Improving method of instruction in classrooms

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***Abstract* – During lecturing, a whiteboard is the instructor's most used tool. While the instructors provide lecture slides to students, the whiteboard contains more valuable information which all are erased as the lecture progress to make space for new content. In this work, a study is performed to improve method of instruction by using an iPad and Apple pencil as a digital whiteboard and marker with a projector. A digital tablet allows to provide all the notes written during a lecture to be saved and provided to students. The technology is used in the classroom to be used as a cheaper and better alternative to the instructor's computer and whiteboard without need of any new software or hardware requirements. The study showed that iPad and apple pencil could be an effective instructor tool if the instructor can utilize available iPad apps.**

Index Terms – Teaching tools, instruction methods, electronic tablets and pencil, student resources, iPad, apple pencil.

INTRODUCTION

A traditional classroom consists of a whiteboard/blackboard for instructors to write and a projector and a screen to project contents from computer. During teaching, we use slides, documents or other digital materials for the presentation. More than that, we use the whiteboard to explain various information, concepts and even use it to write notes. We post our lecture slides to e-campus for our students to refer later but we erase the whiteboard at the end. So, it is up to the students to copy the notes during the lecture if they want to refer to it after the end of the lecture. The content of the board contains a lot of important information which is quite important and necessary for students. Also, many students have to miss the class due to various reasons and they do not know what we covered in the class. They get access to the slides, but we go through various discussions and explanations in class which are difficult to comprehend only through the slides. These contents are equally important for learning and need to be preserved and made available to students in electronic ways.

One way to digitize whiteboard content is to use an electronic whiteboard [1] which is quite expensive and financially a big burden to universities to place in all of the available classrooms. It would require a high amount of budget to implement any new technology in hundreds of classrooms. Instead, in this work, the use of cheaper alternatives, an electronic tablet with a digital pencil is explored. Currently, we can buy cheaper tablets and pencil and the use of a pencil allows us to conveniently and effectively write on it. Using this we can achieve the same purpose as of writing in whiteboard and display it using a projector. As such, faculties could use this combination of technology to digitize the classroom teaching notes and make it available to students rather than an expensive digital whiteboard.

This work presents the result of using iPad Pro with apple pencil 2 as teaching material. The tablet was used to annotate digital slides, create notes in the lecture, record lecture screen with audio and produce other teaching materials which were provided to students through online medium.

RELATED WORKS

Various universities have looked into adopting new technology in the classroom to improve the student learning experience. The University of Washington's Classroom Presenter lecturing system [2] enables instructors to annotate digital slide presentations using the Tablet PC, as well as received student-annotated slide submissions from audience Tablet PC. It promotes an active lecturing environment by combining a standard electronic slide presentation format with the capability for extemporaneous ink annotations by instructors and students using Tablet PCs. It provides two-way communication between instructors and students required in a large class but requires setting up a dedicated broadcast communication which is an additional software and networking requirement. The authors in [3] have reviewed the use of Classroom Presenter technology to analyze the impact on student learning and also summarized the best practices for its use. The work discussed the best practices for the use of digital ink technology in the lecture slides as well as discuss methods to improve student involvement. In [4] Digital Lecture Halls have been created using specific hardware and software such as DigiMax, LearnerLoop to make teaching digital while supporting up to 1000 participants. The authors in [5] present a case study of iPad adoption and use in primary school. The study mentions that the teachers found the benefit of mobility, cost, and convenience makes the device a suitable tool for teaching. However, the device was not primarily used for lecturing and creating teaching materials and was used in a primary school rather than a university.

The above-mentioned works and other similar works mostly use dedicated hardware and software which require additional cost for implementation in a new classroom. In this work, an iPad Tablet is used with apple pencil to teach and present lectures. It was implemented in teaching computer science courses for undergraduate students. The technology is evaluated based on the effectiveness of

teaching, convenience of lecturing and distributing the lecture materials. The quantitative evaluation of the effectiveness is measured by student surveys, use of the annotated slides, digital notes, recorded lectures and other materials by students and impact in student grades with new technology vs old technology.

IMPLEMENTATION

A 12.9-inch 2019 iPad pro with apple pencil 2 and a smart keyboard were used for lecturing one semester in computer science courses. The classroom size is small in area with average of 20 students. The iPad pro has A12X Bionic chip with 64-bit architecture, 512 GB hard disk and wireless connection. The necessary hardware besides the tablet, keyboard, and the pencil was a digital audio/video adapter that has a USB-c to USB and HDMI connector, a 10 ft HDMI cable and a USB mouse. The iPad would substitute a personal laptop and would be connected directly to the projector using the digital adapter via the HDMI cable. The tablet would be controlled by the keyboard, an external USB mouse and using figure gestures. The operating system of the iPad is known as iPadOS and currently, it is at version 13. The operating system is primarily built for the tablet application and lacks many features available in personal computers. Fortunately, iPadOS introduced some of the major features such as multi-windows and mouse control. These features made the use of the tablet in teaching very helpful.

The primary software used for the teaching was Microsoft OneDrive, which was used to store all the teaching documents. Most of the documents would be used directly from the OneDrive hence internet connection was a must, although some of the documents can be saved offline as well. For presentations, Microsoft PowerPoint was used primarily for the ppt files, along with Adobe PDF for pdf files. For notes, Microsoft Word was used and other Microsoft software such as Excel were used as necessary. Google Chrome and Apple Safari were used for web browsing. The default iPad recording software was used for recording the screen and sound and the iPad video editor was used for editing the video. The video would mainly be edited only for the length and no other major editing was done.

The tablet was used in four courses: Introduction to Computer science using Java, C programming language, Discrete Math, Introduction to Artificial Intelligence. The plan was to replace a laptop as well as a digital whiteboard with a laptop. All the notes discussed in the lecture would be written on the tablet instead of the whiteboard. A PowerPoint presentation of the lecture was created, and any notes related to that slide would be annotated on the slide itself. For any new discussion, a blank page would be created and written on it. At the end of the lecture, the file was saved as a new copy and both the original copy and the new overwritten copy would be posted for students to review later.

iPadOS requires the installation of applications through an apple store similar to the iPhone. It is impossible to install advanced software required to teach Artificial Intelligence such as Anaconda Python. As such, the hardware was used minimum in this course and used only occasionally to explain some problems and to draw figures. Important notes would be lectured using the tablet and saved as a digital file and provided to the students. Introduction to Computer Science and C programming course also requires programming tools such as Eclipse and NetBeans which are not available on iPad. iPad does not provide any Java or C compiler, so it is impossible to install any programming tools on the iPad. Fortunately, currently, many online programming tools are available for free which are very reliable and user-friendly. After researching online, two of the free online tools were selected for the course, Repl.it and jdoodle.com, both of which could be used for Java while Repl.it could be used for C as well as other many programming languages. These tools provided enough functionality to teach introductory programming courses.

The apple pencil is a very useful digital pen and could be conveniently used as a pen for the tablet. It allowed to write clearly and display it to students through the projector. It allowed easily to switch between eraser and pencil and also has options to change the pencil color as well as to highlighter and other tools. The combination of iPad and apple pencil allowed to lecture the theory contents conveniently as good as writing on the whiteboard with a marker.

Also, some of the lectures were recorded using the screen recorder of the iPad. The inbuilt microphone of the tablet was used to record audio and record the screen display and save it as a video file. The videos then would be edited and uploaded to YouTube as unlisted videos and the links would be posted on the online course system for students. This allowed the students to revisit the lecture in case they missed it or need to review the course again.

TECHNOLOGY EFFECTIVENESS SURVEY

I. Survey questionnaire and results

A survey was done at the end of the semester in the C and Java programming course to evaluate the effectiveness of the methods of instruction. Survey questions to understand students' use of the new digital materials and their perception by the students was performed. Here are a few samples of the questions:

- Did you find the lecture slides posted on the course website helpful?
- Did you find the programs posted on the course website helpful to understand the concepts?
- Would it be helpful to post the videos of lecture recordings on the course website?
- Some of the lecture recording videos were posted on the course website. Did you find it helpful?
- Some of the lecture notes were posted on the course website for your review. Did you find it helpful?

- Would it be helpful to post the class notes on course notes?
- For lectures, a digital tablet was used and annotated on the slide instead of using just whiteboard. Did you find any difficulty in understanding the concepts due to this change?

The answers were collected on a scale of a range of answers such as

Did not check it at all :1
Not much :2
A little :3
Sometimes :4
Very helpful :5

TABLE I
SURVEY RESULTS FOR C PROGRAMMING COURSE

Question content	5	4	3	2	1
Lecture Slides usefulness	45.45	27.27	27.27	0	0
Online programming tool usefulness	45.56	54.54	0	0	0
Lecture video usefulness	45.45	36.36	9.09	0	9.09
Class lecture notes usefulness	9.09	54.54	36.36	0	0
Should we post class notes online	72.72	27.28	0	0	0
Continued use of online programming tool	100	0	0	0	0
Effectiveness of using tablets instead of whiteboards	72.73	27.27	0	0	0

TABLE II
SURVEY RESULTS FOR JAVA PROGRAMMING COURSE

Question content	5	4	3	2	1
Lecture Slides usefulness	85.71	14.29	0	0	0
Online programming tool usefulness	57.15	42.85	0	0	0
Lecture video usefulness	42.85	42.85	14.30	0	0
Class lecture notes usefulness	28.57	42.85	14.28	14.28	0
Should we post class notes online	57.15	28.56	14.29	0	0
Continued use of online programming tool	85.72	14.28	0	0	0
Effectiveness of using tablets instead of whiteboards	71.43	28.57	0	0	0

As seen in Tables I and II, for all of the questions, more than 70% of the student's answers with options 4 and higher. Since the iPad did not allow the installation of programming tools, an alternate online programming tool had to be adopted for the course. Although it took some time to get adjusted to the tool at the beginning, students liked this tool and recommended to use it in other courses as well. Students recommended posting the digital lecture notes and video recording to the online course system as well. The ratings on the class lecture notes were mixed so more work is needed to make them effective. The final column in both the tables shows that students think the use of tablets instead of whiteboards is more effective and it did not matter that digital whiteboard was not used primarily.

II. Advantage of using tablets and pencils

The primary advantage of the method is obviously the convenience of digitizing all the lecture contents and making it available in the online platform for the students. The microphone of the iPad recorded the sound of the lecturer as well as the students quite clearly. Since the classroom area was small, it could record the students sound as well. The lecture videos recording was of good quality and uploaded along with the lecture notes. A tablet can be used for various other purposes in teaching as well. For example, while preparing notes where we need to write or draw by hand (such as complex equations which takes a lot to create in Microsoft word), we can directly create it in tablet instead of writing it in paper and scanning that paper. A tablet is lightweight and has a long battery hour. It can be carried around the classroom easily during the class (while not projecting) and used without being continuously connected to a power source. There are also devices that allow projecting wirelessly, in such cases the instructor can carry it around and project the contents without using HDMI cable. It can also be used to create lecture videos in office without using external microphones or recording tools in case of online courses. As seen in Figure I(A), the Microsoft PowerPoint can be used to project the lecture slides and then annotated during lecture. In Figure II (B), a simple setup is seen where the tablet is connected to a 32" monitor and USB keyboard and mouse to work conveniently in a desk setup. As such, one general all-purpose device can substitute multiple expensive devices.

FIGURE I
IPAD WITH A) PROJECTOR IN CLASSROOM B) KEYBOARD AND MOUSE

In some of the advanced labs, digital whiteboards are placed where instructors can write, and the contents can be saved digitally. However, such devices are quite expensive and not portable. It would cost a lot to place such devices in all of the classrooms. On the other hand, currently, we can easily find a reasonably priced tablet and, in some cases, cheaper than the personal laptops. For teaching purposes, a cheaper and a basic tablet and a digital pen would be sufficient as it will be primarily used for projecting slides and writing on it and does not need to do any heavy computation. And, all the

classrooms are equipped with projectors and almost all of the faculty needs a laptop, so it would mean that the laptop would be substituted by a cheaper tablet. As such, financially also tablet is a better alternative to use than digital whiteboards.

II. The disadvantage of using tablets and pencils

The main disadvantage was the transition from using a big writing area of whiteboards to the small surface in the tablet. Also, students are used to be taught via whiteboards and the transition was difficult for some of the students at the beginning. Also, since whiteboards are bigger in size compared to the projector screen, we can leave some of the content on the screen and continue working on some other part. This is difficult to do in digital since when we change the slide, we need to back up the slide to get to the previous content. As such it is difficult to retain all the information in the same view. Also, the writing space in a digital tablet is smaller compared to whiteboard which could be restricting for some faculties.

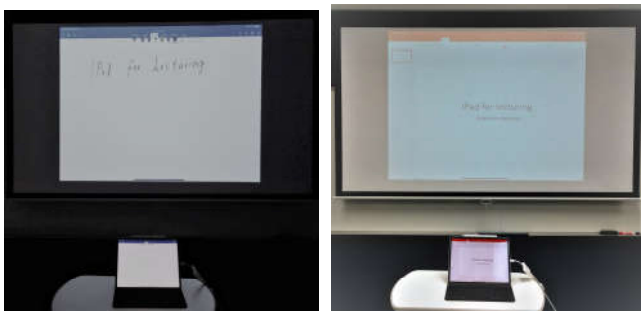

FIGURE II
IPAD PROJECTING MICROSOFT WORD AND POWERPOINT

Another disadvantage was the iPadOS and mainly because it was used in computer science programming courses. The programming courses require specific compilers that cannot be installed in iPadOS. Also, the iPad resolution is not designed for projects. Many applications screens would not project to the complete projector screen thus it would not utilize the complete projector screen available. Only the Microsoft PowerPoint and other presentation apps would be projected to full screen and that only when it was in presentation mode. In Figure II, we can see that when Microsoft Word and PowerPoint (not in presentation mode) is used, the iPad does not project to complete projector surface wasting a lot of space. Also, the iPadOS app store does not have good apps for computer programming languages such as Python, Java, C required to teach computer science courses. Even though online alternatives are available, they are not as convenient. These issues could be resolved by using tablets that allow installed of these tools such as Microsoft Surface tablets.

CONCLUSION

In this work, an iPad and Apple pencil were used in teaching undergraduate courses. The iPad used only the freely available software from iPadOS and utilized online tools for teaching programming languages. From this experiment, the generally available and cheap tablet might be a tool that when matched with a digital pencil could be a teacher's best tool for lecturing. We want to provide all the necessary materials to our students and the most important content is mostly in the whiteboard. A digital tablet and a pencil can allow us to save those content and make it available to our students. It can also help us create a recording of the lecture conveniently. While still, an iPad does not have everything to replace a computer in an office, it can be a teaching tool that can substitute the computer in the classroom as an inexpensive replacement. There might be some compromise while using programming tools, but if that is not the issue then using an iPad and Apple pencil can be a cheaper digital whiteboard replacement.

In the future, a case study on using a digital tablet such as Microsoft Surface will be done which has Microsoft Operating system that allows the installation of most of the software tools required in teaching computer science courses.

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