THE EFFECTS OF INTEGRATING EXTERNAL APPLICATIONS INTO LEARNING MANAGEMENT SYSTEMS (LMS)

An Undergraduate Research Scholars Thesis

by

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RESEARCH COMPLIANCE CERTIFICATION

Research activities involving the use of human subjects, vertebrate animals, and/or biohazards must be reviewed and approved by the appropriate Texas A&M University regulatory research committee (i.e., IRB, IACUC, IBC) before the activity can commence. This requirement applies to activities conducted at Texas A&M and to activities conducted at non-Texas A&M facilities or institutions. In both cases, students are responsible for working with the relevant Texas A&M research compliance program to ensure and document that all Texas A&M compliance obligations are met before the study begins.

I, Siddarth Pandian, certify that all research compliance requirements related to this Undergraduate Research Scholars thesis have been addressed with my Research Faculty Advisor Dr. Tracy Hammond prior to the collection of any data used in this final thesis submission.

This project required approval from the Texas A&M University Research Compliance & Biosafety office.

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ABSTRACT

The Effects of Integrating External Applications into Learning Management Systems (LMS)

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Learning Management Systems (LMS) have become the new norm for education at all levels. Due to the increasing popularity of LMSes, supplemental learning applications are now being tailored to work with an LMS by the use of Learning Tools Interoperability (LTI), which is a standard that helps provide the capability to connect external applications. Despite these advances in educational technology, some instructors seem to have a hard time adopting them. This thesis has two main goals: the first goal is to gauge professor and student interest in using integrated educational apps, and the second goal is to create an LTI application using the current Mechanix platform created by the Sketch Recognition Lab (SRL). In order to gauge interest in integrated software, a survey was sent out to professors and students. N1=29 professors and N2=30 students responded to the survey and gave feedback. Results show that both groups greatly prefer integrated applications over non-integrated applications. Also practical steps were shown on how to make an application LTI compliant.

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Contributors

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NOMENCLATURE

IRB	Institutional Review Board
LMS	Learning Management Systems
LTI	Learning Tools Interoperability
SRL	Sketch Recognition Lab

1. INTRODUCTION

1.1 Motivation

With online learning becoming the new norm, Learning Management Systems (LMS) play an increasingly vital role in higher education [1]. Apart from LMSes, instructors also tend to use multiple external learning applications to aid in their instruction. A potential problem with having too many standalone external education applications is that students and instructors will have to manage different systems. This makes managing grades and deadlines difficult and confusing. Due to these inconveniences, instructors may opt out of using these external applications that were intended to enrich the learning experience of students. A better solution is required to make the usage of external apps easier for students and instructors alike.

1.2 Context

Currently, the top three LMSs are Blackboard (31%) [2], Canvas (30%) [2], and Moodle (18%) [2]. An example of the Canvas LMS is shown in Figure 1.1

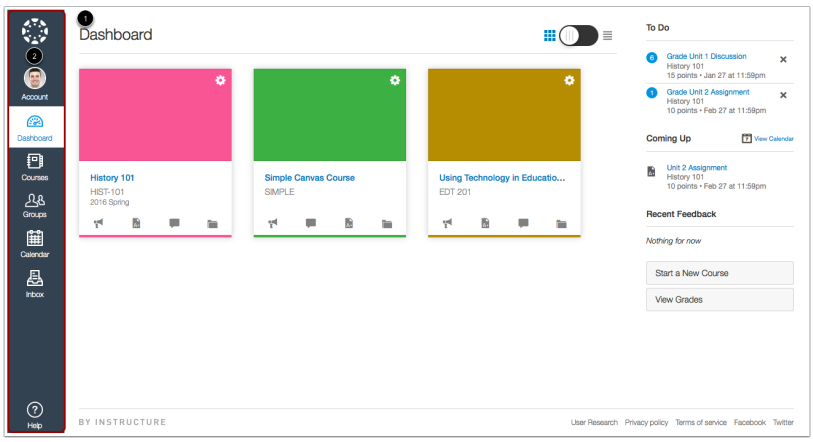


Figure 1.1: Snapshot of Canvas Dashboard[1]

[1] https://richland.instructure.com/courses/1862076/pages/canvas-dashboard?module_item_id=47183588

Canvas is now overtaking Blackboard because Canvas offers better collaboration and group work functionalities for students [3]. And for instructors, Canvas offers better grading functionalities and application integration [3]. Research shows that the compound annual growth rate of LMSes is around 24% [2]. This large growth rate shows that LMSes have a tremendous impact on educational institutions. Every educational institution has the need to manage courses, students, teachers etc. Therefore the market for LMSes is potentially large. Although educational institutions are adopting LMSes at an unprecedented rate, many faculty members are not choosing to use LMSes for reasons that are outlined in prior studies (e.g. Gautreau 2011 [4], Lawler King, 2003 [5]). These reasons are closely correlated with the demographic data of the faculty members. These studies have highlighted the major motivational factors that faculty members consider when adopting new technologies. While previous studies have focused on the usage of LMSes, this study will focus on the usage of external learning applications.

1.3 Research Proposal

Because of LMSes' ever-expanding growth, application developers are now tailoring their educational applications for specific LMSes. These external education applications integrated with an LMSes may drastically alleviate the difficulties of managing courses, students, instructors, grades and deadlines. Although there are many benefits, there can be many other factors which influence an instructor's decision in adopting new technologies, such as the instructor's technology experience, tenure status [4]. It is crucial to know important factors that influence these decisions which are key to the success of external applications. The most promising way to solve the difficulties of managing multiple standalone applications is to use the Learning Tools Interoperability standard (LTI). LTI, developed by IMS Global Learning Consortium, is the standard for integrating any third party application into any LMS (whether Canvas or Blackboard).This will allow students to switch from many different LTI apps with ease. Basically, LTI solves the problem of integrating cloud-based learning application with an LMS [6].

This research study has two main goals: The first one is to understand instructor motivation. This will help us understand how much instructors really care about third party educational

software. Also we can learn about the specific features about educational software that instructors may find most important. It may also prove beneficial to understand students' interest in third party educational software. The second goal is to outline the process to convert a standalone educational application into an LTI compliant application. This will be demonstrated with a sample integration of the Mechanix platform [7], a sketch-based education application developed by the Sketch-Recognition Lab at Texas A&M. This application, used by engineering students, specializes in auto-grading hand drawn diagrams. More information about Mechanix will be provided in the next chapter.

1.4 Scenarios

These are some of the scenarios of how the use of LTI could prove beneficial.

1.4.1 Student-side

Consider the scenario of a student enrolled to a class. The instructor for the class uses three external learning applications which are not integrated into the LMS. Consider the sequence of steps the student takes.

1. The student navigates to each application and creates separate accounts. Each application may have different password requirements, so the student has to come up with a unique login/password chain for each app.

2. The student auto-saves the password on their desktop so that they do not have to remember each username and password.

3. The student is travelling and intends to use their laptop to finish homework.

4. The student forgets password for each application and has to go through the "forgot password" process for each of them, because the password is not auto-saved on the laptop.

The above process is clearly time consuming and wastes valuable time. Another annoyance is that whenever the student submits an assignment, they are not able to see the grades reflected

immediately on the LMS. It usually takes the instructor up to a week to update the grades on the LMS.

In the previous scenario, the integration of the three applications into the LMS would make the student's life easier. The student would just have to log in to the LMS, and click on the app/assignment he would like to use within the LMS, and then the student will be auto-logged into the desired application. The applications would be embedded within the LMS so that everything is one place and easy to navigate. The student would also be able to seamlessly navigate from application to application with ease. Finally, grades in the LMS will be immediately updated with the submission of an assignment.

Figure 1.2 shows that the student will have separate logins for applications without LMS integration. Figure 1.3 shows the student will have a single login into the LMS for applications with integration.

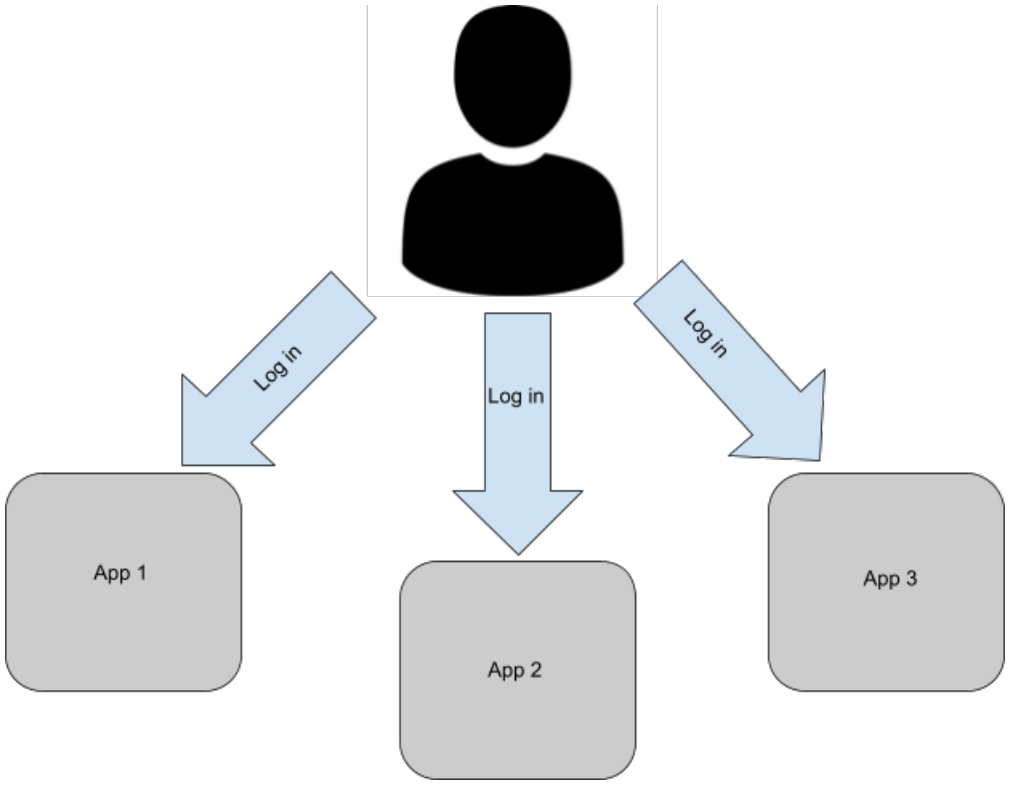


Figure 1.2: Student Login Process without Integration

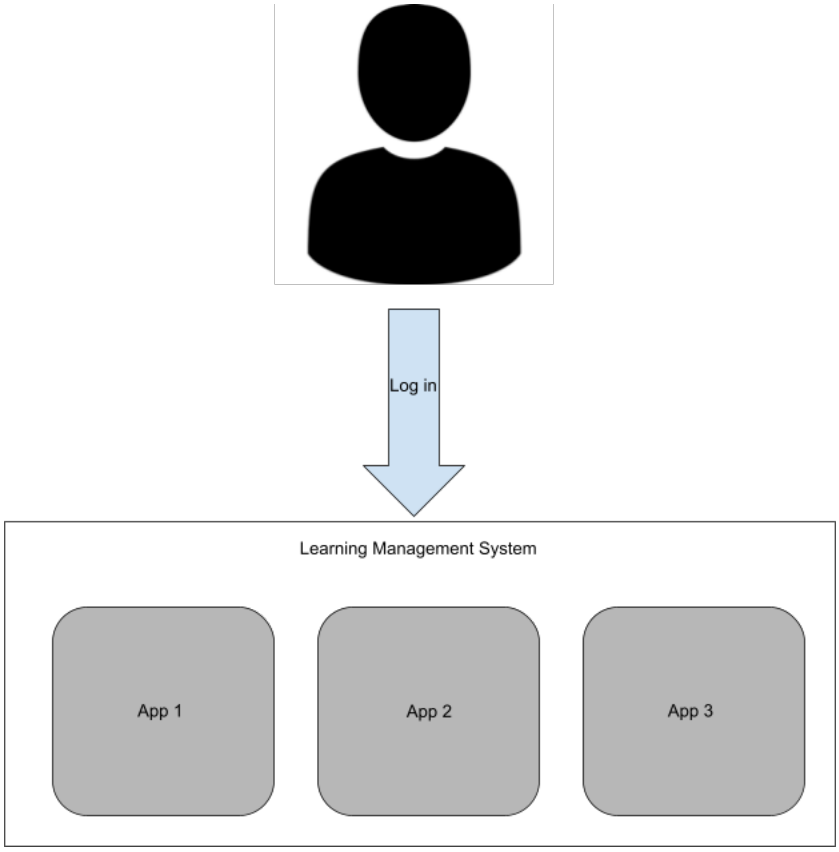


Figure 1.3: Student Login Process with Integration

1.4.2 Instructor-side

Consider the scenario of an instructor managing three external applications for a class. Each application would have three separate procedures to setup. The instructor would need learn these procedures. Once fully set up, the instructor would have to manage grades. Each application has an export grades to comma-separated values (CSV) option [8]. This would capture all of the students' grades in a tabular format. The instructor would export the grades to a CSV and make the TAs update the students' grades in the LMS. This process can prove to be laborious.

In this scenario, the integration of these application with the use of LTI would also make the instructor's life easier. The instructor would just have to choose the desired app from the list of LTI compatible apps and setup with minimal configuration. The grades will automatically be

passed back to the LMS immediately after completion of an assignment. Therefore the instructor would not have to put much efforts in managing grades. Since everything is one place, instructors would also have a better experience.

1.4.3 Developer/Admin-side

Consider the scenario of a developer of an external application. The developer is tasked to integrate the application into Canvas (i.e. the LMS used by the university the developer works for). The developer then writes specific code to integrate the application with Canvas exclusively, without the use of the LTI standard. Let's say that the application becomes more popular and another university wants to use it. The problem is that the primary LMS for this new university is Blackboard, not Canvas. The developer would then have to make another version of the application with a separate integration with Blackboard. A developer would have to repeat process this with each and every LMS they wish to integrate with. This is obviously very inefficient and time consuming.

By conforming to the LTI standard, the developer could eliminate all the problems mentioned before. Through the use of LTI, the application would be able to integrate with any LMS, thereby future proofing the application. Even if predominant LMS changes within 5-10 years, the application would still function with the newer LMS.

2. RELATED WORKS

As mentioned earlier, there are multiple motivating factors that influence an instructor's decision to adopt new technologies. In the paper by Gautreau [4], She identifies the main motivation factors that that influences faculty decision to adopt an LMS. These factors are explained by motivation theories such as motivation hygiene theory and diffusion of innovation theory. Researching these theories are essential in order to formulate a comprehensive survey that gauges an instructors interest in adopting an LTI app for an LMS. While Gautreau's paper focuses more on the integration of LMSs themselves, this paper will focus on the integration of third party education applications. The same theoretical framework outlined in her paper will be applied to this research. The following are the motivation theories.

2.1 Motivation Theories

2.1.1 Motivation Hygiene Theory

According to Herzberg's Motivation Hygiene Theory, there are two main factors for job satisfaction: motivating factors and hygiene factors [9]. Motivating factors are factors that directly impact your motivation such as recognition/praise, fulfilling work etc. Hygiene factors, on the other hand, are factors which could possibly demotivate you if you do not receive them but do not directly impact motivation. These factors include pay, working conditions, administrative practices etc. This study by Herzberg is particularly useful because proper survey questions can be crafted that targets this theory. Administrative practices is one of the main hygiene factors that is relevant to this research. Therefore questions regarding the role of university practices in influencing instructor's decision to adopt an LTI/LMS can be asked in the survey.

2.1.2 Diffusion of Innovation Theory

The other relevant theory is called Diffusion of Innovation Theory developed by Rogers, a professor of communication studies. This theory pertains to the rate of adoption of new technolo-

gies. According to this theory, there are five main categories of people: innovators, early adopters, early majority, late majority, and laggards [10]. As the names suggest, innovators are the people who adopt a new technology the first, and laggards are who adopt it the last. The following Figure 2.1 from Rogers (1995) portrays these category of people vs the market share of the new technology.

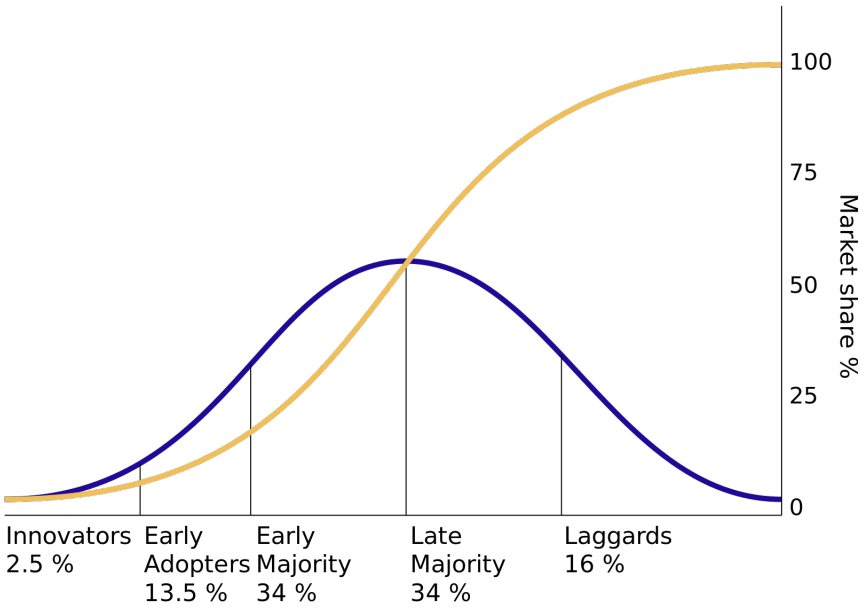


Figure 2.1: Categories of people vs Market share [10]

Since LMS's are a relatively new technology, the Diffusion of Innovation Theory still applies. LTI is an even newer technology since it originated in 2010 [11]. A hypothesis is that faculty who are innovators and early adopters are going to be the most likely to adopt LTI apps. Therefore, we need to identify some of the demographic data of faculty members who are early adopters of new technologies. Question about age, tenure status, gender, department, computer proficiency, salary (optional), and history are all relevant.

2.2 Mechanix Platform

As mentioned earlier, Mechanix is a sketch recognition tool that provides an efficient means for engineering students to learn how to draw truss Free Body Diagrams (FBD) [12]. In large engineering class sizes, instructors are not able to provide detailed and meaningful feedback to students [13]. Mechanix was designed to solve this problem. Using techniques in artificial intelligence (AI) and other sketch-recogntition algorithms, Mechanix is able to identify shapes, their relationships, and other features of their drawing [13]. Therefore, this platform is able to provide immediate personalized feedback to the student. Figure 2.2 shows an example of a hand-drawn FBD in Mechanix.

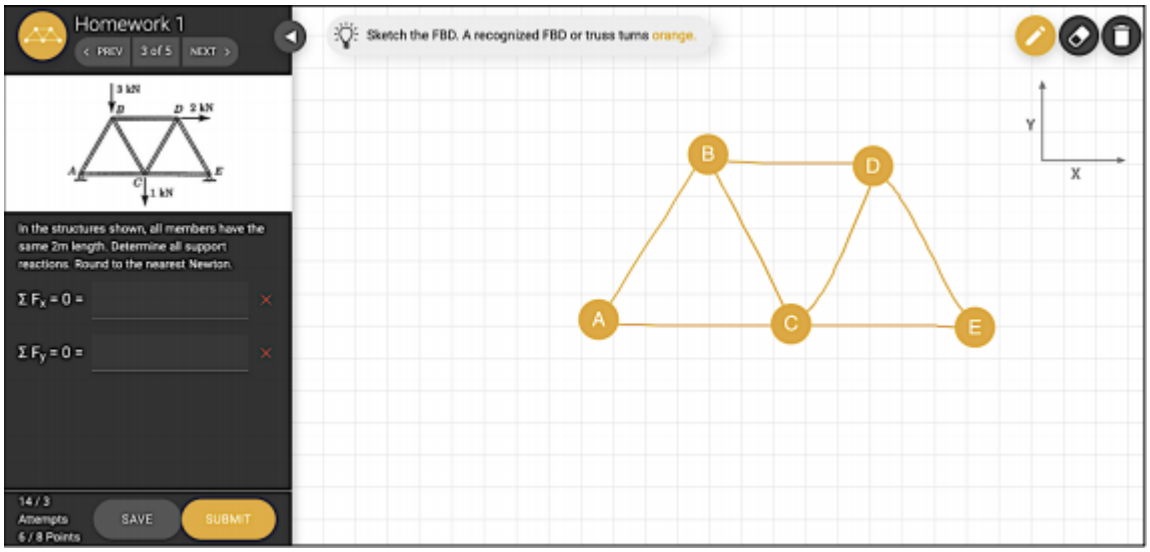


Figure 2.2: Example of hand-drawn FBD within Mechanix [13]

These AI tools have the potential benefit of providing automatic grading for creativity driven design problems [14]. Studies have shown that students who solve their homework using Mechanix perform better than their peers who do not [13]. AI applications in general have been shown increasing a students' performance and motivation [15]. By integrating these applications into an LMS, more instructors will have more options when choosing applications for their class-

room. Studies have also shown that adaptive LMS systems (systems with interoperability features) enhance student learning [16]. The study by Al-hudhud concludes that LMS system designers should add interoperability features with other technology systems [16]. Therefore, in order to further enhance instructor and student experience in Mechanix, the application will be integrated within an LMS. This procedure is explained in more detail in the next chapter.

3. METHODS

3.1 Survey Design

The survey was designed to gauge interest in LTI applications. The questions were designed to be likert scale questions because as it provides an easy way to work with quantitative data. The survey is split into three logical parts: 1) questions gathering demographic data, 2) questions targeting motivational theories 3) questions regarding instructor sentiments on integrated and non-integrated software. The following are snapshots of the instructor survey. The student survey also follows a similar format.

3.1.1 Part 1 of Survey

In this part, questions about age, gender, academic title/rank, and department are asked. This can provide insight into factors causing a specific sentiment toward integrated/non-integrated software.

3.1.2 Part 2 of Survey

In this section, questions related to the motivation theories are asked. Figure 3.1 contains some snapshots from the survey.

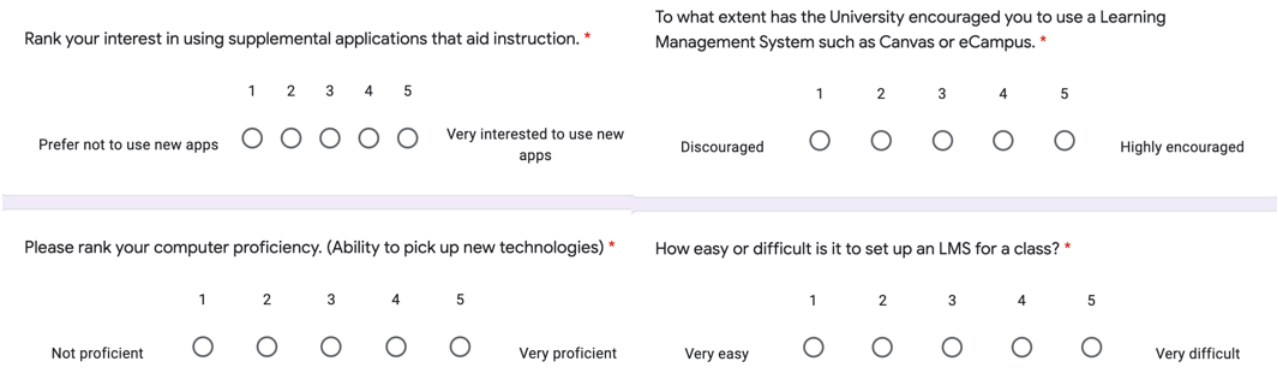


Figure 3.1: Questions from Part 2

The top right question targets the motivation hygiene theory since we ask about the extent to which the University has encouraged the use of LMS. This will give us insight unto the administrative practices within the university. The other questions target the Diffusion of Innovation theory. For example, people who have selected 5 for computer proficiency are most likely innovators or early adopters. Whereas a person who selected 1 or 2 would most likely considered a late adopter or a laggard.

3.1.3 Part 3 of Survey

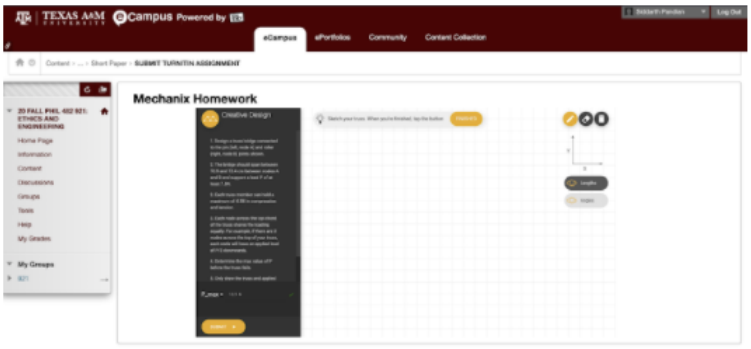
This part asks about the instructors sentiment toward integrated and non-integrated software. Questions about non-integrated software are asked first, which are proceed with the same questions about integrated software. Figure 3.2 shows questions from the survey that ask about non-integrated software. Figure 3.3 shows questions that ask about integrated software.

How do you feel about supplemental applications that are NOT integrated with an LMS.

	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
I would be willing to use these in my classroom	○	○	○	○	○
I find it easy to set up these for my class	○	○	○	○	○
I find it easy to communicate due date changes to students	○	○	○	○	○
I find it easy to give students their grades	○	○	○	○	○
I find it easy to manage multiple third party applications for a class	○	○	○	○	○

Figure 3.2: Questions about Non-integrated Software

How do you feel about supplemental applications that are integrated with an LMS. Consider the visual for the app Mechanix below (an application using sketch-recognition in order to grade engineering diagrams)



	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
I would be willing to use these in my classroom	◯	◯	◯	◯	◯
I find it easy to set up these for my class	◯	◯	◯	◯	◯
I find it easy to communicate due date changes to students	◯	◯	◯	◯	◯
I find it easy to give students their grades	◯	◯	◯	◯	◯
I find it easy to manage multiple integrated third party apps for a class	◯	◯	◯	◯	◯

Figure 3.3: Questions about Integrated Software

The questions for integrated software has a sample visual so that the subject has an idea of what integrated software may look like.

3.2 Statistical Analysis Design

3.2.1 Paired Sample t-test

The reason why the same questions are asked for the integrated and non-integrated software is that a paired sample t-test is used. A paired sample t-test is used when want to measure the difference between two measurements from one group [17]. In this case, we want to figure out if there is a noticeable difference between mean sentiment of non-integrated software vs integrated software for both the instructor and student groups. The null-hypothesis is that there is no difference between the two sentiments and the alternate hypothesis is that instructors have a more positive sentiment towards integrated software. A one-tailed distribution with a 5% significance level will be used (the p-value will be computed [18]).

3.2.2 Two Sample t-test

The second test that will be used is a two sample t-test [19]. This is used when we are taking a single measurement from two separate groups. In our case, the two main groups are students vs instructors. However other groups can be created within the instructors, such as laggards vs. early adopters or instructors from age 30-40 vs. instructors from age 50-60. These groups can be formed using the part 1 and part 2 questions from the survey. However for this experiment, the mean sentiment values from the students and instructors will be compared. The null hypothesis is that there is no difference between the mean sentiment between integrated and non-integrated software and the alternate hypothesis is that there is a difference between the sentiments.

3.2.3 Design Visual

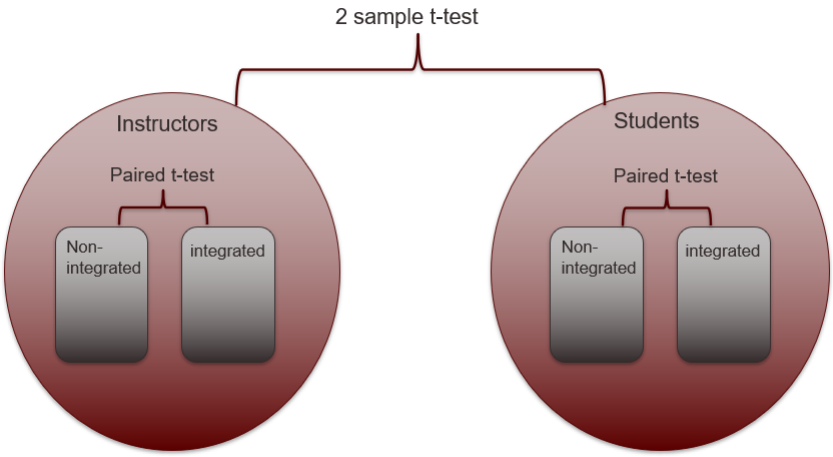


Figure 3.4: Instructors vs Students

In Figure 3.4, the instructor and student circle represents the instructor and student group respectively. Within the instructor group, each instructor is asked a set of questions relating to their sentiment on non-integrated and integrated software. A paired sample t-test is performed between these sentiments. The same goes for the student group. The paired sample t-test is run within the instructor and student group. And a two sample t-test is then run measuring differences between the sentiments of two groups.

3.3 How do we integrate software into an LMS?

The possible benefits of LTI integrations were addressed in the introduction. But how difficult is it to actually implement an LTI app? Before we get into the implementation details of LTI, we must first ask what is standard LTI. LTI is a single sign on assertion (SSO) [20], or in other words a one way directed identity. It is a way for someone to go from the LMS to some other web service already logged in. In this case, the credentials used in the LMS will be passed directly to the Mechanix web application. A predefined key and secret (username and password) is shared

between the tool and the LMS. There is a sign in process that happens. The predetermined key and secret is shared between the LMS and the app. A launch happens which is a POST request which sends user information to the app and also signs that request. The app can then send back content to the specified user or auto-login the specific user specified in the form POST. A holistic representation of the LTI workflow is shown in Figure 3.5.

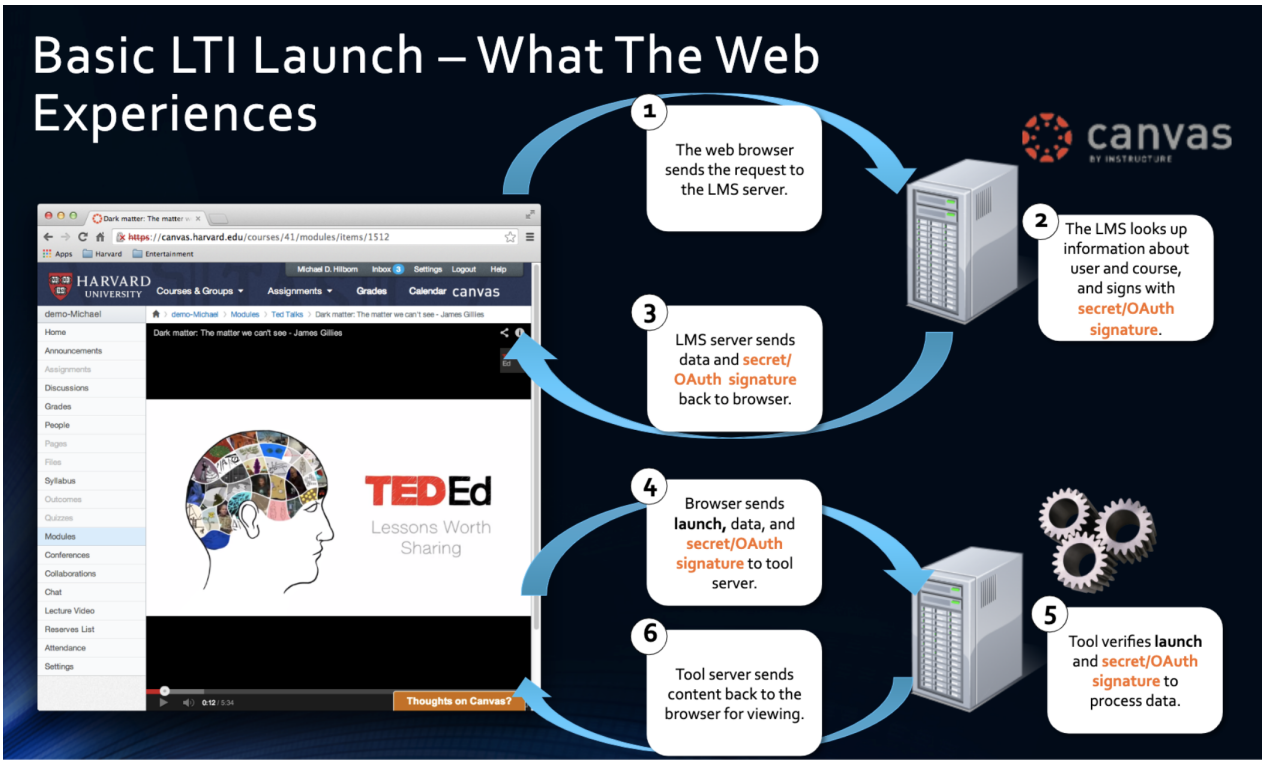


Figure 3.5: LTI process [21]

Figure 3.5 shows the entire LTI process from end to end. However for the prototype that will be demonstrated, a simple bare-bones implementation of an LMS developed by Harvard University [22] will be used. The workflow for the process that will be demonstrated follows more closely to Figure 3.6.

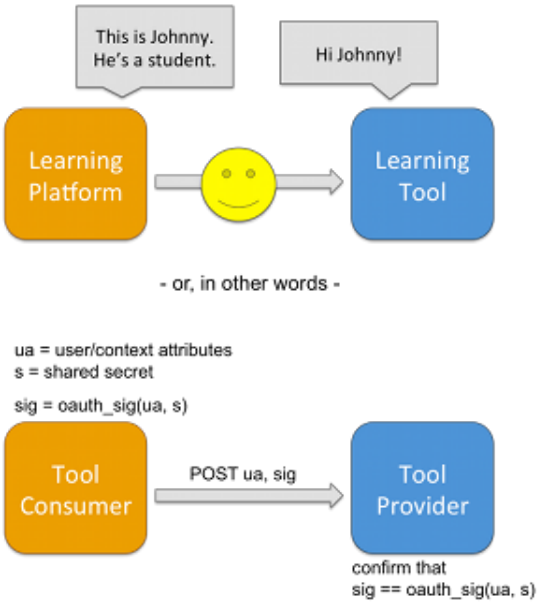


Figure 3.6: Simplified LTI process [23]

There are only a few things that we need to change to the Mechanix application to make it LTI compliant. The steps include: 1) Create an endpoint to accept LTI launch. 2) Verify OAUTH signature using shared secret. 3) Return content based on the credentials in the POST body.

Terminology

Throughout this paper, terminology from the LTI documentation will be used. These terms are important to note.

- Tool Provider: In most cases it is the learning application. More generally, it is the application that gets consumed by the Tool Consumer.
- Tool Consumer: In most cases it is the LMS. More generally, it is the system that uses the Tool Provider
- LTI Launch: Signed POST request coming from the Tool Consumer and sent to the Tool Provider

4. RESULTS

After receiving the IRB approval, the survey was sent out to instructors and students. 29 instructors decided to participate in the instructor survey and 30 students decided to participate in the student survey. However, only 27 out of the 29 instructors answered all of the questions completely. A large number of instructors and students were from the engineering department (73% of instructors and around 50% of students). The instructor respondents were male dominated (75.9%) whereas the students were split evenly between male and female. Overall, there was good diversity of people who responded. More information about the demographic data can be seen in Appendix A (Figures 5.1, 5.2, 5.3 and 5.4 show information about instructor demographics and Figures 5.5, 5.6 and 5.7 show information about student demographics).

All of the data was handled in Microsoft Excel. Excel function were used to take averages and compute t-tests. Since we are computing sentiments between integrated and non-integrated software, we need to assign sentiment values to responses. The following list shows each response mapped to a value between 1 to 5.

- Strongly Agree to 5
- Somewhat Agree to 4
- Neutral to 3
- Somewhat Disagree to 2
- Strongly Disagree to 1

A response of "Strongly Agree" or 5 corresponded to a very positive sentiment and a response of "Strongly Disagree" or 1 corresponded to a very negative sentiment. The average sentiment values for each student and instructor were computed in Excel and can be seen in Appendix A (Table 5.1 shows average sentiment scores for each student and Table 5.2 shows average sentiment scores for each instructor).

4.1 Instructor Survey Results

Overall, most instructors seemed very interested in using supplemental applications in their classrooms regardless of whether the applications are integrated or not. Figure 4.1 shows instructors' interest in supplemental applications.

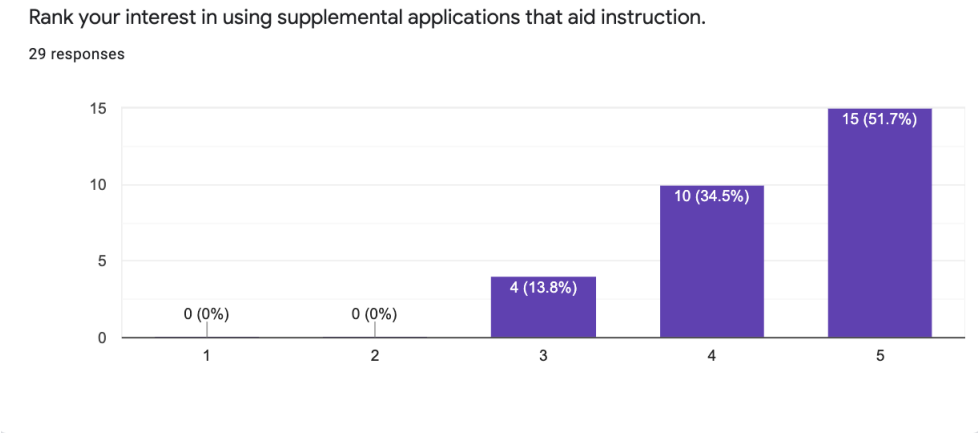


Figure 4.1: Instructor Interest in Supplemental Applications

Another interesting finding is that most professors considered themselves to be technologically proficient (this can be seen in Figure 4.2). The intention of this question was to distinguish the category that the instructor belonged to from the diffusion of innovation theory in Figure 2.1. A person who ranks themselves low in computer proficiency will most likely be a late adopter, and a person who ranks themselves high in computer proficiency will most likely be an early adopter. However, since over 96% of professors consider themselves high in computer proficiency (a score of either 4 or 5), the comparison between a late adopter and early adopter cannot be made.

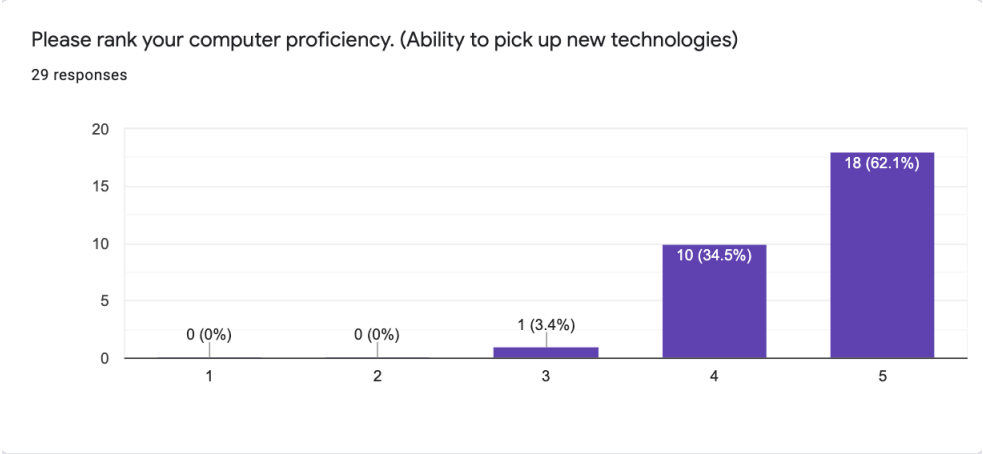


Figure 4.2: Instructor Computer Proficiency

Another important survey question was the question that asked about the extent to which the university encouraged use of LMS. Figure 4.3 shows the instructors response to this question. The results show that there is strong administrative support (hygiene factor) for the use of LMS.

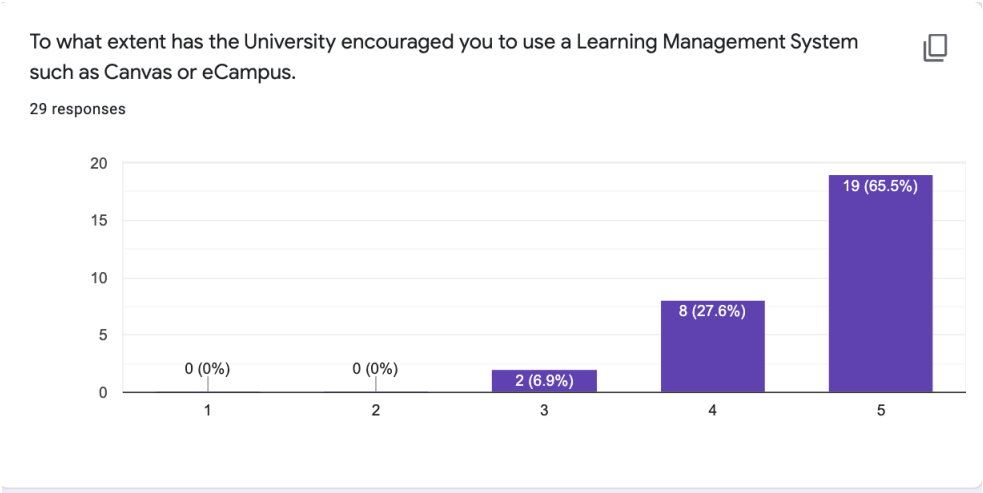


Figure 4.3: Extent of University Support to use LMS

Finally, when instructors were asked what integrated educational apps they use, none of

the instructors responded with examples actual integrated educational applications. Instructors seemed to use a very narrow set of grading/utility integrated applications such as Turnitin [24], Gradescope [25], Google Drive [26], or Honorlock [27].

4.1.1 Paired Sample t-test Results

In order to figure out if there is a difference between the sentiment of non-integrated software and integrated software, a one tailed paired sample t-test is used. The p-value obtained for the instructor group was < 0.05. Therefore we reject the null hypothesis that the mean sentiments are the same, and accept the alternate hypothesis that the integrated software sentiments were higher. To summarize, instructors generally preferred integrated software over non-integrated software.

4.2 Student Survey Results

Students on the other hand had mixed responses about third party software. Figure 4.4 shows students' response when asked their interest in third party software.

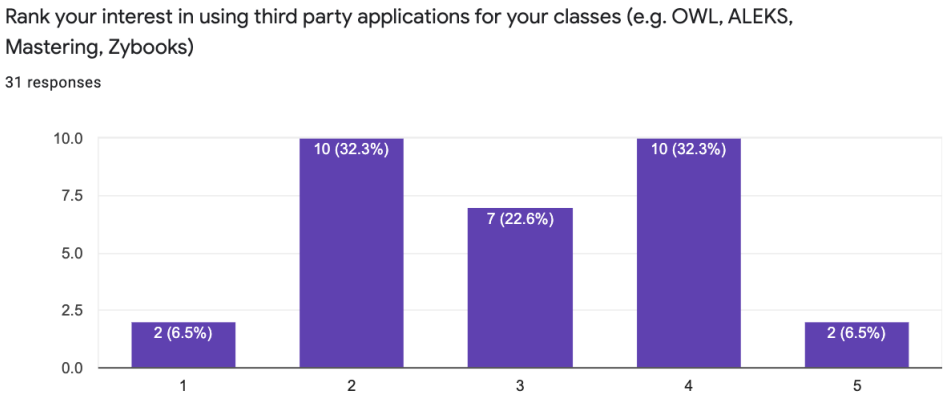


Figure 4.4: Student Interest in Supplemental Applications

Although, we received mixed responses for student's interest in educational applications, students interest for integrated educational applications seemed to be high. Students commented

that they liked the visual of the Mechanix integration. They also commented that they liked the idea of having multiple education applications in one unified portal. The next section quantifies the students' sentiments. To summarize, students, like instructors, prefer integrated software over non-integrated software.

4.2.1 Paired Sample t-test Results

The p-value obtained for the students was < 0.05. Therefore we reject the null hypothesis that the sentiments between integrated software and non-integrated software is the same. We accept the alternate hypothesis that students have a more positive sentiment towards integrated software.

4.3 Instructors vs Students

Do instructors and students have the same sentiments toward integrated software? A two sample t-test is performed to answer this question. The p-value obtained from this test was $\approx 0.1111 > 0.05$. This means that we fail to reject the null hypothesis that students and instructors have the same sentiments towards integrated software, which implies that instructors and students have similar sentiments.

4.4 Mechanix LTI Prototype Results

To create this prototype a basic LMS implemented in PHP by Harvard University [28] was used. This LMS has the ability to send a launch, or in other words send a signed POST request to the learning application. Figure 4.5 shows the simple LMS that is used as well as the POST request that is being sent.

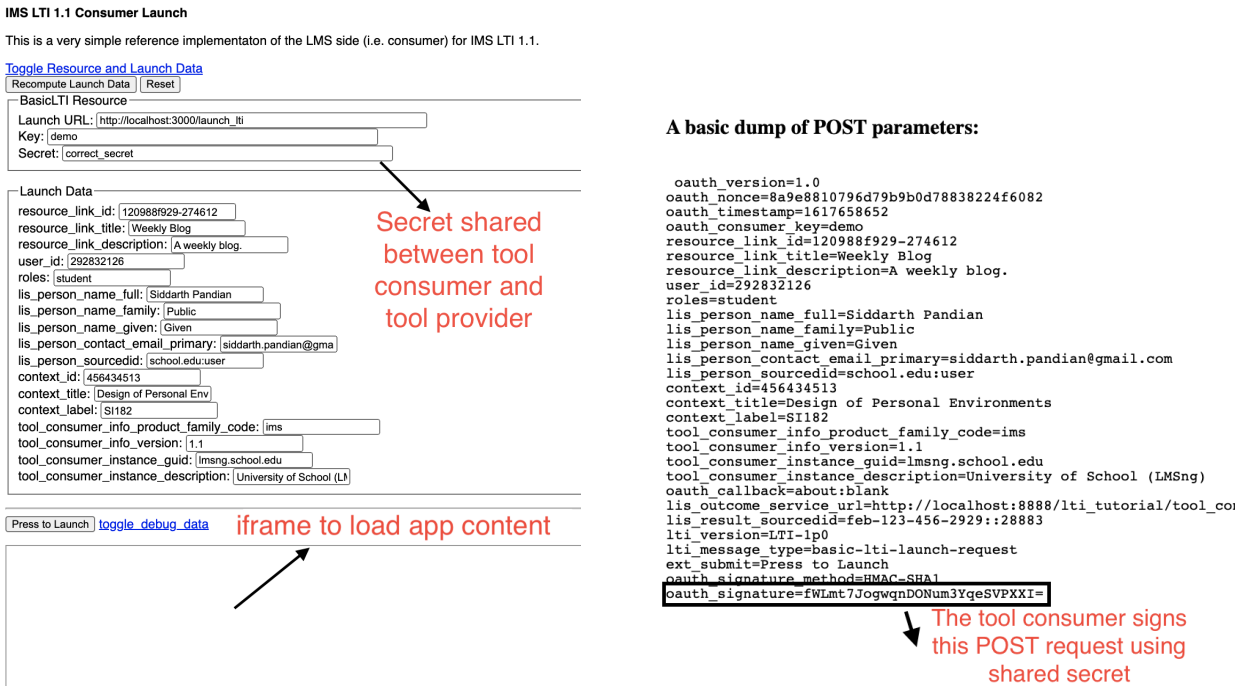


Figure 4.5: (left) Simple LMS (right) POST Parameters Sent to Tool Provider

In the left image of Figure 4.5, under the Basic LTI Resource section, you can specify the endpoint of the tool provider and configure the consumer key and shared secret. For this demo, the secret as "correct_secret" was configured between the learning tool (Mechanix app) and the LMS. The LMS gets the credentials for the user from the LMS servers and sends it in the Launch Data. In Figure 4.6, you can see that if the LMS has the incorrect secret key ("incorrect_secret" was used), the signature is invalid. This means that the learning tool is not able to trust the information that is being sent.

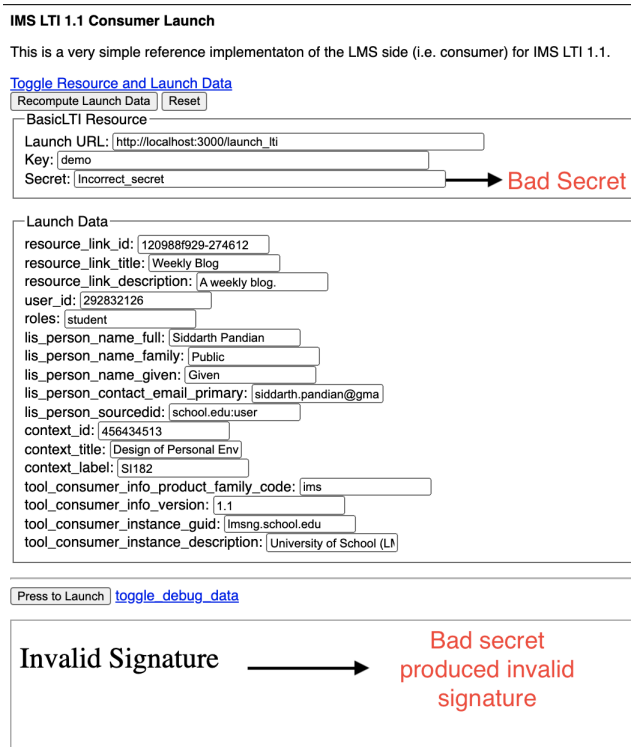


Figure 4.6: Bad Secret Produces Invalid Signature

But assuming, that everything is configured correctly, the user is auto-logged in to the learning tool, and the content is loaded in an iframe within the LMS. Once launch is pressed, the Mechanix app auto logs in the user specified in the POST and loads the assignments page into the iframe as seen in Figure 4.7.

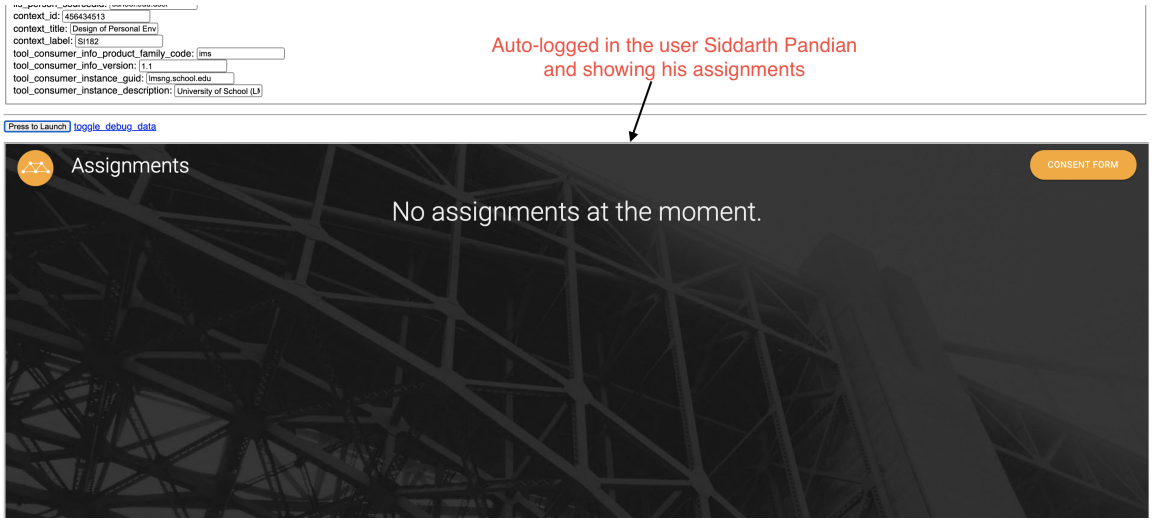


Figure 4.7: Successful LTI Launch

In order to achieve this integration, a route called "/launch_lti" was added to Mechanix, which accepts the launch from the LMS. An npm library [1] was used to verify the OAUTH signature of the request. Once the request was verified, the Mechanix database was searched for the user specified in the request and returned the content for that user, bypassing the tradition login system used in Mechanix. Since LTI is a standard used across all LMSs, this process would be the same for Canvas integrations as well.

[1] https://www.npmjs.com/package/ims-lti

5. LIMITATIONS AND FUTURE WORK

Although the results are showing clear trends, there are some limitations that should be noted. Future work is also necessary to understand the full impact of application integration.

Limitations

One limitation from the user study was that a little over 96% of the instructors considered themselves high in computer proficiency. The original intention was to group the instructors into instructors who were less proficient vs. professors who were very proficient in order to compare laggards and early adopters. However, this classification cannot be made because there is an unequal distribution of laggards and early adopters. An improvement to the survey would be to include a more objective test to verify the instructor's proficiency. This test could include questions that are of a more technical nature such as questions related to word processing, spreadsheet proficiency, and managing computer files.

Another limitation was that Canvas docker image for local development required space of over a 100 GB [29], which is impractical to use on a personal computer. Therefore a simple generalized LMS was used instead. In the future, a local instance of Canvas can be installed on Texas A&M servers and used to test LTI integrations.

Future Work

Currently the Mechanix integration only supports auto-logging the specified user. In the future, we will be working on adding the grade-passback functionality to Mechanix. With this functionality, Mechanix will be able to pass a student's grade back to the LMS. We will be testing this integration with Canvas as apposed to the general LMS that was used in the prototype. Once the integration with Canvas is complete, a second user study can be performed where professors and students test out the integration and compare it with a non-integrated version of Mechanix.

6. CONCLUSION

This study was performed in order to measure student and instructor interest in integrated educational applications. Apart from the user study, simple steps were shown on how to convert a standalone learning application in to an LTI compliant application. The main takeaway from this study is that instructors and students alike prefer integrated software over non-integrated software. Despite the great interest in using these applications, instructors still only tended to use a limited set of integrated applications. This is mainly due to the limitations of the applications themselves. EduAppCenter is the website that contains the collection of all LTI compliant applications which was developed by instructure, developer of Canvas [30]. Out of the thousands of educational applications, about 500 are in the LTI app collection, and only a small subset of them of them are educational content applications [30] (as apposed to utility applications such as Gradescope, Turnitin, Google Drive, and Honorlock). Instructors should be given the freedom to chose between using the integrated version of an application vs a standalone version. However since most of these applications are not integrable, instructors do not have that choice. Through the use of LTI, developers can now more easily integrate these applications with an LMS. The future goal is to give instructors a variety of options to choose from when selecting supplemental applications.

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APPENDIX A: SURVEY RESULTS

Table 6.1: Average Sentiment Score Per Student

Participant	Non-Integrated	Integrated
1	3.666666667	4
2	4.666666667	4
3	3	3.666666667
4	2.833333333	3
5	3	4.666666667
6	1.833333333	3
7	3.833333333	4
8	3.666666667	4.166666667
9	3.333333333	3.5
10	2	3.333333333
11	3.666666667	3.5
12	2.5	3.833333333
13	3	3
14	3.166666667	3
15	4.666666667	4.333333333
16	4.166666667	5
17	4.333333333	3.5
18	3	4
19	3.5	3
20	4.166666667	3.666666667
21	2.333333333	2.666666667
22	2.333333333	2.666666667
23	1	5
24	4.833333333	4.333333333
25	3	4.666666667
26	3.666666667	4
27	2.833333333	3.833333333
28	3	3
29	4.666666667	4.666666667
30	4.166666667	3

Table 6.2: Average Sentiment Score Per Instructor

Participant	Non-Integrated	Integrated
1	4	4.4
2	4.6	4.6
3	4.4	5
4	2.6	4
5	4.2	3.8
6	3.6	3.6
7	3	4
8	2	4.4
9	3	3.8
10	4	3
11	4.6	3
12	3.8	4.2
13	3	2.8
14	3.8	5
15	3	3.4
16	4.4	3.2
17	4.6	4.4
18	1.8	5
19	4	3
20	3	4.6
21	2.2	2.2
22	1.4	4.2
23	4.2	5
24	3.8	4.8
25	5	5
26	5	5
27	3.6	4

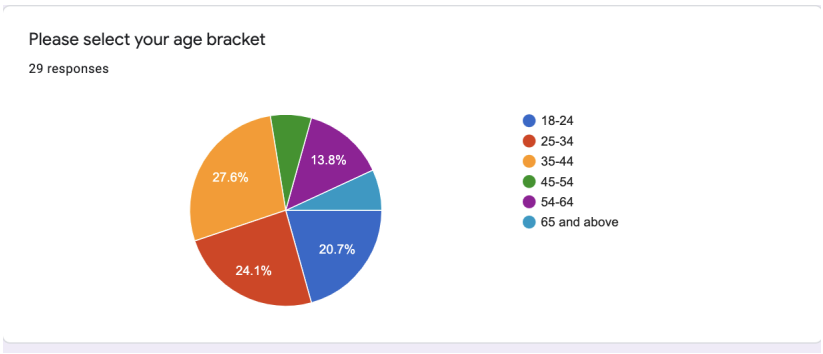

Figure 6.1: Instructor Age

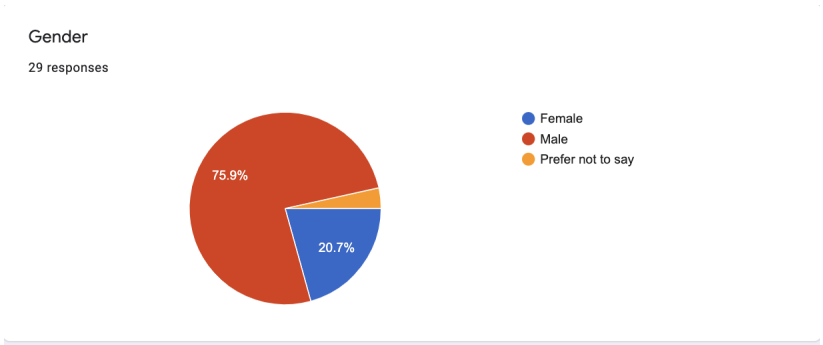

Figure 6.2: Instructor Gender

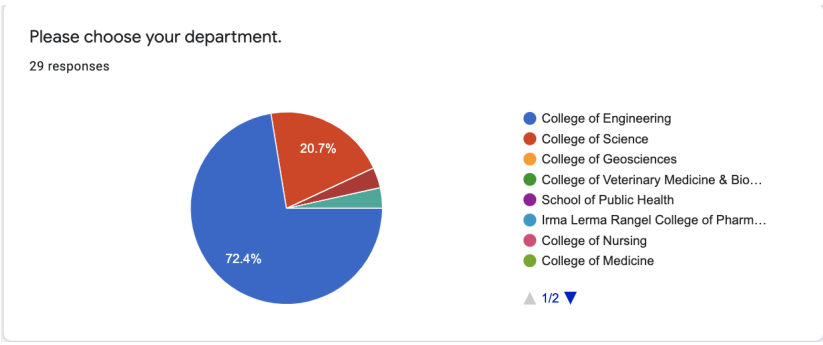

Figure 6.3: Instructor Department

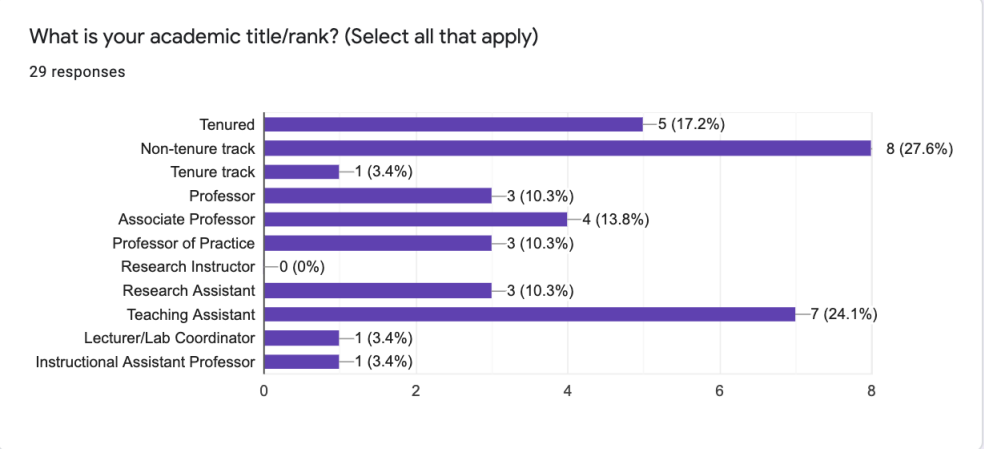

Figure 6.4: Instructor Academic Title/Rank

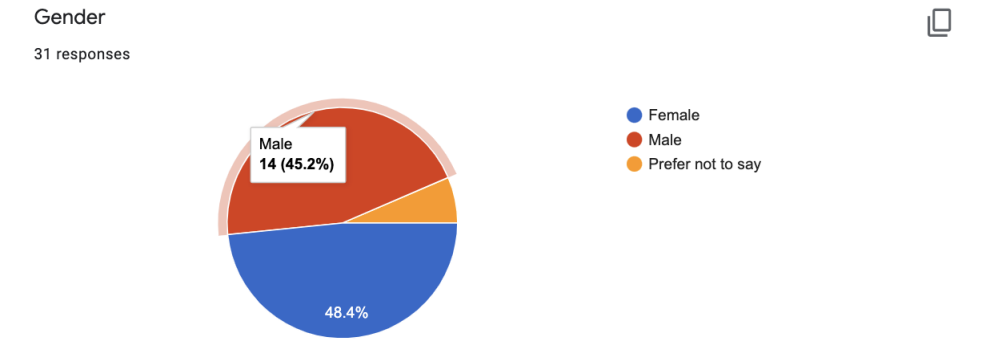

Figure 6.5: Student Gender

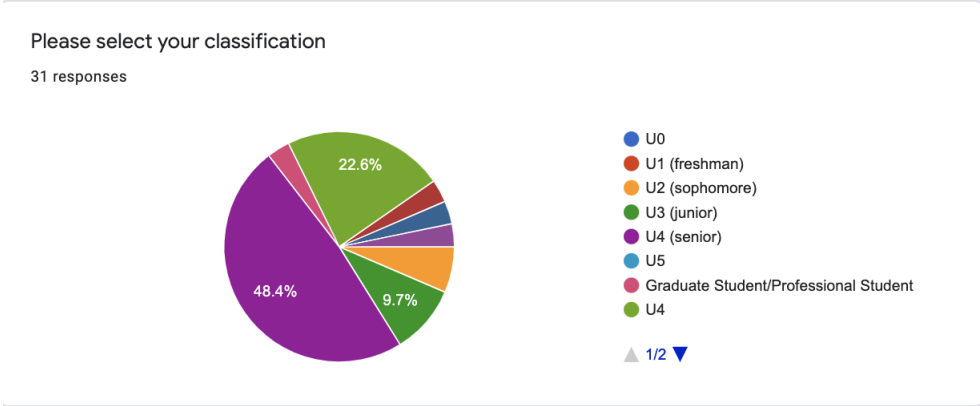

Figure 6.6: Student Classification

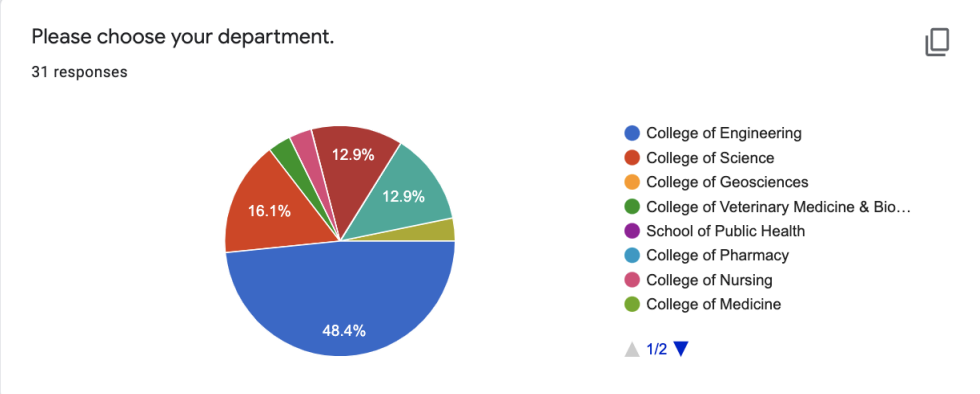

Figure 6.7: Student Department