Following Student Gaze Patterns in Physical Science Lectures

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Abstract. This study investigates the gaze patterns of undergraduate college students attending a lecture-based physical science class to better understand the relationships between gaze and focus patterns and student attention during class. The investigators used a new eye-tracking product; Tobii Glasses. The glasses eliminate the need for subjects to focus on a computer screen or carry around a backpack-sized recording device, thus giving an investigator the ability to study a broader range of research questions. This investigation includes what students focus on in the classroom (i.e. demonstrations, instructor, notes, board work, and presentations) during a normal lecture, what diverts attention away from being on task as well as what keeps a subject on task. We report on the findings from 8 subjects during physical science lectures designed for future elementary school teachers. We found that students tended not to focus on the instructor for most parts of the lecture but rather the information, particularly new information presented on PowerPoint slides. Finally, we found that location in the classroom also impacted students' attention spans due to more distractors.

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INTRODUCTION

A fundamental keystone in education research is to help our students learn. Whether the research involves labs, problem solving, tools for learning or lectures, our goal is to help our students learn and understand a plethora of topics. New technology may aid in this endeavor. Eye-trackers are one piece of technology that provides an additional piece of data with which we can better understand our students and the impact of what we do with our students in our lectures.

In this study, we focus specifically on student attention in lectures. To aid us in this task, we use a portable eye-tracker which shows us what students look at during the course of a lecture. Thus we can investigate the following research questions: (1) what do students focus on during a lecture, (2) what will divert the attention of a student away from being on task and (3) what keeps a student on task during a lecture. If we better understand what keeps our students focus during a lecture, then we are able to change how we teach our lectures to maximize the amount of time our students stay on task.

THEORETICAL FOUNDATION

There is a popular belief that student attention in lectures typically only last for the first fifteen minutes [1-3] or that the longer a student is in a class, the more their attention span decreases [4]. This belief has been challenged in the literature [5]. However, we could find no studies incorporating the use of eye-trackers in Science, or in this case Physical Science lectures.

An eye-tracker measures the point of gaze and the movement of the eye from one gaze point to another. This measurement serves as an indicator of attention, the sustained focus of cognitive resources on information while filtering or ignoring extraneous information [6]. Tracking eye movements thus shows shifts in attention. One way to explain shifts in attention is the moving-spotlight theory in which attention can be thought of as a spotlight that moves as focus is directed towards intended targets [7,8]. When the spotlight illuminates information, or when information is attended, more efficient information processing can take place. However, during spatial shifts of attention this spotlight is turned off while attention shifts towards the next attended location [7,8]. This shift in attention takes place in three mental phases: (a) a subject disengages attention from the current focus, (b) a shift in attention to the new location occurs, and (c) attention is finally engaged at the new location [9].

The goal of this study is not to compare different teaching styles or approaches in lecture, but rather to gain preliminary data on students gaze patterns in a lecture that has a high degree of strategies from physics education research such as the use of multiple representations [10] and talk to your neighbor tasks which can include physics jeopardy tasks [11].

However, there are certain trends that have been reported in the literature in physics and in other disciplines that are applicable to this study. The first is the idea of "changing things up" in lecture [12]. This idea is that there needs to be activities placed in a lecture to break up the traditional information transfer model. Humor has also been reported not only as a tool to garner attention but to increase student achievement [13]. Finally, we can investigate the impact location in the classroom has on attention [14].

SETTING

The students in this study are from Kennesaw State University (KSU). KSU is a suburban school north-west of Atlanta, GA. KSU has a student enrollment of almost 23,000 students. The class in this study (which is taught by the first author) is called ISCI 2002.

ISCI 2002 is a basic physical science content course for pre-service elementary school teachers. The course consists of two lectures a week that are one hour and fifteen minutes long as well as a two hour lab section. Almost all of the students in the class are female and in their early 20's.

The subjects were students who volunteered to wear the eye-tracker. The eye-tracker is Tobii's latest device. It is a portable eye-tracker that records data for 70 minutes. Each subject wore the eye-tracker for the entire lecture. The data combines audio and video with a dot representing where they are focusing. In Figure 1, the instructor is going over the answers to an in-class quiz while the subject is looking at the diagram.

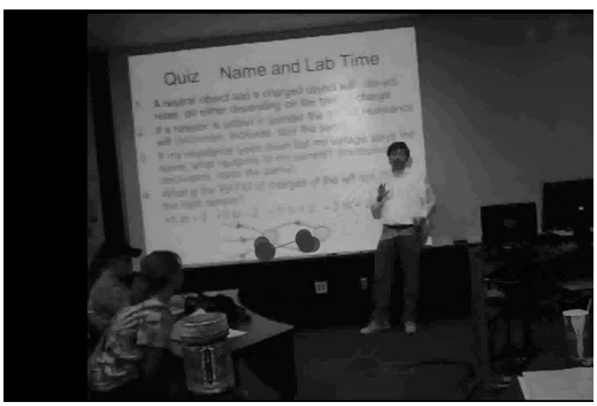

FIGURE 1. Screenshot of output data from eye-tracker.

There are a total of 8 subjects (all female). The instructor did not have a large number of students volunteering for the experiment which limited the ability to do certain comparisons. The subjects did not receive any benefits for participating in the study. Subjects 1 through 8 had the following end of semester grades: 80.60, 90.05, 86.48, 85.43, 82.37, 82.16, 82.18, and 86.71. Their average was an 84.50 while the class average was 83.67. A t-test shows our sample is not significantly different than the class. All 8 subjects also sat in various parts of the classroom.

The professor for the lectures is well versed in Physics Education Research and utilizes many strategies in the classroom such as talk to your neighbor tasks, a plethora of forms of assessment, simulations and finally multiple representations [10]. The professor consistently receives high evaluations. He relies heavily on power point slides and gives students the opportunity to print out the slides (minus answers) in advance or they may download the slides..There were no demonstrations because the students will probably have limited funds for science. Thus the professor wanted to give them resources such as videos and simulations from the internet they can use in their own classroom when they teach science.

METHODOLOGY

We analyzed the eight videos in one minute blocks. Each subject wore the eye-tracker only one time. During each minute interval, the researchers recorded what the subject looked at, what diverted or kept their attention and whether they were on task or off task. We considered a subject on-task if they were looking at the board, the instructor or the slides in some format or if they were talking to their neighbors during relevant assessment questions. If a student looked at classmates, cell phones or walls for example, we considered this to be an off task activity.

We placed the times in Table 1 when a subject went off-task during that minute. This does not necessarily mean they were off task for the entire minute. A quick eye movement for a fraction of a second towards a classmate or something else was not considered off task, only if it exceeded a few seconds.

The first two authors are professors at KSU and analyzed 4 of the videos each (separate from each other). The last two authors are beginning researchers and they analyzed 2 videos that each professor had. Thus each video was analyzed by one professor and beginning researcher.

TABLE 1. Time Subjects Went Off-Task.

Subject	Minute(s) into Lecture When Off-Task
Subject 1	5, 11, 12, 13, 67,68
Subject 2	2, 6, 15, 25, 47, 48, 58, 59
Subject 3	3 – 6, 25, 26
Subject 4	9, 10, 27, 63, 65, 68
Subject 5	38, 46, 48, 51, 53, 62, 63, 68
Subject 6	2 – 5, 19, 22 – 27, 31, 32, 40, 43 – 46, 49 – 54, 61 – 63, 65, 66, 68, 69
Subject 7*	25, 26, 33 – 36
Subject 8	13, 29, 42, 46, 51, 54, 59

*Subject 7 only had data for first 42 minutes

FINDINGS

One of the most interesting findings in this study was regardless of all factors the students spent very little time focusing on the actual professor. Students read the power point slides or looked at their notes instead. There were noticeable exceptions. When the professor became very animated, drew something on the board, injected humor or if he was using analogies that were not listed in the power point slides then the students tended to watch him. Students also focused on the professor when he was going over the answers to the weekly quizzes. Lastly, student question and answer sessions yielded polar opposite results. In most cases, the students focused on the classmate asking a question, then on the professor answering and back and forth during interactions. However, some students would quickly go off task at this point. Even with all of these cases though, the students spent the majority of their time looking at things other than the professor.

With all of the subjects, a new slide tended to either keep student interest or divert it to the board. When a student looked at a slide on the board, the first place they look at is the title, then a picture or diagram if one was present and then they focus on any text in the slide. The subjects generally read all of the text on a slide before they would look elsewhere, such as at the professor. New slides, either entirely new or new information appearing on the slide were not the only things to bring a student back on task. Videos were another good way to capture student attention. Finally, when the professor moved around the room (not just in the front of the room) and started to get close to a subject wearing the eye tracker, this would cause the subject to divert their attention back to an on task activity, either the slides or the professor.

We found several factors that appear to influence whether or not a student tended to be on-task or off-task. The first is if students printed out notes available to them before lecture. If they did, they seemed to pay less attention to the board and tended to get off task (looking around the room, at a cell phone or at other students) quicker than those students who had to copy everything down. However, those students tended to look at the professor more compared to students who took notes on paper and rarely looked at the professor while he discussed the information on the slides.

Most of the distracters for our students are not surprising. Texting or surfing the web (typically Facebook) was the biggest distracter even though this is discouraged lecture. Other students in the class were also distracters. This was especially true if a student was entering class late or leaving class early. Other times it was just the students themselves, either actively engaging in conversation with the subject or not doing anything wrong at all at times. Sometimes it was their belongings; other students' computer screens caught a lot of attention from the subjects.

These distracters are sometimes due to the location of the students in the classroom. The students in the last row tended to be distracted the easiest due to the students in front of them and a large number of computer screens visible in front of them. The students on the extreme sides of the classroom seemed to be distracted as well because most of the time they had to turn their head at some angle in order to see the notes on the board. Some of their off task time included looking straight ahead at the wall on the other side of the room. This finding supports reference 11 that the students in the front and center of the classroom tend to do better as our study shows these students were not as easily distracted by their surroundings.

Finally it is important to note that we were not able to discern any type of clear pattern as to how long into a lecture do the subjects typically go off task. Rather, when do subjects lose interest in the class? We noticed that in two subjects, they tended to go off task more after half an hour into the lecture while another was good for the first 50 minutes of the lecture. Three of the subjects were distracted equal amounts over the course of the entire lecture. One of the students hardly went off task and then another student was on task in the middle half of the lecture (12 minutes through 45 minutes) but not on the front or end part of the lecture.

DISCUSSION & IMPLICATIONS

Though more analysis needs to be done, the preliminary results suggest things that both reinforce and challenge previously held beliefs about lectures. The first challenge is the notion that students only absorb information in set blocks of the lecture, usually the beginning and the end of the lecture. Though we reported in our findings that students started to get off task at certain points in time or were off task frequently, it was never the case that a student was completely off task for any large length (more than 3 minutes) of time throughout the lecture. There was no pattern among the subjects as to when they were off task most of the time. Some students lasted the first 30-40 minutes, while another was good in the middle chunk of the class while some others were constantly distracted throughout the entire lecture.

Our findings support the idea that student location in a classroom may impact student performance. We noticed that students in the front and the middle of the classroom tended to be on task more than students on the extremes because those students in the back of the room have more visible distractors. However, we need to collect more data to determine how strong the correlation is between the length of time a student's gaze pattern suggest they are on task with their performance in the classroom.

The data can also be interpreted in different ways in regards to how to enhance a lecture. For example, if an instructor wants a student to actually look at them while they are explaining a concept, then they should refrain from putting any notes or slides on the board before they talk about that topic. However, if an instructor wants fewer distractions then consider the fact that when the students wrote out all of their notes and didn't have power point slides, they were far less distracted from other objects in the room.

However, it is important to restate that, what we are reporting on is where students look during a lecture. This does not mean nor do we imply that if a student is not looking at the professor then they are not listening. If a student writes a lot of notes, does that mean they are better off than those who printed them out? This is something that needs to be investigated further because it could be that though they are on task more with regards to what they are looking at, they may not be processing the information as well as someone who already has the notes and occasionally goes off-task. There are many possible interpretations to this work which is part of the limitations of this study and some in which we will try to address in future studies as described in the next section.

LIMITATIONS & FUTURE WORK

Like other research, eye-tracking is not exact. Though it is a tool to aid us in our research, we have to be careful in our data interpretation. It only shows us what the student looks at; we cannot say for sure what the subject is thinking at the time. For example, if a subject watches the professor use an analogy we do not know if the student is understanding the analogy or simply looking at the professor and thinking about what the professor is wearing.

A limitation of the equipment is it only records data for 70 minutes while the lectures were 75 minutes. Subject 7 lost the last half hour of audio for some reason. We also lose the ability to track a person's view if they move just their eyes to an extreme angle (i.e. they look down at their notes or cell phone while keeping their head looking forward).

Particular to this study, we used each subject only once so we are not able to identify trends of theirs. For example, subject 6 spent a great deal of time off task with her cell phone. We don't know if this was always the case or if there was a pressing matter that caused her to spend so much time on it this one lecture.

Finally, we need to be very conscientious of the Hawthorne effect [15]. This is an effect where subjects change their normal behavior simply because they are part of an experiment. It is tough to say how prevalent this effect was because in many sessions, the subjects were occasionally doing things that were discouraged in lecture, mainly texting on the cell phone.

In our future students, we plan to address these limitations by conducting the study for a longer amount of time. We plan to record every lecture in the same course but only use about six students. This will allow us to get a minimum of four sessions per person. We will also hold a follow up interview session with the participants to probe for deeper understandings of their mindsets at particular points in the lectures.

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