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TESTING FOR TRANSFER OF LEARNING IN EDUCATIONAL PALLIATIVE CARE VR SIMULATION

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EDUCATIONAL PALLIATIVE CARE
VR SIMULATION

by

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ABSTRACT

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Because palliative care scenarios are difficult to simulate, a VR simulation including four unique end-of-life scenarios is developed to provide more experience to nursing students before graduating and completing tasks in the field. Such applications have a wide range of possible inputs, making them difficult to test. However, testing is essential to ensure that a product meets its original requirements in addition to achieving its intended purpose of transfer of learning. Thus, a testing strategy is proposed to assess validity and fidelity of the simulation using both objective and subjective means. The performance of both nursing students and experts will be compared in various contexts. Additionally, questionnaires and group discussion will be used to evaluate how closely the simulation resembles the real-world task. The proposed test plan not only contributes to

relieving the deficit of end-of-life care in nursing, but to the testing of educational VR systems.

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CHAPTER 1

INTRODUCTION

1.1 The Senior Design Project: Creating a VR Simulation

Virtual Reality (VR) allows users to experience a world different from what is physically in front of them through simulated sight, sounds, and haptics. One application of VR is for training purposes on how to perform a specific task, for example golf putting [1] and welding [2]. These training simulations are advantageous because they provide safe training environments, flexibility for repetition, and low physical resource requirements. [3] Several studies have shown the effectiveness of using VR as a teaching tool. A survey paper found that performance was improved in the real task after having performed the task in VR for most published studies, especially those involving psychomotor skills or procedural tasks. [4]

The medical field, including nursing, is rich in such skills and hence utilizes VR simulations in degree programs more often in recent years. As opposed to mannequin-based simulations and face-to-face lectures, VR education is more time-cost effective. In addition, it can be extended to situations that are otherwise difficult to simulate, however it has technological issues and lacks realism. Despite these disadvantages, there are ways to minimize them.

Due to the aforementioned advantages of VR, the Nursing Department at the University of Texas at Arlington asked for a simulation to train undergraduate nursing students in hospice and end of life care to mend the deficiency of knowledge in this area.

[6] The simulation is currently being developed by Computer Science senior design teams and features four distinct scenarios in which the user must provide care for a patient before and after death. In Scenario 1, the user provides care in the hospital and communicates the status of the patient with the doctor. In Scenario 2, the user prepares the home for the patient's return from the hospital. In Scenario 3, the user provides care at home and observes the patient's worsening condition. Lastly in Scenario 4, the user provides post-mortem care and communicates the next steps to the family.

1.2 The Honors Project: Testing the VR Simulation for Transfer of Learning

In addition to developing a product, software testing ensures that all technological components are working correctly and that the software fulfills its intended purpose. Testing is required in order to have baseline reliability and usefulness for a product upon release, VR simulations being no exception. [5] The main goal of testing is to check whether the software meets the customer's requirements in a systematic fashion. A test plan is a formal document that looks different depending on what is being tested and may consist of detailed instructions for testing components (both small and large scope), milestones to determine development progress, and ways to test validation. The same software requirements that are used to create the product itself should be used to create the test plan. Once the product is finished being developed, the test plan can be carried out and applied to the product. If any the product fails any tests, the product will go back into development and the testing process will be completed again.

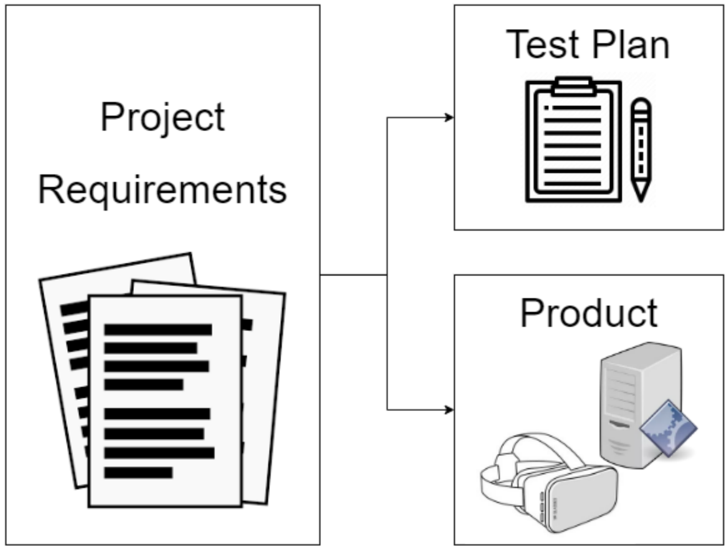

Figure 1.1: Relationship Between Project Requirements, Test Plan, and VR Product

Challenges to general VR testing include the large array of possible user input, making it infeasible to test programs exhaustively. More specifically, challenges to educational simulations include determining if the simulation resembles real life and if the material was learned and can be applied to the real-world version. Both are hard to quantify in an objective manner and there exists lack of documentation and research on how to test such simulations. Therefore, the goal of this study is to create a formal test plan for the hospice care educational VR simulation. There are many different types of testing, however the proposed test plan will test for transfer of learning including validity and fidelity.

The formal test plan is generated by using the project's documentation and defines both the parts that will be tested and how they will be tested. The purpose of this test plan is to ensure that the VR nursing simulation fulfills its purpose of preparing nursing students for real-world hospice care before graduating, a concept known as transfer of learning. This paper describes how transfer of learning, validity, and fidelity can be evaluated and specifically how these components can be tested with respect to the VR nursing hospice simulation. However, because the project is currently still in development, the test plan will be conducted at a later time and analysis of the test plan's results are not in the scope of this paper. The test plan will not only help optimize the specific product but will also contribute to the research of testing educational VR applications. As VR becomes more commonplace in the medical field, having a test plan of another medical field application will allow test plans for transfer of learning to be created more easily.

CHAPTER 2

LITERATURE REVIEW

In order to create a test plan for a nursing VR simulation, testing methodologies for other types of simulations were studied, including specific applications and general-purpose methodologies. Overall, there have been a few reviews of the effectiveness of using VR as a teaching tool. One such survey paper summarized the current literature on educational VR systems, focusing on how each simulation was assessed for validity. All the papers included an objective performance metric such as completion time or test scores and many studies asked for user feedback to determine what concepts were learned. Multiple-choice questionnaires were used to assess this but failed to incorporate a theoretical approach to obtaining an in-depth understanding. It was proposed that long-form essay questions, oral examinations, or group discussions could provide more insight. There is also a lack of checking for long-term retention of information in VR simulation testing. [4] This work is useful for establishing a basic outline for testing VR, but also informs the decision to check for memory retention of users. Two different methods of instruction were compared for knowledge retention after one year and after two years of learning. Long term knowledge retention was shown to decrease drastically after one year, however only slightly decreased after the second year [7]. Therefore, long-term retention of simulation users should be checked after one year and compared with these results to see if the VR simulation is a comparable method of instruction.

Another study provided a framework for validating VR training simulations. They outlined several different types of validation and fidelity and explained how transfer of learning can be achieved. High fidelity leads to increased validity. High validity leads to increased transfer of learning which is the goal of the VR simulation. Transfer of learning occurs when the same skills in the virtual environment can be applied in both similar and dissimilar contexts of the same problem. More specifically, construct validity was found to be a major factor of transfer of learning while face validity is more minor. Psychological and physical fidelity are closely related and equally contribute to validity and thus also contribute to transfer of learning. [8] Therefore, a successful test plan that aims to test the usefulness of a VR simulation will test for validity, fidelity, and transfer of learning. To do so, performance in situations that resemble the training and those that differ in some regard should be compared. Additionally, the performance of both novice and experts in the domain of application should be compared. The real-world task should also have one-to-one counterparts in the simulation in terms of psychological and physical aspects to ensure fidelity.

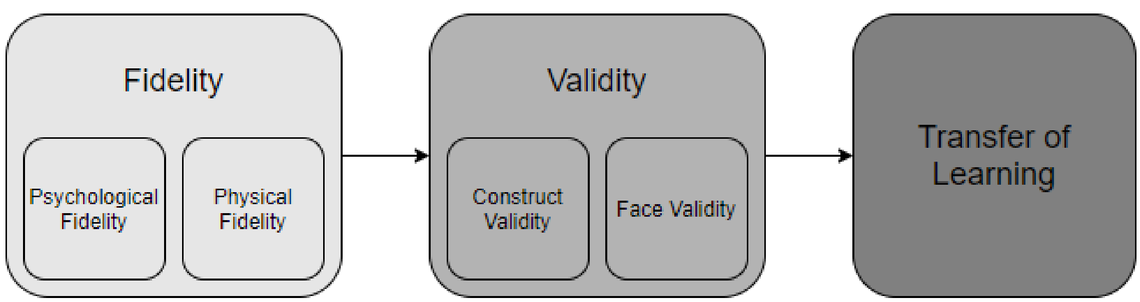

Figure 2.1: Depicts the Relationship Between Fidelity, Validity, and Transfer of Learning

The different types of fidelity and validity of a VR golf simulation were analyzed. Putting performance was determined through objective scoring, presence was determined via questionnaires, and fidelity was determined by the discrepancy between perceived and actual putting distances. The participants included 18 golf experts and 18 novice golfers whose performances were compared. [1] Performance can be measured both objectively and subjectively to determine both fidelity and validity of a VR simulation.

CHAPTER 3

METHODOLOGY

The purpose of the simulation is for nurses to train with it and be able to apply that training to both old and new contexts. Therefore, transfer of learning is tested. Should the test results indicate low transfer of learning, testing many components will allow a root cause to be determined. For this reason, both fidelity and validity will be tested because they contribute to transfer of learning. More specifically, psychological fidelity, physical fidelity, face validity, and construct validity will be tested in addition to transfer of learning. If the simulation is lacking in any of these areas, then the product will go back into development. This section explores what each component of transfer of learning is and how they can be tested.

3.1 Fidelity

3.1.1 Psychological Fidelity

When a virtual reality simulation elicits the same response in users compared to the real-world task, it is said to have high psychological fidelity. Therefore, this can be tested by recording and comparing the responses from the virtual simulation and responses from the real-world task. One way to objectively record a user's reaction is to record reaction times to certain stimuli within the simulation. In the VR hospice care simulation, the user must perform suction on the patient because of the excess fluid that has built up in the patient's mouth. The user's reaction to this event occurring will then be recorded. So that responses can be compared fairly, only response times will be recorded for the task in virtual reality and the real-world task with similar context.

3.1.2 Physical Fidelity

There are several components that contribute to physical fidelity, such as how the simulation looks and sounds, but the most influential aspect to transfer of learning is presence. For this reason, only presence was added to the test plan. Psychophysiological indicators and user feedback are typically used to evaluate presence. Heart rate during the simulation and the real-world task are to be recorded for comparison. User feedback on presence is gathered by using the Wilmer & Singer Presence Questionnaire that was revised by the UQO Cyberpsychology Lab. A standard presence score will be used in the test plan to determine whether the VR simulation has sufficient physical fidelity.

3.2 Validity

3.2.1 Construct Validity

A checklist of key requirements will be created from the project's software requirement specification. Before groups are given the simulation to train with, testers will ensure that every item on the checklist is present in the simulation and thus ensure that the real-world task has a one-to-one counterpart in the simulation. Once the product has passed this stage of testing, it will be given to multiple groups for testing. Both novices and experts will perform the simulation. Novices for this test plan are defined to be undergraduate nursing students at the University of Texas at Arlington, while experts are defined to be nurses who have experience in hospice and end of life care. Their performances will then be recorded and compared. The performance metric used is a score based on correct actions taken in the simulation, whether it be real-world or virtual. Another performance metric to be used is completion time.

3.2.2 Face Validity

Because face validity is subjective for each user, it must be evaluated in a subjective manner. Therefore, a survey will be given to those that train with the VR simulation. Then a group discussion will follow the survey to gain a deeper understanding of the participant's views. The goal is to find out whether the simulation was close enough to real life so as not to distract from learning. Any distracting aspects of the simulation will be isolated and found out so that it can be fixed.

Simulation Aspect	Definition	How to Test	Test Plan
Psychological Fidelity	Elicits similar psychological response as the real-world task	• User feedback. • Measuring physical and mental demands of the task.	Compare reaction times to stimulus in sim and in real-world task.
Physical Fidelity	Looks and behaves like the real-world	Measurement of presence: • user response • psychophysical indicators	Compare heart rate of those in the sim and those completing real-world task Standardized Presence Questionnaire
Construct Validity	Represents real-world task accurately	• Real-world task must have 1 to 1 counterparts in the sim • Experts perform better than novices	Create checklist of counterparts from project requirements. Compare performance of experts and novices.
Face Validity	Users view it as realistic	User feedback.	Post training surveys and group discussion.
Transfer of Learning	Perform better in similar and dissimilar contexts of the task after training w/ sim	Compare performance of test and control groups in 2 variations of the real-world task.	Compare performance in real-world hospice care simulation of similar and dissimilar contexts.

Table 3.1: Simulation Aspects to be Tested

3.3 Transfer of Learning

To test transfer of learning, two groups will be formed: nursing students who train with the VR simulation (test group) and nursing students that do not perform any simulation for end-of-life care (control group). Then both groups will perform real-world palliative care scenarios, including one scenario that is a similar situation and another scenario that is a dissimilar situation to that of the VR simulation being tested. The VR simulation includes taking care of a patient with esophageal cancer whose condition worsens after being transitioned to at-home hospice care. The similar context simulation will be taking care of a patient whose condition worsens and requires performing suction and using the Glasgow coma scale to assess the patient's status. The dissimilar context situation will consist of taking care of a patient with dementia who similarly transitions into hospice care and requires compassionate communication with family members, however he will not be as responsive and thus it will be difficult to identify the patient. The performance of the two real-world scenarios will be recorded and compared for each group. The test group should perform better than the control group in both real-world scenarios.

CHAPTER 4

DISCUSSION

This section describes the details of the nursing simulation test plan and the steps that must be taken in order to receive results from applying the test plan to the product. In order to test for transfer of learning, validity and fidelity, two major contributing factors of transfer of learning must be tested. All three aspects are evaluated when carrying out the test plan. After the virtual reality simulation is finished being developed, it will go through several phases of testing as defined by this test plan.

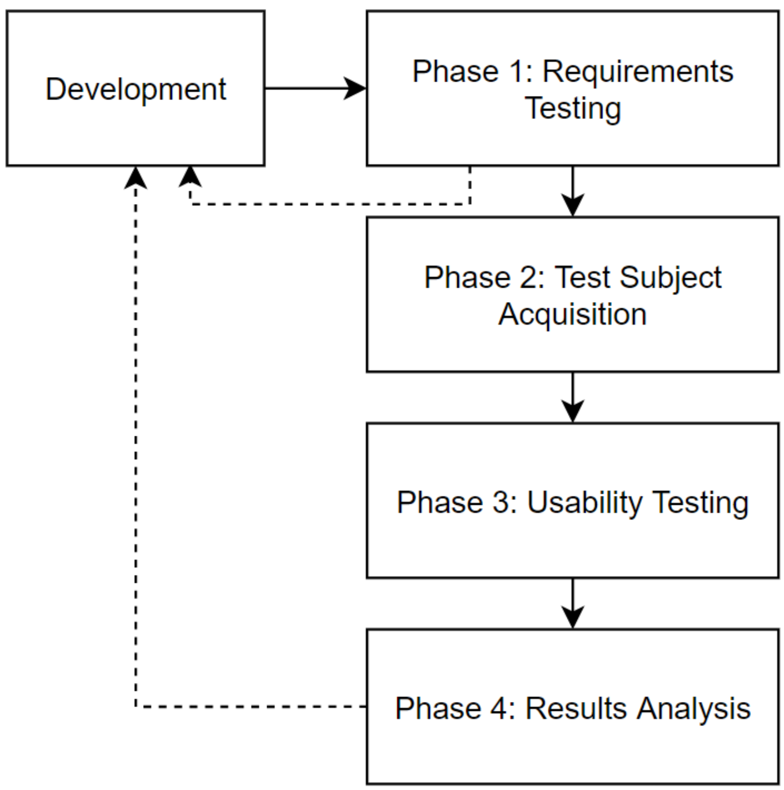

Figure 4.1: Four Phases of the Proposed Test Plan

The first phase, the requirements testing phase, consists of testers ensuring that all requirements are met in the simulation. These requirements include the one-to-one counterparts that must be present in each scenario of the VR nursing simulation. The first phase will take approximately 1-2 weeks. If any requirement is missing, the product must go back into development. Once the first phase is passed, test subjects of both novices and experts will be found to perform the simulation in the second phase. Each expert participant must have at least 10 years of experience in hospice care and be available to perform all four scenarios. Four different groups of undergraduate nursing students will be taken as the novice test subjects: students in junior semester 1, students in junior semester 2, students in senior semester 1, and students in senior semester 2. The groups will all perform the simulation at similar times, however the goal is for one of the four scenarios of the VR simulation to be performed in each of the four semesters of nursing school. The third phase is usability testing. The fourth and final phase is to analyze all the results and compare each aspect to its desired benchmark. If the benchmark is not met, then the product will go back into development to fix the area in which it was lacking. This phase will determine what specifically needs to be fixed in development and redefine the project requirements if need be.

Due to the nature of hospice care, it is difficult to simulate a real-world task, and thus it is hard to compare the virtual and real-world performance metrics. This is a challenge not only for this specific domain, but for many applications of educational VR.

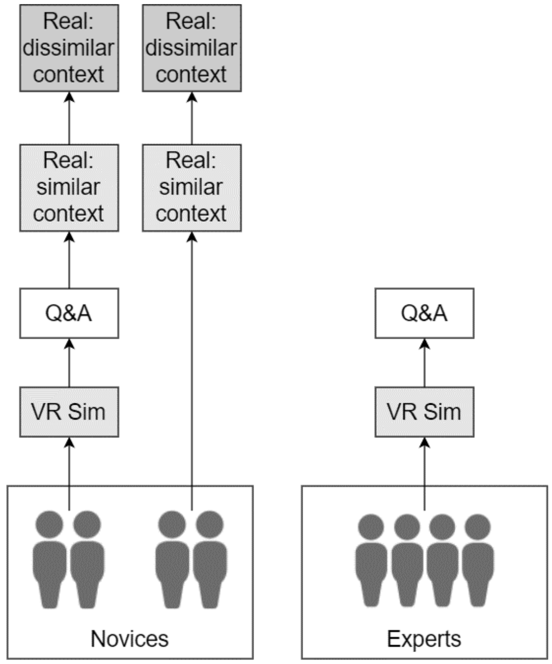

Figure 4.2: Phase 3 Usability Testing

The original appeal of VR is that it makes situations that are normally inaccessible and rare accessible more often and in more places. However, it is this very aspect that makes educational VR simulations difficult to test for construct validity. The real-world tasks of similar and dissimilar context are also simulations and therefore only a representation of the real-world task. In hospice care, it is hard to simulate these situations. However, this test plan provides an initial approach to testing a hospice care VR simulation by following the pattern of previous successful testing strategies for VR golf and military simulations.

CHAPTER 5

CONCLUSION

In recent years, VR has been used as a modality for training in many different fields such as sports, military, technical trades, and now the medical field. However, for these tools to be adopted widespread, they must be tested for usefulness. Because these simulations are educational, to ensure usefulness means to ensure that the product has high transfer of learning. This research proposes a testing methodology specifically for hospice and end of life care scenarios for nurses which contributes not only to the education of nursing students, but to the testing for transfer of learning in educational VR systems. Future work is to implement this test plan on the nursing VR simulation in question and continue to improve upon the simulation's transfer of learning so that usefulness is maximized.

APPENDIX A

PRESENCE QUESTIONNAIRE

PRESENCE QUESTIONNAIRE
(Witmer & Singer, Vs. 3.0, Nov. 1994) *
Revised by the UQO Cyberpsychology Lab (2004)

Characterize your experience in the environment, by marking an "X" in the appropriate box of the 7-point scale, in accordance with the question content and descriptive labels. Please consider the entire scale when making your responses, as the intermediate levels may apply. Answer the questions independently in the order that they appear. Do not skip questions or return to a previous question to change your answer.

WITH REGARD TO THE EXPERIENCED ENVIRONMENT

1. How much were you able to control events?

|________|________|________|________|________|________|________|

NOT AT ALL SOMEWHAT COMPLETELY

2. How responsive was the environment to actions that you initiated (or performed)?

|________|________|________|________|________|________|________|

NOT MODERATELY COMPLETELY
RESPONSIVE RESPONSIVE RESPONSIVE

3. How natural did your interactions with the environment seem?

|________|________|________|________|________|________|________|

EXTREMELY BORDERLINE COMPLETELY
ARTIFICIAL NATURAL

4. How much did the visual aspects of the environment involve you?

|________|________|________|________|________|________|________|

NOT AT ALL SOMEWHAT COMPLETELY

5. How natural was the mechanism which controlled movement through the environment?

|________|________|________|________|________|________|________|

EXTREMELY BORDERLINE COMPLETELY
ARTIFICIAL NATURAL

6. How compelling was your sense of objects moving through space?

|________|________|________|________|________|________|________|

NOT AT ALL MODERATELY VERY
COMPELLING COMPELLING

7. How much did your experiences in the virtual environment seem consistent with your real-world experiences?

|________|________|________|________|________|________|________|

NOT MODERATELY VERY
CONSISTENT CONSISTENT CONSISTENT

8. Were you able to anticipate what would happen next in response to the actions that you performed?

|________|________|________|________|________|________|________|

NOT AT ALL SOMEWHAT COMPLETELY

9. How completely were you able to actively survey or search the environment using vision?

|________|________|________|________|________|________|________|

NOT AT ALL SOMEWHAT COMPLETELY

10. How compelling was your sense of moving around inside the virtual environment?

|________|________|________|________|________|________|________|

NOT COMPELLING MODERATELY COMPELLING VERY COMPELLING

11. How closely were you able to examine objects?

|________|________|________|________|________|________|________|

NOT AT ALL PRETTY CLOSELY VERY CLOSELY

12. How well could you examine objects from multiple viewpoints?

|________|________|________|________|________|________|________|

NOT AT ALL SOMEWHAT EXTENSIVELY

13. How involved were you in the virtual environment experience?

|________|________|________|________|________|________|________|

NOT INVOLVED MILDLY INVOLVED COMPLETELY ENGROSSED

14. How much delay did you experience between your actions and expected outcomes?

|________|________|________|________|________|________|________|

NO DELAYS MODERATE DELAYS LONG DELAYS

15. How quickly did you adjust to the virtual environment experience?

|________|________|________|________|________|________|________|

NOT AT ALL SLOWLY LESS THAN ONE MINUTE

16. How proficient in moving and interacting with the virtual environment did you feel at the end of the experience?

|________|________|________|________|________|________|________|

NOT PROFICIENT REASONABLY PROFICIENT VERY PROFICIENT

17. How much did the visual display quality interfere or distract you from performing assigned tasks or required activities?

|________|________|________|________|________|________|________|

NOT AT ALL INTERFERED SOMEWHAT PREVENTED TASK PERFORMANCE

18. How much did the control devices interfere with the performance of assigned tasks or with other activities?

|________|________|________|________|________|________|________|

NOT AT ALL INTERFERED SOMEWHAT INTERFERED GREATLY

19. How well could you concentrate on the assigned tasks or required activities rather than on the mechanisms used to perform those tasks or activities?

|________|________|________|________|________|________|________|

NOT AT ALL SOMEWHAT COMPLETELY

IF THE VIRTUAL ENVIRONMENT INCLUDED SOUNDS:

20. How much did the auditory aspects of the environment involve you?

|________|________|________|________|________|________|________|

NOT AT ALL SOMEWHAT COMPLETELY

21. How well could you identify sounds?

|________|________|________|________|________|________|________|

NOT AT ALL SOMEWHAT COMPLETELY

22. How well could you localize sounds?

|________|________|________|________|________|________|________|

NOT AT ALL SOMEWHAT COMPLETELY

IF THE VIRTUAL ENVIRONMENT INCLUDED HAPTIC (SENSE OF TOUCH):

23. How well could you actively survey or search the virtual environment using touch?

|________|________|________|________|________|________|________|

NOT AT ALL SOMEWHAT COMPLETELY

24. How well could you move or manipulate objects in the virtual environment?

|________|________|________|________|________|________|________|

NOT AT ALL SOMEWHAT EXTENSIVELY

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BIOGRAPHICAL INFORMATION

Alexis Lueckenhoff started her undergraduate in Computer Science at the University of Texas at Arlington in Fall 2018 and enrolled in the Honors College as a freshman. Since then, she has completed many Honors contracts studying topics further in depth such as virtual machines, automation, and unsupervised machine learning algorithms. During Alexis's first year, she worked in campus recreation as a lifeguard and climbing wall attendant while completing her studies. After her second year, she joined the Heracleia Human Centered Computing Lab as an REU (research experiences for undergraduates) where she worked on developing a web-based game to assess executive disfunction in children. The summer before her final year of undergrad, she interned at ARGO Data Resource Corporation as a Software Application Developer where she worked on front end bug fixes, software documentation, and backend data mapping. After graduating in May 2022, she will work in industry at Lockheed Martin Corporation in Fort Worth as a Software Engineer Associate on the Mission Control Systems team.