses across the program, but there are some limitations since not all courses in a program include Intellipath. We are developing more Intellipath courses. All CS courses in the new BS of Computer Science program are scheduled to include Intellipath by the end of 2018.

- *Advanced decision-making tools*: The data collected in Intellipath has been utilized for assessing and assisting student learning and faculty engagement. Algorithm based big data analytics has been playing a key role here. However, the Intellipath data including assessment and analysis results is basically displayed on the dashboard without further recommendations. Instructors need to analyze the results to make decisions. Advanced big data analytics and Artificial Intelligence (AI) technologies can be utilized further to analyze various data and make some decisions automatically or provide some recommendations based on the analysis results for the instructors.

- *Mobile application*: The CTU Mobile app for both iOS and Android was released in January 2016. Students can use it to check assignments, participate in live chats, send emails, review discussion boards, and track their academic progress. The faculty version is also available for overview of the courses including student engagement, emails, announcements, and creating or editing a live chat. Intellipath is partially available in those mobile apps with limited functions. The full Intellipath version mobile apps will be released in the near future.

- *Adaptive Learning at ground campuses*: Besides the online campus, CTU has two ground campuses where the courses are taught in traditional classrooms. Technically, there is no restriction to bringing Intellipath into a ground class. We are doing some research and testing to apply the online Intellipath on traditional classroom teaching at the ground campuses so that the traditional ground students can take the advantages of Adaptive Learning as well.

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