Highlights in Art and Design
ISSN: 2957-8787 | Vol. 7, No. 3, 2024

Practical Teaching Case: Experimental Eye-Tracking Study on Library Virtual Space Design

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Abstract: Eye-tracking experiments can be used to evaluate the popularity of design spaces. In this thesis, eye-tracking experiments are employed in the practical teaching of the "Ergonomics" course to provide feedback on the feasibility of library virtual space design. Firstly, in the course teaching, research subjects were selected and two virtual library spaces were built for eye-tracking experiments, with results showing that applying eye-tracking technology to space design is feasible, and participants prefer conventional library virtual spaces. Meanwhile, it is further confirmed that the use of design experiment feedback in practical teaching reform can improve students' subjective enthusiasm.

Keywords: "Ergonomics"; Eye-tracking Experiment; Practical Reform; Virtual Space Design.

1. Introduction

The theoretical content of "Ergonomics" is diverse and boring. Students majoring in art and design have a relatively weak cultural foundation compared to other engineering students and generally lack interest in learning theoretical courses[1]. At present, design-experiment-feedback design is a new teaching reform model in China, which can effectively mobilize students' subjective initiative. In view of this, the design practice teaching model of "Ergonomics" is combined for reform[2]. First, two virtual library spaces were designed and the relevant data from eye-checking experiments were used to understand which library space children with Autism Spectrum Disorder (ASD) prefer [3]. Through this design experiment approach, students are encouraged to actively learn and master knowledge and skills[4].

2. Overview of the Implementation of Eye-tracking Experiment in the Reform Practice of "Ergonomics"

Students majoring in art and design have a poor foundation in cultural courses. Although most students are intelligent, quick to accept new things, and have a wide range of knowledge, there are also a small number of students who lack motivation and dislike learning when facing design theory courses. They use their mobile phones to play games, chat, browse web pages, and even sleep in class. In order to change this inefficient state of theoretical teaching, teachers have adopted various methods such as random questioning, in-class testing, and classroom interaction, but with minimal results[5]. In the past two years from 2022 to 2024, the author and his peers used eye-tracking experiments to implement experimental and practical teaching activities for the course of "Ergonomics"[6]. The scope of classroom implementation includes about 200 students of design classes, who were enrolled in 2021 and 2022, and teaching reforms have been implemented (as shown in Table 1), with some exploratory attempts made.

Table 1. Implementation phases

Begin	Finishes	Work content and focus	Overall progress of the project
2023.1	2023.12	Preparation of experimental conditions and implementation of experiments	Condition preparation, pre-experiment
2024.1	2024.6	Apply and summarize	Experimental practice
2024.7	2024.9	Feedback and reflection	Decide on a scenario

3. Implementation of Experimental Projects in Practical Teaching

In the experimental teaching of design majors, there are few experimental bases, poor experimental conditions, and difficult projects. Therefore, project-based teaching is adopted in teaching, and project-based, discussion based, and inquiry based teaching methods are used in off campus internship bases to allow students to practice with tasks, improve internship initiative, and enhance internship effectiveness [7]. This course strengthens the cultivation of students' practical and hands-on abilities through teacher projects, practical designs, and experimental feedback. Innovative design practices are carried out to effectively cultivate students' practical and innovative abilities, achieving the talent cultivation goals of this major[8].

3.1. Virtual Space Design

In this study, two library virtual spaces with the same layout and different details were designed [9]. Space construction with SketchUp Pro2021. Design a space that comes from the surrounding environment by combining relevant stories. Secondly, Unity3D was used for spatial preference comparison eye-tracking experiments. Using virtual software technology SteamVR, space design was imitated in a head-mounted eye-tracking device, making the modification of space flexible and operable [10]. The specific spatial design is shown in Table 2.

Table 2. Design of library virtual space

The name of the space	Spatial design ideas	Space display
Library Virtual Space 1 (Abbreviation: Space 1)	Impact space: According to the preliminary element experiments in the laboratory, the children with autism love the green and blue in the arc and color, and add impactful tree-shaped bookshelves in the space. The resulting library memory interactive space 1.	
Library Virtual Space 2 (Abbreviation: Space 2)	Conventional space: Compared with space 1, more green elements are added, and the space is more neatly arranged, and there are no impact objects. The resulting library memory interactive space 2 was designed.	

3.2. Experimental Site and Equipment Selection

The subjects of this study were selected from 30 children with ASD in the integrated education class of Rainbow Dream Rehabilitation Hospital in Xianning City. The inclusion criteria are: 1) According to DSM-5, every child had a clinical diagnosis of ASD from a doctor. And all subjects scored above 67 on the Autism Spectrum Assessment (ABC) scale for children (with a total score of 57 for screening and 67 for diagnosis) [11]. 2) According to the subsequent experimental requirements, participants need to have simple language expression ability and basic cognition of things, including accurate descriptions of the shape, color, and size of things [12]. 3) After explaining the experimental principles clearly to the guardians of the children participating in this study, the researchers signed an informed consent form with them. The exclusion criteria are: 1) Individuals with IQ below 70. 2) Patients who experienced vertigo in 3D virtual space, failed to accept optical stimulation, had a history of obvious movement disorders, or had neurological disorders or psychiatric symptoms. Finally, 10 children with ASD aged 8-14 were selected as the research objects.

Fig 1. ViVE Pro Eye external headset

The equipment used in the entire study includes the following: 1) ViVE Pro Eye external head mounted eye-tracking device; Resolution: 2160x1200 for both eyes, 1080x1200 for one eye; Refresh rate of 90fps; Tracking location: 4.5 * 4.5m; Sensory controller x2 (as shown in Figure 1). 2) Equipped with a camera for recording and documenting the research process. 3) Time recording equipment.

3.3. Experimental Implementation and Conclusion

The experiment mainly focuses on spatial preference, using eye-tracking technology to conduct the experiment, with each person completing each scene within 30 seconds. Before the experiment began, the subjects put on the head-mounted eye-tracking device to perform eye-tracking and pupil calibration and began to adapt to the scene. During intervention, eye-checking related data (eye heat map, eye gaze frequency, total gaze time, average gaze time, first gaze time) were collected and the experimental results were recorded through video [13]. Finally, through eye-checking data analysis, the library virtual space that the subjects relatively preferred was obtained. The experiment was conducted in the activity classroom of Xianning Rainbow Dream Rehabilitation Hospital, and the environment was kept quiet during the experiment. Each experiment had 1 subject, 1 equipment operator, 1 video recorder, 1 data recorder, and 1 guide.

In this study, a visual analysis was conducted on multiple baseline charts across subjects (i.e. plotting collected data and visually examining differences between stages and across subjects), and visual analysis and paired t-test statistics assisted with nonparametric metric were used[14], to determine whether there was a functional relationship between intervention and outcome variables [15].

During the experiment, eye-checking data related to the subjects were collected using eye-checking equipment, and the subjects watched Space 1 and Space 2 simultaneously in the same space to compare the spatial preference. Figure 2 is a descriptive statistical chart of eye-checking fixation frequency, total fixation time, average fixation time, and first fixation time. Through the analysis of the above data, it was found that there was a significant difference ($P<0.05$) between Space 1 and Space 2 in terms of eye-checking fixation frequency and total fixation time (as shown in Table 3).

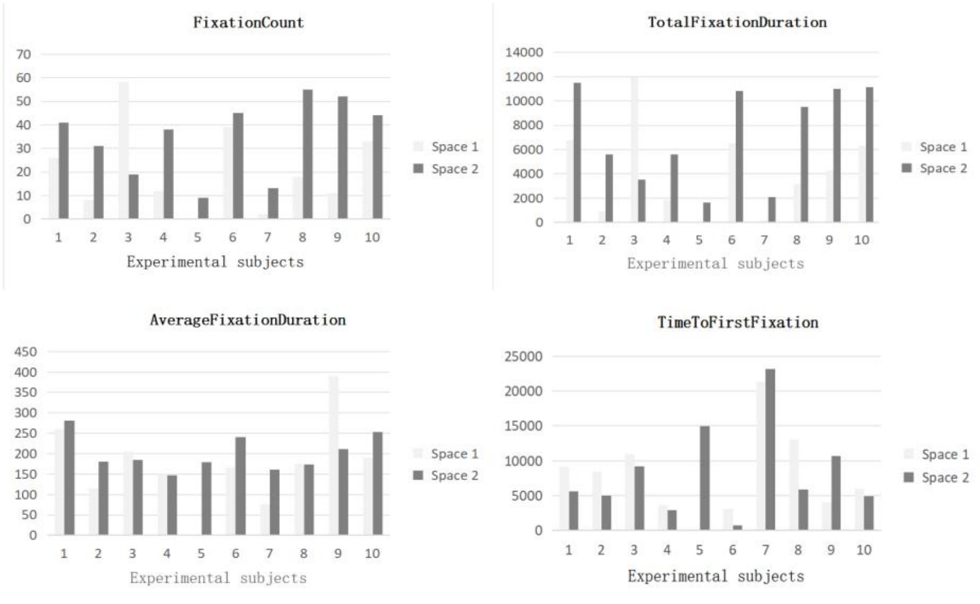

Fig 2. Descriptive statistical chart of eye movement-related data

Table 3. Comparison of space 1 and space 2 eye tracking data

Data	Space 1M(SD)	Space 2M(SD)	Paired T-test T-value
FixationCoun	20.70(18.32)	34.70(16.15)	-2.00(p=0.08)
TotalFixationDuration	4177.00(3765.57)	7234.30(3980.99)	-2.23(p=0.05)
AverageFixationDuration	172.84(105.16)	201.07(43.52)	-0.95(p=0.36)
TimeToFirstFixation	7952.90(6137.34)	8297.80(6602.44)	-0.17(p=0.87)

The eye-tracking results are displayed in the form of a heatmap [13], with the order of gaze concentration being: red>yellow>green. These criteria can provide a more intuitive understanding of which elements on the page are most focused on. Figure 3 shows the eye-checking comparison heatmap of 10 subjects for Space 1 and Space 2. And as a whole, it can be observed that the majority of participants prefer Space 2. Overall, more attention is paid to the left side of Space 2 and the right side of Space 1. Specifically, the subjects had a longer visual focus on the curved bookshelf area block in Space 2. In Space 1, the subject's line of sight stayed longer in the curved seat area.

Fig 3. Heat map of space 1 and space 2 eye movements

3.4. Conclusion of Experiment Design Feedback

Eye-checking technology was used to analyze the liking of virtual space. The relative preference of the designed space was tested through experiments, in order to provide useful reference for the targeted therapeutic intervention and rehabilitation interior space design for this special group.

During the research, it was observed that high-functioning children with ASD were able to independently observe their favorite parts of the space, and this was intuitively reflected in the data results. Therefore, eye-tracking technology can be applied to the sensory preferences of children with autism. This is beneficial for the spatial design and intervention program formulation of special populations.

4. Comprehensive Evaluation of Experimental Projects in Practical Teaching

By collecting feedback and reflections from teachers and students after class, it is concluded that 90% of students reported good learning outcomes, high enthusiasm and initiative, while another 10% were not very cooperative and had poor overall completion rates. But later on, they gave feedback to the teacher that they hoped to use classroom teaching and study seriously in the next class. They also showed interest in the process of eye-tracking experiments, but the data processing for evaluation was somewhat difficult, so they hoped to further develop data processing software to automatically evaluate and provide feedback on the results. However, students generally hoped to use experimental and practical teaching in their next classroom learning.

5. Conclusion

By organizing and summarizing student related data within the scope of teaching reform implementation from 2023 to 2024, and comparing and analyzing feedback from peer experts and students, it was found that eye-tracking experiments have achieved good results in the reform of the "Ergonomics" course. Eye-tracking technology has been used to study the popularity of environmental space design, providing new ideas for designing virtual spaces.

This experimental teaching has improved students' initiative in learning, consolidated their knowledge, and strengthened their theoretical and practical abilities. The research results have constructed a distinctive practical teaching reform model suitable for designing professional theoretical courses, which also has guiding significance for the reform of "ergonomics" courses and similar courses in other majors.

Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethic Institutional Review Board of Wuhan Polytechnic University (protocol code BME-2024-1-22 and date of approval 14 September 2024).

Acknowledgments

University Teaching Research Project (No. XM2024004): Exploration and Practice of Practice Teaching Reform of Art Design Major in the Context of Transformation of Applied Undergraduate.

Colleges and Universities. Hubei Provincial Department of Education Philosophy and Social Science Humanities Project: Research on Rehabilitation Environment Research and Design for Autistic Children in Hubei Province (20Y097).

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