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Measuring the Dynamics in Learning

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Abstract

This work in progress paper describes a method of recording video/audio data of a learning cycle to measure the actions that a student takes when provided with instruction and feedback in a mechanics course taught using flipped pedagogy. Video provides the ability to record data in a way that can be analyzed to answer research questions after the event has occurred and allows a researcher to see additional details that may not have been viewed at the initial gathering of the data. The video/audio data is used to measure the actions of a student learning the mechanics theory in the flipped mechanics course and measure the actions of a student when try-again feedback is employed with provided practice problems. The recordings are the screen of a Microsoft Surface Pro 3 and any audio produced in the vicinity of the Microsoft Surface Pro 3. The recorded data contains the "dynamics" of the "learning cycle" as the student receives initial instruction and applies the instruction to the practice problems. The dynamics of the learning allows the instructor to truly assess how a student uses provided instruction while learning new material.

Introduction

This work in progress paper describes a method for measuring the "learning cycle" of students participating in a flipped course that uses try-again feedback for practice problems. The term "learning cycle" is defined here as the cycle where an instructor provides instruction to a student, the student uses the instruction to complete a task based on the information learned from the instruction, the student receives feedback on the task, and the student uses the feedback to correct misconceptions or misunderstandings from the instruction before new instruction is provided. The measurements are the physical actions and processes that a student performs in the learning cycle. This cycle can be related to some models of educational feedback [1-6] where the two-feedback-loop model presented by Narciss [6] is an example that shows how instruction, tasks, feedback, and new instruction are interconnected in a cycle. But, the relation to feedback models is not the focus of this paper. The emphasis of this paper is to measure all the actions of a student in the entire learning cycle where the instruction is provided using a flipped course with try-again feedback used with the practice problems. The measurement will be used to assess how a student uses both the instruction and feedback provided.

An instructor controls a lot of variables in a learning cycle and therefore can governor many factors that occur during learning. These variables include the method of instruction delivery, the type of assessment performed, the type of feedback provided, etc. But, the instructor cannot control the learning factors of the student. These learning factors include the knowledge and beliefs of the student [3] and the internal control (what the student does) of the student [6] that affects how the student uses the tools available to them in the learning cycle. These tools include course notes, textbook material, the internet, peers, the instructor, other qualified individuals, etc. Many of these tools are provided as part of the instruction, but some of these tools are sources outside of the instructor's control. The student may or may not use these tools in the way the instructor intended and misuse of these tools may hinder the learning process without any feedback to the instructor of the misuse of these tools. The feedback normally received by the instructor occurs

during direct interactions with students, during the assessment of student performance of assigned tasks, during analysis of any data recorded by a learning management system (LMS) used [7], and/or during assessment of answers to any surveys provided by the instructor. This type of feedback to the instructor does not provide details of the tools used and the associated actions used in a learning cycle. The details of the use of these tools and associated actions is defined here as the "dynamic" performance of the student. Instructors normally do not see the dynamic performance of a learning cycle, but the dynamic performance provides useful information about a learning cycle. The specific research questions for this work are related to a learning cycle in a flipped mechanics course that requires the measurement of the dynamic performance. The questions are:

1. How and when do students use the resources provided in a flipped course?
2. What do students do when they receive negative feedback?
3. What external tools do students use during a learning cycle?
4. What actions/activities negatively influence the learning cycle?

The course used for this work in progress was a sophomore level mechanics course taught at a satellite campus of a four year university. The instruction was provided using online content provided with a LMS. Interactive pdf files were used to explain the theory and provide examples of how to apply the theory to example problems [8]. The assessment of the learning was based on student response to web-based practice problems provided through the LMS and in-class exams. The web-based practice problems used try-again feedback [9] to provide the students opportunities to retry missed questions. Try-again feedback is feedback that informs the student if their answer is correct or incorrect and allows the student to repeat the problem. This work in progress paper uses video data to provide a means to answer the research questions about this course where the video data provides additional details of the learning cycle not recorded through web-based practice problems and in-class exams.

Much of the dynamic performance in learning occurs outside of the classroom. One way to document this performance is with the use of video. Video data was used with a single student throughout an entire semester of a mechanics course. Technology provides numerous options for recording data and this paper discusses a means for recording the dynamic performance of the learning cycle for this student. This paper will briefly review the use of video data in educational research, briefly review the assessment of student performance, and briefly review the use of flipped courses as a means of providing instruction; explain the procedure used to obtain video data of dynamic performance; discuss ways in which an instructor might use information about learning collected in the data; and conclude with some recommendations and explanations of future work.

Literature Review

Research using video data has been occurring for numerous decades and spans from the social sciences [10] through mathematics [11] to engineering [12]. Both quantitative and qualitative researchers have used video data [13] because some researchers see video data as the most comprehensive way of studying educational learning [14]. The reason for this belief is that researchers can repeatedly examine the data to get more details related to the current question, to

reveal things that were unnoticed during the initial data inspection, and to ask new questions after the data is obtained [15, 16]. The use of videos to obtain educational data has been used in both clinical and classroom settings [11] where the video data is used to assess numerous topics related to education. Obtaining video data outside of a clinical or classroom setting introduces many difficulties in the data collection design because of camera and microphone placement [14] and because of potential ethical issues related to capturing video data [11, 13]. These difficulties need to be considered in the design of an experiment when capturing video data for analysis and will be discussed.

Most assessment of student learning obtained from a learning cycle in courses similar to the mechanics course used in this study uses closed ended questions [8, 17, 18]. Closed ended questions have a unique solution and usually only have a limited number of pathways for the student to obtain the correct answer. Assessment of the student work on these task provide quantitative data about the perforce of the student to the instruction that was provided [19]. This quantitative assessment has no information about the process a student uses to learn the content or complete the assigned task. A completed task does not contain the work and processes used by the student to complete the deliverable and the completed task is therefore a "snap shot" of the outcomes of a learning cycle. This snap shot provides limited data for the research questions of this paper.

Flipped courses are courses where the instruction provided in the classroom is changed from a "traditional" class. In flipped courses, the traditional in-class lectures are provided to the students in some form outside of the classroom setting [20-22]. The classroom time is used to answer in depth questions related to the theory, work on projects associated with the theory, or work on practice problems and apply the theory [20, 23]. Most survey data from the students' perspective related to the use of flipped courses to provide instruction is positive [21, 24], but the increase in learning from this delivery method is inconclusive. Some research reports an increase in learning [23] and other reports no significant difference in relation to traditional instruction [25]. One of the relevant questions for this research is how do students use the resources provided in a course of this structure? Answering this question requires student engagement with the online instruction that is provided. Surveys have been used to measure the engagement of students with online content [26], but the exact usage of the online content was not measured. The use of the online tools may affect the learning and therefore may cause instructors to change the online content as information about the student usage becomes available. A LMS has been used to measure some of this data [7], but the data only records time stamps of usage and therefore lacks details. This research looks to provide additional data of the dynamic performance in these courses that will assist instructors in developing the tools and instruction used in flipped courses.

Methods

The design of the data collection in this study is to record all student dynamic performance in a flipped mechanics course using video. The design provided some difficulties to overcome in maintaining the confidentiality of the participant. The goal of the data collection was to record video continuously as the subject worked on the specific course. The subject participated in the course instruction during class with peers, in study sessions with pears, at home individually, and during breaks at work with engineering coworkers. All of these locations could not be subjected

to recording of video and audio data with cameras in the typical means of video data recording. Therefore another option was sought to obtain the video data of the student actions and record the audio. A Microsoft Surface Pro 3 tablet computer (referred to hereafter as a Surface) provides a means for obtaining the desired video data because they are portable and software can be added that records the screen and/or built in cameras on the device. These Surfaces also integrate laptop functionality with a surface that can be used to work on practice problems as a student would with paper and pencil. A student was approached and invited to participate in this initial study of using a Surface to record the dynamics of learning. This student was chosen because of the willingness to participate and the maturity level demonstrated by this student in completing assignments. The course structure and student feedback for this study was designed as explained in reference [8]. The student performed all of the course work with the Surface and submitted the numerical answers to the LMS using the Surface. The student immediately received feedback about the correctness of submitted answers and was recorded in the video and LMS.

Figure 1 shows a screen shot of a recorded video of a Surface where the subject is reviewing practice problems in preparation for an exam. The subject is reviewing a projectile motion problem where an object has an unknown initial velocity with a specific direction. The object travels in a parabolic path with the only force acting on the object being the weight. The object lands at another location of known displacement from the initial location. The subject has chosen to use kinematics to solve this problem as shown in the initial steps of the solution method. The subject provides the question in black on the screen and starts the solution process in the color green. The subject used "think aloud" protocol in solving this problem without any direction from the researcher. The video data also has several other items besides the research subject's direct actions that can be used in measuring the learning cycle. The date and time are capture automatically in the corner of each of the videos. This particular screen shot shows that the subject was reviewing the practice problem in the afternoon (time on the task bar). The task

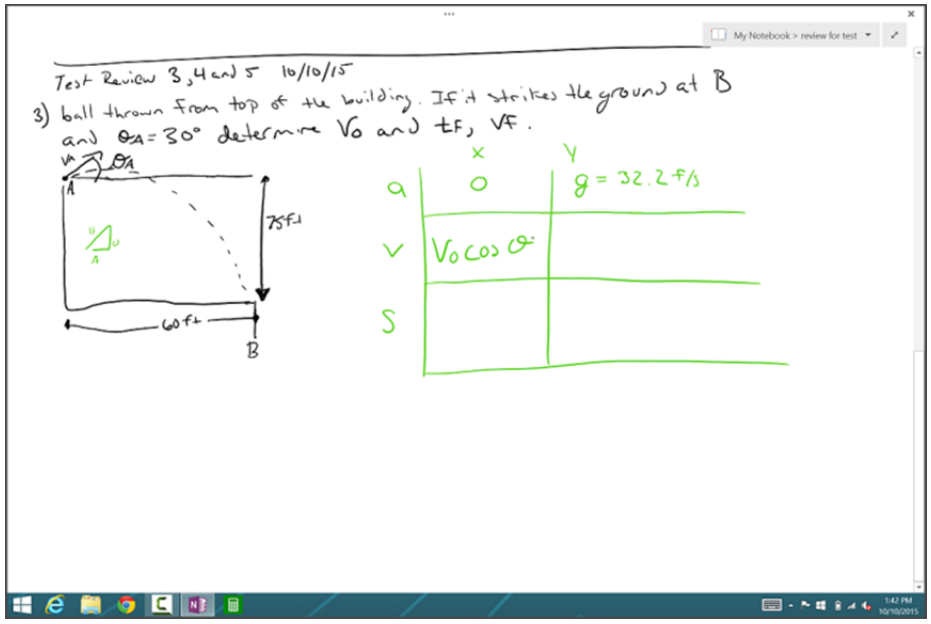

Figure 1. Screen shot of recorded data from the Surface where the subject is working on a projectile motion problem.

bar also shows what other programs are open and being used at any moment. In this screen shot, the subject has the recording software open, a calculator program, and Microsoft One Note (used as an electronic form of paper). This screen shot shows that the student did not have any web browsing software open and therefore was not reviewing any of the instruction provided by the instructor of the course through the LMS.

Using the Surface allowed the student to access the online instruction from the LMS and turn around and work on the practice problems using the same device as if the subject was working with paper and pencil. The focus of the research questions were related to how the subject used the instruction provided and how the subject reacted to feedback. Therefore, video of the surroundings was not essential to answer the research questions and the built in cameras were not needed. The software Camtasia was used to record all of the Surface screen activities and record all audio produced by the research subject and the subject's surroundings. The research subject had the capability of changing the settings in the software to record either of the two built-in cameras of the Surface, but the researcher asked the subject to leave these cameras off. As a participant in the research, the research subject needed to hit the record button every time that the subject accessed any material related to the course of the research. Once the participant was done reviewing instruction or working on practice problems in this course, the subject needed to stop the recording software. This procedure provided the research subject with the ability to start and stop the recording of the video data without any interaction from the researcher. Due to the size of the produced videos, the video data was extracted on a weekly basis to keep from filling the hard drive of the Surface.

Figure 2 shows an example of a screen shot of the recorded data where the research subject is reviewing the provided instruction and taking notes on the Surface simultaneously. This screen shot again shows the student working with the instruction in the afternoon (seen by the date and time), shows that a web browsing program is open (Google Chrome), shows the Camtasia

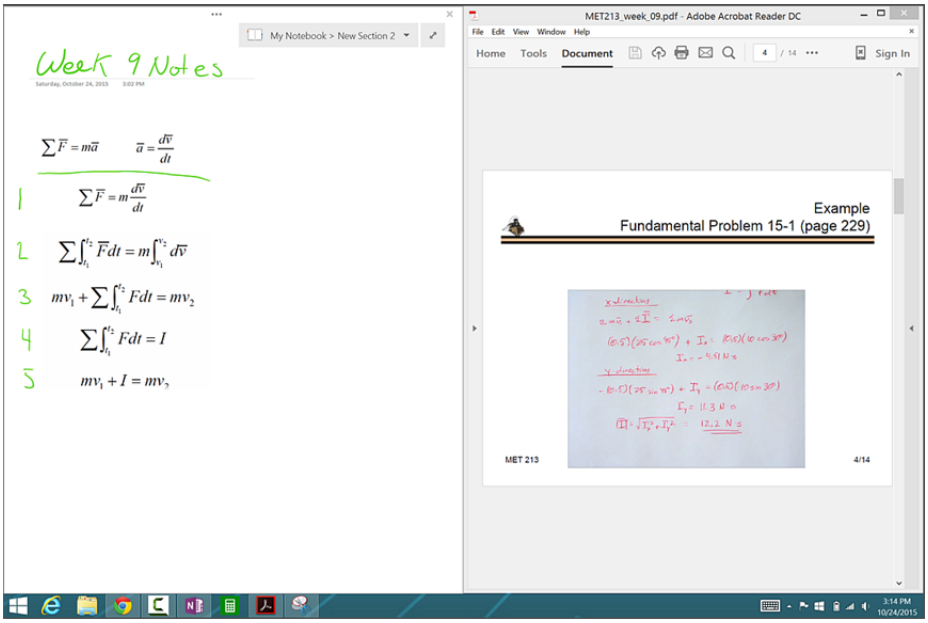

Figure 2. Screen shot of recorded data from the Surface where the subject is reviewing instruction about impulses and momentum.

software is recording the screen, shows OneNote is open with the subject taking notes, and shows the Microsoft Snipping Tool is open where the subject was cutting details from the instruction into their notes.

Results

The results for this work in progress paper are limited to date. The data set is still being analyzed and transcribed. Some trends are seen in the data that has been reviewed. This test subject does review all of the course notes in the interactive pdf files before looking over the solved practice examples. The researcher assumed that many individuals focus most of their time reviewing the practice examples and ignoring the review of the theory in the notes. As shown in Figure 2, this research subject reviewed the notes, extracted the important points (equations in this case) to see how those points were related to the practice problems. The researcher did not expect the research subject to spend as much time and detail reviewing this information.

Another trend that the researcher noticed was the use of "think aloud" protocol in the recording. The researcher did not request that the research subject do this action, but the research subject did provide this audio in the recordings and provides a lot of insight in the research subject's actions. The subject used this protocol to provide additional information in the data for the researcher but, the use of think aloud protocol will not be required for future subjects to preserve the naturalistic problem solving environment.

There are also several instances of the research subject being distracted by other activities. These activities include surfing the internet and conversations with peers or coworkers that are not related to the content of the course. This data could be used to verify the actual time that the research subject worked on the course content in relation to the time that an individual believes they have worked on the course content.

Discussion

There are several advantages to using a Surface to record student dynamic performance. The main advantage is that the Surface provides a means of recording video data of a student's dynamic performance in a setting outside of the classroom or a controlled learning environment. Most of the literature about video data use locations where cameras can be setup to record the interactions and actions of students in a controlled learning environment that is not a typical location where students study. These students may be more cognitive of their actions as they see the cameras that are doing the recording. The procedures used here allows for the recording of video data without major interventions in the subject's actions. The recording is occurring in the background while the subject is performing their normal activities for learning while the subject is physically located somewhere that they normally use for learning. The Surface also allows the subject to have access to the use of software on a computer and the video data records the interaction between the student and the software.

A couple of actions can be viewed as either an advantage or disadvantage when using the Surface to record data in this fashion. The action being an advantage or disadvantage is dependent on the test subject. The first action that falls in this category is that the student has

access to the Surface stylus that provides them with numerous tools (including the use of multiple colors, highlighting, erasing, cut and pasting figures, etc.). These actions allow a student to quickly work on tasks and assignments in ways that may improve their study organization and their learning. But, some students may feel uncomfortable using a stylus and Surface to take notes and complete assignments. This tool may hinder their progression through the learning cycle. The other action that falls in this category (being either an advantage or disadvantage) is that the subject is in control of turning the recordings on and off. This process insures that the subject knows the recording is occurring and therefore may cause the subject to be more cognitive of their actions. The subject could therefore be more focused on the work, but negative actions may not appear in the data that normally occur when a subject is in a learning cycle.

Recording video using a Surface for educational data has some definite disadvantages as well. In this research, the Surface cameras were turned off. The cameras are not adjustable and can only record in a single direction. This limitation limits the researcher in the ability to record actions outside of the screen that includes any work with peers or reviewing a text book. Eliminating the use of the cameras does allow the confidentiality of people in the proximity of the subject to be maintained because no video recording of these individuals are recorded.

The audio data also causes a confidentiality issue because of the proximity of other people to the research subject. The research subject that is using the Surface knows about the research project and has signed a consent form that was reviewed by an Institutional Review Board. Any person that is near the subject during the active video/audio data collection may be recorded on the audio portion of the data. These individuals may not be aware of the research that is being performed and the data that is being recorded. The specific details of the interaction of these individuals need to be deleted from the data set to maintain the confidentiality of those individuals, but the subject interacting with other people can be a valuable part of the data set. It is impractical to try to determine all of the individuals that may come into contact with the subject during the data recording to obtain consent forms and this issue needs to be considered on a case by case basis.

The amount of data obtained from an individual subject is very large. Reviewing this data, transcribing the audio data, and analyzing the data is very time consuming. An instructor could not review the dynamic learning of an entire class to understand what each student was doing and how they were learning. This video/audio data can provide feedback to the instructor to shows trends about how the instruction that is being provided is used by some students. This feedback will help an instructor to analyze better ways to provide the instruction to the students in ways that helps the student, but would be difficult to personalize the instruction for each student using this type of data. The video data can also be compared to data recorded with a LMS. A LMS records when students access certain content, when students submit assignments, etc. The majority of LMS data is time stamps, but this video data will provide a better understanding of the actions being performed with the time stamped LMS data.

As the data is being reviewed, specific items are being extracted from the data set to answer the research questions as presented in the introduction. Here the data that is being extracted to answer each research question is presented with the associated hypothesis for each question and

how the data will provide information to prove or disprove the hypothesis *Question 1*: The time stamps and actions on the videos are being used to answer how and when the student uses the resources provided in a flipped course. The hypothesis is that the student will review all of the notes and all of the worked example problems prior to starting on the homework. The data will record each time a provided resource is accessed and the data will show how the student uses that resource during the learning cycle and therefore show the organization of the resource use by the student. *Question 2:* The try-again feedback will inform the student if the answer is correct or incorrect. Once the student is informed that the answer is incorrect, the data will show the specific action that the student takes. The hypothesis is that the student will retry the question. The data will show if the student retried the question, returned to the resources, how many times the student retried a question with negative feedback, or show some other course of action. *Question 3:* The data will show external resources used. The hypothesis is that the student will use internet resources, peers, etc. during the learning cycle. The data will record any internet resources visited and the audio of any outside resources used during the learning cycle. *Question 4:* This question is the most difficult to answer because the results may be subjective from the researcher's point of view. The hypothesis is that the student will perform actions that cause some change in the learning cycle where the student is not focused on the learning cycle. For this question, each action that is not considered part of the learning cycle (surfing the internet, talking with peers, etc.) may cause the student to become distracted or do activities that are not inductive to learning. Some of these actions may be the student taking a needed break or getting side tracked. The data will show these different actions and the researcher has to determine if these actions are negatively influencing the learning cycle. The answers extracted from this data will be for this single participant and cannot be generalized for all students. Numerous participants will need to be tested in order to generalize the results.

Future Work

The future work for this project is to finish analyzing the video/audio data for the current subject in order to answer the research questions posed. An additional literature review is being implemented to determine the best method to analyze this type of data to answer the research questions. There is a total of 25 gigabytes of data to analyze as well as the associated data recorded with the LMS. Some of the data can quickly be eliminated from this research because the subject gets distracted and performs other actions outside of the instruction of this course as explained in the discussion. The research subject did stay on task for the majority of the recordings and therefore most of the data needs to be transcribed.

Additional test subjects need to be recorded to record data from individuals that may use the instruction differently. Currently only one subject has participated in this project with another subject actively recording their dynamic performance. The limitation for recruiting additional participants in the project is the current lack of funding for additional Surfaces. Additional subjects will allow for the researcher to make broader conclusions about the actions of students in flipped courses and once a funding source is obtained, an entire mechanics course taught using flipped pedagogy will be recruited to participate as test subjects.

Conclusion

Video data provides details that are not easily recorded with other means. Using a Surface to record the process of dynamic learning of a learning cycle provides an instructor with a better understanding of the struggles and the limitations of the instruction provided. This understanding would be seen when students repeatedly use any part of the resources provided or try to find additional resources that cover certain topics. The instructor can readdress those topics are provide the additional resources for all the students. The actions that a student takes in a learning cycle are not normally provided for assessment in a traditional setting, but the procedures explained here allows those actions to be recorded.

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