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Engaging Undergraduate Students in Research through Interactive xFlight Simulation Project Using Eye Tracking Device

Dr. Adeel Khalid, Kennesaw State University

Adeel Khalid, Ph.D. Professor Industrial and Systems Engineering Office: 470-578-7241

Dr. Awatef Omar Ergai, Kennesaw State University

Dr. Awatef Ergai received her Ph.D. from Clemson University in 2013. Currently, she is an assistant professor at Kennesaw State University (KSU) and has been in this position since the Fall of 2017. Prior to this position, she served as an assistant teach

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Abstract

In this study, undergraduate students ranging from freshman to seniors are involved in various steps of research. The objective of the study is to understand and discuss the benefits of involving undergraduate students in research study early in their academic careers. In the study, the research students help investigate the impact of gaming experience on the ability of participating students to learn and follow instructions. An Experimental Flight (xFlight) simulator is used in conjunction with an eye tracking device to study the difference in behavior of experienced gamers and novice gamers when flying an aircraft on a simulator through a simple mission. The research students contribute in this on-going study with collecting and analyzing literature, recruiting participants, conducting experiments, collecting data, analyzing data and drawing inferences. Reflections of research students are discussed in this paper.

1. Introduction

The undergraduate research students are involved in the study of an interactive xFlight simulation using eye tracking device. Global aviation is suffering pilot shortage, and by 2032, it is expected that international aviation will be 80,000 pilots short [1, 2]. Hence, there is an immediate need to identify ways to expedite pilot training. Researchers have found that gaming positively impacts cognition and hand-eye coordination. Specifically, the abilities of people with expertise levels in video gaming have significantly affected performance scores in many flight simulators. However, these studies lack generalization due to the small sample size. This study investigates whether prior gaming experience impacts the flight performance of novice pilots using a large sample size, flight simulator, and eye-tracking metrics. During data collection, student researchers get hands on experience with participants and data acquisition. They gather data on two student groups for this study: students with little or no prior experience with gaming and those with significant gaming experience. Both groups receive initial training on basic operations and control of an aircraft on an FAA approved flight simulator. Training is provided by the research students. After the initial training, participating students are asked to fly a straight and level mission (maintaining a consistent altitude, heading, and attitude). During this task, participants wear eye-tracking glasses to record what controls their eyes are attending to. They are also graded based on a rubric. The results from this on-going research will not only determine whether there are statistically significant differences in how the two groups learn to fly the aircraft, but also set a precedent for gaze tracking in aviation research.

Extensive research has been performed on subjects including eye tracking, visual scanning, situational awareness and flight performance. It has been established that specific gaze patterns and behaviors on instrument panels during Visual and Instrument flights can improve flight performance. Researching gaze behaviors can provide insight on the visual attention of participants

and assist researchers on their studies. Using eye-tracking can quantify the amount of attention given to each region of the instrument panel in a flight simulator in a controlled environment. Alexander and Wickens found that 2D coplanar Integrated Hazard Display (IHD) format was better in supporting flightpath tracking and change detection performance when compared to a split-screen display [3]. Allsop and Gray studied the effects of anxiety on attention and gaze behavior in aviation and found an increase in percentage dwell time toward the outside world in the anxiety conditions. They discovered an increase in the randomness of scanning behavior when anxious [4]. Dehais, Causse and Pastor presented pros and cons of using eye tracker in a light aircraft in a standard and degraded flight conditions. They found out that pilots spent less time glancing at the instruments and focused on fewer instruments in the degraded condition [5]. Dijk, Merwe and Zon studied the relevant human factor tools for situation awareness assessment of pilots. Pilot behavior was studied in a malfunctioning aircraft. Although eye movement alone did not provide sufficient picture of pilot situational awareness, but when combined with subjective, self-rating metrics, they offered more comprehensive look at situational awareness [6].

Prior research has found that gaming has a positive impact on cognition and hand-eye coordination. Specifically, the abilities of people with expert levels of video gaming have significantly improved performance scores in many flight simulation studies [3-10]. Participants in the highly experienced group attained better performance rating and higher scores than the less-experienced group. However, these studies lack generalization due to the small sample size. While they all agree that expert gamers have improved scores on flight simulators, the lack of large sample size on any one study creates inaccuracy. Due to this oversight within the research, there is no conclusive evidence to support the theory that gaming experience has a positive impact on flight performance. Furthermore, the implementation of gaze tracking software to research pilots' gaze patterns is an established field, however using this technology to analyze the differences between novice and expert gamers when flying on a simulator is novel. Research students are involved in performing literature review, summarizing, and documenting their findings. This exercise helps them build self-confidence and encourages them to explore studies well beyond what is required for the traditional college education. It has been established that students actively working on hands-on engineering projects learn above and beyond the traditional classroom instruction. Kokotsaki et. al. [8] indicate that active student-centered form of instruction leads to student autonomy, constructive investigation, goal-setting collaboration, and enhanced communication skills. Projects like this also address a wider set of learning styles, promotes critical and proactive thinking, and reflection. Mills et. al. [9, 10] argue that the current engineering programs do not provide sufficient design experience to students. Because of this, graduates often lack communication skills and teamwork experience. Engineering programs need to develop more awareness among students of the social, environmental, economic, and legal issues. These issues are better addressed in a project-based learning environment than in any other classroom setting. Almulla performed a quantitative study to investigate the relationship between project-based learning, collaborative learning and disciplinary subject learning among others that in turn produced student engagement [12]. They stress the importance of engaging university students early in their educational careers in research activities. Miller et. al. discuss in depth the value of engaging undergraduate students in research [13]. They highlight the deficiencies, challenges, opportunities, and benefits of engaging undergraduate researchers from diverse backgrounds

including underrepresented and minority students. This current project provides an opportunity for the research students to improve their collaboration, communication, and critical thinking skills.

2. Methodology

Engaging undergraduate students in research offers numerous benefits to students. In this study, we investigate the experience of undergraduate students who take part in a xFlight (Experimental Flight) simulation research project to investigate how much of the student learning is impacted by method of teaching. Six undergraduate research students involved in this study include four freshman, one sophomore and a junior. Their tasks include but are not limited to:

1. Recruit student participants.
2. Conduct literature review.
3. Conduct pre-flight surveys.
4. Demonstrate participants the flight video.
5. Verbally walk participants through the flight controls.
6. Monitor participants' simulator flight for 5 minutes per participant.
7. Conduct post-flight surveys.
8. Draw inferences.

By involving undergraduate research students in this study, their interest and engagement in the subject seems to increase. Using semi structured interviews, their perspectives on performing literature review, going through the Institutional Review Board (IRB) approval process, Collaborative Institutional Training Initiative (CITI) training, recruiting students, conducting experiments, collecting, and compiling data, and performing comparative analyses is discussed. Also, the impact of engaging undergraduate students in research on their resulting career paths is discussed.

2.1 Project Description

The purpose of this on-going study is to determine if there is a connection between the number of hours one plays video games and their ability to follow simple flight instructions. Additionally, the goal is to determine if the amount of time spent playing video games has an effect on the hand-eye coordination of a novice pilot. We hypothesize that both the gaze patterns and rubric scores of the gamer pilots will resemble those of expert pilots resulting in shorter dwell times, level flight, controlled movements, etc. Through the course of this study, we aim to discover a quantifiable impact gaming has on new pilots and gather enough data to reliably predict flight performance based on a subject's level of video game experience. An additional stretch objective of this study is to investigate whether prior gaming experience has any impact on flight performance of novice pilots using a large sample size, flight simulator, and eye tracking metrics.

The research students helped recruit 30+ undergraduate student participants. The participants fly a pre-determined flight mission while the research students oversee the study. Another objective of the xFlight project is to investigate whether prior gaming experience has an impact on how quickly a person can learn to fly an aircraft using a flight simulator. The student population targeted for this study include both male and female freshmen to seniors between the ages of 18-22. Two

sets of student groups are recruited for this study. Set#1 has little or no prior gaming experience. Set#2 is composed of students with significant gaming experience. Participating students are put in these groups through self-identification during the initial recruitment. Both groups are given initial training in basic operations and controls of an aircraft using the flight simulator. They are also shown a detailed video that demonstrates the flight controls, instrument panel, flight operations, navigation and the mission [5]. The video was created by former research students in a previous study. After the initial training, students are asked to fly a straight and level mission (maintaining a consistent altitude, heading, and attitude). During this task, participants wear eye tracking Pupil Invisible glasses to record the instruments their eyes are attending to. The Pupil Invisible Eye Tracking System used for this study is shown in Figure 1.

Figure 1: Pupil Invisible Eye Tracking System [11]

Moreover, a five-scale rubric is used to evaluate their flight performance. The eye tracking data are analyzed using iMotions software [11]. Additionally, inter-rater reliability is measured for data generated from four coders who assess the flight performance of the participants using the rubric. Data collected during this study is used to perform statistical analysis. Average flight performance scores of the two groups are calculated and compared in addition to eye tracking metrics such as time spent on each control (dwell time) and saccade counts. The study will help determine whether there are significant differences in how well students fly the flight simulator based on their prior experience with gaming.

The flight simulator used for this research is a motion-based Precision Flight Controls Flight Training Device (FTD) shown in Figure 2. It uses an open cockpit training environment which provides easy access for setting up experimental instruments including flight data and video recording. It also provides access for research students to study the student participant subjects while they are flying the aircraft. Research students capture the video of the instrument panel, outside environment displayed on the monitors and the eye-tracker tracks eyes of the pilot flying the aircraft.

The eye tracking glasses enable researchers to follow the natural gaze and attention of participants in any environment. Understanding how participants behave in truly natural settings requires moving out of the lab and taking research tools to them. Eye tracking glasses are entirely non-invasive, allowing for unprecedented insight into how people see the world. The data captured from these flights is processed using iMotions software. Participants are also graded based on a rubric focused on measuring flight performance. The rubric is shown in Table 1.

Figure 2: Flight Training Device (FTD) - aka Flight Simulator

Table 1: Flight Simulation Evaluation Rubric

No.	Task / Points	5	4	3	2	1	Points Earned
1	**Maintain Aircraft Heading**	10 degree deviation or less	10-20 degree deviation	20-30 degree deviation	30-40 degree deviation	Completely lost the sense of direction	
2	**Maintain Aircraft Altitude**	100 ft. deviation or less	100-200 ft. deviation	200-300 ft. deviation	300-400 ft. deviation	Completely lost the sense of altitude	
3	**Maintain Aircraft Speed**	10 kts deviation or less	10-20 kts deviation	20-25 kts deviation	25-30 kts deviation	Completely lost the sense of speed	
4	**Keep Wings Leveled**	10 degree attitude deviation or less	10-20 degree attitude deviation	20-30 degree attitude deviation	30-60 degree attitude deviation	Completely lost the sense of attitude	

Figure 3: Basic Flight Instrument

Participant students learn the basic flight instruments for visual flight – also known as the six pack as shown in Figure 3. They are instructed to scan all these instruments during the flight. Their eye tracking patterns during the short flight are recorded and later analyzed by the research students. The idea is to determine how much time they spend looking at the instruments versus the outside environment projected on monitors. The research students then compare this data between the novice and expert students. As part of the study, research students are trying to find answer to the following questions:

Research Questions:

1. Does video gaming impact flight performance, dwell time, and saccade counts? Does experience in gaming impact gaze behavior?
2. Is there a difference in flight performance between novice and expert gamers when they fly a flight simulator?
3. Is there a significant difference in the gaze behavior between the novices and experts?

Research students conduct pre-flights surveys to determine the participating student level of experience in gaming, their experience in aviation, demographics etc. After the flight, research students ask the participants to fill out a post-flight survey. The post-flight survey is shown in Figure 4. By gathering this data, the researcher students analyze how gaming experience impacts students' eye tracking metrics while operating a flight simulator. Using the gaze tracking

equipment, researchers look at how gaze patterns relate to gaming experience, and how these two factors influence flight performance.

IRB#: 18-048 Flight Training Simulation
Date_____

Post Flight Survey

Student No. _____

Group: _____

Year at College (Circle One): Freshman – Sophomore – Junior – Senior

Major: _____

Answer the following questions. Rank it on the scale of 0 to 9 where 0 indicates 'Strongly Disagree' and 9 indicates 'Strongly Agree'.

No.	Question	Score
1	Flying the aircraft and completing the mission was a simple task	
2	I feel that given the information, I was able to complete the mission really well	
3	Taking part in the flight training simulation piqued my interest in aerospace	
4	I found this to be a challenging and exciting experience	
5	I want to fly this mission again to improve my skills	
	Total	

Comments:

Figure 4: Post Flight Survey

The post flight survey data is collected and analyzed. This survey helps the research team understand the level of interest and perception of the participating students. Their self-evaluations are also compared with their flight performance data as gathered using eye-tracking devices. Research students also participate in student recruitment, CITI training, and IRB training. These details are described in the following sections.

2.2 Collaborative Institutional Training Initiative – CITI

Research students are required to take the Collaborative Institutional Training Initiative (CITI). They learn the ethic of conducting research that involves human subjects. After completing the required modules, they are required to take and pass a test to become eligible to participate in the research study. Research students are recruited through the office of undergraduate research, in-class announcements and word of mouth. Students are encouraged to get involved in research

starting in their freshman year. CITI training is required for Institutional Review Board (IRB) approval.

2.3 Institutional Review Board – IRB

The research students participate in the submission and approval of the Institutional Review Board (IRB) packet. This includes but is not limited to completing the CITI training, putting together consent forms, putting together and getting approval of the flyers to recruit student participants, drafting the IRB proposal, putting together the rubric etc. By going through this exercise, the research students get a detailed exposure of the research process involving human subjects. For this study, since no personal data from the subject student is collected, an expedited IRB review and approval was completed.

2.4 Student Recruitment

Research student recruitment is done in collaboration with the office of undergraduate research. Seed funding is provided by the research office. The office collects proposals from all investigators from all the research disciplines at the university. Selected proposals are then presented to students interested in getting involved in research. Students give their first, second and third preferences depending on the available research topics. These research students are then paired with the principal investigators (faculty members) for each study. In the present study, four undergraduate students were selected to serve as research students in addition to two Undergraduate Research Assistants (URA) who are interested in this research study. A limited amount of funding is provided to these students for their work. Additional funding is provided by first year scholar program to get four freshman students involved in research early in their academic careers.

After the research students are selected, they are trained by the faculty members to understand the research process. In addition to conducting the literature review, CITI training, and IRB approval, research students also help with recruiting student participants.

3. Results: Perceptions of Research Students

For this on-going study, the research students are asked the following questions during the study. The intent of these questions is to improve the research experience and further enhance their involvement. Responses to these questions are gathered from students and are listed below:

1. <u>What motivated you to participate in this research experience?</u>

One student remarked:

"The main motivator for me was the money offered by being a first year scholar. I chose this project specifically because the flight simulator sounded very interesting and I play video games myself, so I was interested in seeing what the results would be."

Another student indicated:

"The potential of possible helping the world, and the scholarship money."

Another commented:

"What motivated me to participate in this research was the urge I had to feel apart of something fun outside of school that I could learn about."

Another research student pointed out:

"What motivated me to this research was the opportunity and room to growth with each giving task."

Another student said:

"The urge was to involve myself in something aviation related because in the future, hopefully, I work somewhere in the airport. When I first saw about it, I was immediately interested and I wanted to be involved already. If it's somewhere in aviation, I'm most likely going to be at it."

As seen from these comments, students who take part in this study are intrinsically motivated. This opportunity promotes their interest further. The second question and the responses are as follows:

2. <u>What have you gained / expect to gain by participating in this research?</u>

One student said:

"I have gained knowledge on the difficulties of collecting a large number of participants for a study. I have also learned how questions and the research procedure are formulated and tailored to get the most relevant important information for the study."

Another student commented:

"I expect to gain knowledge on how to write a manuscript, and I have gained knowledge in experimental research conducted on humans."

Another student stated:

"By participating I this research, I have gained knowledge in the controls of an airplane that pilots use. I also expect to gain even more knowledge solely based on how this study goes with the gamers and non gamers and its relation to pilot training."

Another student observed:

"I have gained a lot of things from this research like research experience, knowing how to make an IRB and eventually being able to attend NCUR [student conference]."

Another student mentioned:

"A lot of hard work and dedication went into this research project, but what I've gained from it is that you have to work with a group to receive multiple POV's from other perspectives. Everything from the recordings, putting up flyers, learning how to properly turn the system on and fly it was incredible. Taking research and data from our collections is awesome to be apart of."

From these comments, it can be observed that by participating in this study, students gain self-confidence and self-reliance while acknowledging the experience gained in the various tasks needed to conduct a research study. The next question and student responses are as follows.

3. What has worked well in the overall research process?

There is always room for improvement in any research study. We wanted to gather research student perspectives on what we could do to improve this study. One student mentioned:

"I think there are things to improve on in the research process and we are improving them this semester, but one thing I think has worked well is the way we collect data on data collection days."

Another student pronounced:

"Having a QR code that takes you directly to the page to sign up for appointments and recording & obtaining data for grading."

This is a worthwhile suggestion. We are considering incorporating this to make the signup process easier for the participating students. A freshman student who recently joined the team observed that:

"What has worked well in the overall research process has been the meetings. Though we haven't gotten much done, we always are able to meet and the communication is good."

Another student stated:

"What has worked well in the research was our conducting of the research and development with our data."

Collaboration and teamwork are additional skills that these students learn participating in this research study. Another student commented:

"Working in groups definitely helped our overall research process, as well as meeting every Friday understanding what tasks we went over and completed."

These insights help the faculty members to continue to improve the research process for students. What might appear as a routine meeting might have deeper benefits to research students than those intended by the faculty. Also, the students realized the importance of communication in these weekly meetings, which is a critical skill needed for STEM fields in the 21st century. The next question and student responses are listed below.

4. What are your plans after graduation? How has this research experience influenced your plans to work in a specific field (post graduate education, specific industry, academia etc.?) Explain.

The intent of these questions is to understand if by participating in this study, students are beginning to form realize their long term career path. For example, one student remarked:

"This has helped me gain knowledge and experience of what a day in the life may be like for my major. Although I do plan to change my major to either computer science or bioengineering, this gave me experience in the research field, which will give me a competitive edge when applying for jobs."

Another student commented:

"My plans after graduation are to work with other engineers at the company I am interning with this summer. This research experience actually hasn't influenced my plans to work in the field I chose. I always knew I wanted to be in stem but I guess I can say this research experienced really made me more motivated to stay in the pathway I chose."

Another student stated:

"My plans after graduation will be to get a master's in industrial and systems engineering. This research influenced my plans by focusing on a research-based job and furthering my love for research."

Another student observed:

"My plans after graduation is find a job that's stable and reliable, although this research has allowed me to gain experience in working apart of aviation, so hopefully I'm able to work for an airline company or airport where it seeks Industrial Engineers."

As can be seen from these comments, this research study (like other similar studies) helps students realize the value of participating in research projects that are not a required part of their regular curriculum. These studies help students explore new ideas and solidify their long-term career trajectories. The last question and the corresponding responses are listed below.

5. <u>How can the process be improved to make this research more meaningful?</u>

The intent of this question is to empower the research students so they can influence and improve the study. One student suggested:

"I would say it could be improved by the programs giving us the money we need to get the best supplies for our study. We are limited because we have to rely on [student name] for a camera and it would be nice if we did not have to do that. The process would be faster and we could get our data faster."

Having more hardware resources can certainly improve the data collection process. Also, senior students serve as custodians of the equipment. As junior students are trained, they are given more and more responsibilities. Another student pronounced:

"I think once the data collection is done and we start collaborate on the paper the research will start to feel more meaningful to me..."

Another student observed:

"I just wish conducting the actual experiment wasn't as time consuming as it is; so that we could include more participants on each day we conduct it."

Another student stated:

"This job is very meaningful to me anyway but to make it more important would have to be the longevity of the research."

Another student recommended:

"I think allowing us to be more involved with the project would be meaningful for me, so teaching us how to set up the system, the simulation, the computer. Basically like giving us a closer glimpse to how it's like running a research project like this."

This suggestion highlights the value of involving students in research early in their academic careers. Over the course of this study, the faculty members have observed that students that have been involved in this study the longest have matured and significantly improved their research skills. They are also helping train the newcomers.

4. Conclusions

In this study, undergraduate students are involved in conducting on-going research to understand the impact of gaming experience on the hand-eye coordination of students. Research students go through the process of literature review, data collection, training, recruitment, experimentation, analysis etc. They use a flight simulator in conjunction with an eye-tracking device to monitor how well novice and expert gamers fly a pre-defined mission. Both groups are given the same set of instructions. Research students hypothesize, conduct experiments, collect data and then help determine whether there are significant differences in flight performance and learning styles between gamers and non-gamers. The value of involving undergraduate students in research is discussed. Students are extremely satisfied with the research experience and acknowledge the various benefits gained from participating in it. Student perceptions on the impact of getting involved in this study, its long-term implications, and suggestions for improvement are captured. The research study to explore the value of prior gaming experience and student learning styles is expected to continue. The observations and recommendations from research students will help refine this study. Faculty hope that undergraduate students will continue to participate and earn numerous benefits by getting involved in similar studies. A plan is underway to formally enroll students in an undergraduate laboratory-based research course where they can earn credit for their work on this and other similar future studies.

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