EFFECTS OF ATTENTION GUIDANCE INVIRTUAL REALITY LAB FOR DIGITAL CAMERA COURSE ON STUDENTS' COGNITIVE LOAD, ACADEMIC PERFORMANCE AND EXPERIMENTAL TIME

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SULTAN IDRIS EDUCATION UNIVERSITY

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ABSTRACT

This research was aimed to analyze the effects of attention guidance in a virtual reality lab on students' cognitive load, experiment time consumption and academic performance. For this purpose, the virtual reality lab with and without attention guidance for the digital camera course was designed and developed. The quasi-experimental design was employed to collect relevant data. The experiment involved 80 students from two universities in China whose major is the digital media art. In each university 40 students were selected as control and experimental groups respectively. The data obtained was analyzed by using ANOVA and linear regression statistical methods. The findings revealed that there were significant differences in cognitive load ($F(1, 78) = 33.73$, $p<0.05$, partial eta squared = 0.30) and academic performance ($F(1, 78) = 7.31$, $p<0.05$, partial eta squared=0.09), however, there was no significant difference in time consumption ($F(1, 78) = 0.01$, $p>0.05$). In terms of linear regression, the findings indicated that there was a significant relationship between cognitive load and students' academic performance ($F(1, 78) = 15.38$, $p<0.05$, $R^2=0.17$), and there was no statistical significance between cognitive load and students' experiment completion time ($F(1, 78) = 1.18$, $p>0.05$). Overall, the research findings indicated that students exhibited lower cognitive load and higher academic performance in the virtual reality lab with attentional guidance. Furthermore, the regression analyses revealed that cognitive load can negatively predict learning outcomes ($\beta=-0.41$, $t=-3.92$, $p<0.05$); academic performance improves as cognitive load decreases. In conclusion, the teaching effects of the virtual reality lab for the digital camera course with attention guidance are better than virtual reality lab without attention guidance. Finally, the research findings can be a useful guideline for virtual reality lab design in achieving a more effective learning outcome.

KESAN BIMBINGAN PERHATIAN DALAM MAKMAL REALITI MAYA UNTUK KURSUS KAMERA DIGITAL TERHADAP BEBANAN KOGNITIF, PRESTASI AKADEMIK DAN TEMPOH MASA EKSPERIMEN PELAJAR

ABSTRAK

Kajian ini bertujuan untuk menganalisis kesan bimbingan dalam makmal realiti maya terhadap bebanan kognitif, prestasi akademik dan tempoh masa eksperimen pelajar. Untuk tujuan ini, makmal realiti maya dengan dan tanpa bimbingan perhatian untuk kursus kamera digital telah direka bentuk dan dibangunkan. Reka bentuk eksperimen kuasi digunakan untuk kutipan data yang berkaitan. Kajian ini melibatkan 80 pelajar dari dua universiti di China yang mengambil jurusan seni media digital sebagai major. Di setiap university, 40 pelajar dipilih untuk kumpulan kawalan dan 40 pelajar sebagai kumpulan eksperimen. Data yang dikutip dianalisis dengan menggunakan kaedah statistik ANOVA dan regresi linear. Dapatan menunjukkan bahawa wujud perbezaan yang signifikan terhadap bebanan kognitif ($F(1, 78) = 33.73$, $p<0.05$, partial eta squared = 0.30) dan prestasi akademik ($F(1, 78) =7.31$, $p<0.05$, partial eta squared =0.09), tetapi tidak wujud perbezaan yang signifikan terhadap tempoh masa eksperimen ($F(1, 78) =0.01$, $p>0.05$). Berdasarkan terma regresi linear, dapatan menunjukkan terdapat hubungan yang signifikan antara beban kognitif dan prestasi akademik pelajar ($F(1, 78) =15.38$, $p<0.05$, $R2=0.17$), dan tiada kepentingan statistik antara beban kognitif dan masa penyelesaian eksperimen pelajar ($F(1, 78) = 1.18$, $p>0.05$). Secara keseluruhan, dapatan kajian mendapati bahawa pelajar menunjukkan bebanan kognitif yang lebih rendah dan prestasi akademik yang lebih tinggi di dalam makmal realiti maya dengan bimbingan perhatian. Analisis regresi juga menunjukkan bahawa bebanan kognitif dapat memprediksi hasil pembelajaran secara negatif ($\beta=-0.41$, $t=-3.92$, $p<0.05$); iaitu, prestasi akademik meningkat apabila bebanan kognitif berkurangan. Kesimpulannya, kesan pengajaran makmal realiti maya bagi kursus kamera digital dengan bimbingan perhatian adalah lebih baik daripada makmal realiti maya tanpa bimbingan perhatian. Akhir sekali, dapatan kajian ini boleh menjadi garis panduan yang berguna untuk reka bentuk makmal realiti maya bagi mencapai hasil pembelajaran yang lebih efektif.

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VR	Virtual Reality Cognitive
CLT	Load Theory User
UI	Interface
UX	User Experience
UEQ	User Experience Questionnaire

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H2 Wen, P., Ali, A. Z. M., & Lu, F. (2022). Attention guidance in virtual reality lab: A conceptual framework. *International Journal of Education and Research, 10*(4), 33-46.

CHAPTER1

INTRODUCTION

1.1 Overview

Nowadays, the sustainable development of digital media art urgently needs talent, training and practical application follow-up. To promote the healthy development and virtuous cycle of the digital media art industry, the Ministry of Education of China approved the Communication University of China to officially set up the first higher education major in ‘digital media art’ in China in 2002 (Zhu, Wang, & Zhou, 2008). So far, more than two hundred universities and colleges have a professional programme in digital media art design(Geng, 2015).As an important basic course in that programme, a digital camera course plays a significant role in improving students' aesthetic accomplishments and artistic creation ability (Jiang & Lee, 2010).

At present, the experimental teaching of digital camera courses in China is relatively weak. The problems in traditional experiments are (a) different kinds of scenes that the scripts of films, TV plays and literature need cannot be provided with absolute certainty, due to such factors as time, place, climate and season; (b) the rotation of different scenes requires several staff, waiting to coordinate staff and equipment and refilming unsatisfactory scenes, consuming time and labour; (c) some imaginary and dangerous scenes will put actors and staff at great hidden risk if they refilm repeatedly. Therefore, a developing tendency of photography and camera experimental courses is to construct a digital camera virtual experimental teaching platform, to realise the integration of all virtual experimental teaching resources. The learning materials in a virtual realitylab help in achieving the course goals and effectively completing the course results (Kumar et al., 2021).

Using the virtual reality lab includes abundant configurable scenes, various materials that students can change at will and lighting and camera locations they can schedule at any time. Also, students can obtain the actual effect of simulation quickly, so they can have the feeling of a real environment and grasp the basic methods of integrated application of scene design and scheduling lenses, lighting and performers. Besides, it is possible to form a team elsewhere and test different kinds of techniques of expression repeatedly for individualised design, to ensure the best state of performers and equipment. In the meantime, the class can avoid sudden dangerous accidents and promote the effect of the experiment.

Multimedia teaching contains complex, multilevel information that consumes learners' working memory or cognitive resources (Mayer, 2005). virtual reality labs include a great deal of relatively complex information, and learners must bear more cognitive load (Achuthan, Brahmanandan, & Bose, 2015). In virtual reality labs, methods for guiding learners' attention and conscious information processing are particularly important. Previous studies have found that doing so in multimedia learning can promote learners' understanding of knowledge and problem-solving (Canham & Hegarty, 2010). For example, it is possible to improve the learning effect by informing learners of important visual information with highlighting, colour, acceleration and other visual clues (Ge, Unsworth, & Wang, 2017). Therefore, in the virtual reality lab, studying the function and effect of adding attention guidance is very important. Attention guidance can facilitate learners' paying attention to the information that relates to learning tasks and simplify their visual search process. They can also get help with finding important information and make room for working memory to integrate information and construct psychological representations, promoting their learning effect.

1.2 Research Background

The digital camera course is a core undergraduate course for students who major in digital media technology, digital media art, animation, photography, radio, film and television programme production. Photography and camera labs are important teaching venues for these experimental courses (Cheung, 2016). Digital camera technology is a course that includes both theory and practice. Its characteristic practical operation is more prominent in teaching; usually, the experimental course has more teaching contents than the theory course. The pattern design of a digital camera experimental course is mainly to train students' overall thinking ability while cultivating their operational ability.

The teaching patterns are as follows. Teaching includes a variety of practical methods, such as demonstration teaching and practical and comprehensive exercises, to lay a solid foundation. In task requirements, the students can gradually improve, from basic operation to creation. Incentive mechanisms, such as curriculum assessment and work display, can encourage students' motivation to learn (Darius, Gundabattini, & Solomon, 2021). As an important part of the digital media art course system, the digital camera experimental course plays an irreplaceable role in the study of professional courses. To learn it well, students must not only grasp technical mastery but also have creative artistic thinking ability.

Teachers must seek more effective methods and cultivate a variety of outstanding digital media art professionals. They can promote the healthy development of digital media art in colleges and universities while improving its teaching quality. The current digital-media technology influences the traditional curriculum design of higher education. Technology promotes the emergence of innovation standards, teaching methods and evaluation mechanisms. The design of an experimental curriculum also enables teachers to improve their teaching (Shnai, 2018).

Activities in the lab can improve students' achievement and interest in the subject and help them learn more. In combination with a sound teaching framework, learner support, content and supervisor interaction, these labs can lead to better learning results and more abundant learning experiences. Future work will evolve to make good use of advanced technologies and implement innovative labs in different educational settings (Hofstein & Lunetta, 2004). New learning and teaching quality are most important in education. Teachers are not only the source of information; they also take on the role of managers and teachers who develop students' interaction and cultivate and develop their key social personality characteristics. In most colleges and universities using traditional classroom teaching, teachers and students have both exposed the limitation of teaching effects. Teachers must encourage discovery learning and heuristic research methods (Senthamarai, 2018). The idea of the virtual reality lab is to apply virtual reality technology, combined with a traditional teaching

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mode, to integrate immersive teaching ideas and stimulate students' enthusiasm for participation, a means of teaching that practical application guides.

Many studies have shown that virtual labs can improve students' achievements and interest in topics and help them learn more (Höhner et al., 2020; Janonis et al., 2020; Seo, Malone, Beams, & Pine, 2021; Wattanasin, Piriyasurawong, & Chatwattana, 2019). Virtual labs have many advantages in these areas (Alkhaldi, Pranata, & Athauda, 2016). Many disciplines have established them in universities around the world, and problems that real experiments cannot solve find solutions in virtual reality labs (Hernández-de-Menéndez, Vallejo Guevara, & Morales-Menendez, 2019).

Many virtual reality lab courses have proved superior to real experimental courses in some respects. E#xamples include a comparative study of students' knowledge in physics virtual-experiment learning (Foreman, Hilditch, Rockliff, & Clarke, 2020); research on virtual physics and practical operation experiments by undergraduate students (Darrah, Humbert, Finstein, Simon, & Hopkins, 2014); a study on the self-efficacy beliefs in a virtual teaching experiment for students majoring in early childhood education (Bautista & Boone, 2017); evaluation of user interface applications in virtual chemistry labs (Jagodziński, Wolski, & Technology, 2015); immersive and interactive medical research in virtual reality labs (Berg & Steinsbekk, 2020); virtual reality training in neurosurgery (Alaraj et al., 2011); research on virtual simulation of a digital circuit experiment (Yang, Shiping, Yabo, & Miaoliang, 2007); using virtual reality to analyse motion performance (Bideau et al., 2009); virtual viewing of archaeological sites and historical information about their various key points and assessment of application users' learning performance and their interest in the subject (Christofi et al., 2018).

Examples from psychology include the effectiveness of virtual reality therapy in reducing speech anxiety of college students (Harris, Kemmerling, & North, 2002); using virtual reality to understand high school students' defects (Manouchou et al., 2016); use of virtual reality authenticity and fidelity as well as stimulation or environmental control for autism assessment and intervention (Parsons, 2016); the potential of virtual reality as the basis for the development of dedicated applications for culture and education (Pappa, Ioannou, Christofi, & Lanitis, 2018). Research applications include virtual learning environments from the perspective of students' learning motivation (Ainley & Armatas, 2006); research on acquiring knowledge and skills through virtual reality simulation of the real world (Stavroulia, Christofi, Zarraonandia, Michael-Grigoriou, & Lanitis, 2019); community-based pedestrian safety training in virtual communities (Schwebel, Combs, Rodriguez, Severson, & Sisiopiku, 2016). These examples of the research using virtual reality labs in different professional fields show its advantages, to some extent.

From a cognitive and physiological point of view, the brain cannot distinguish the interactions between highly realistic virtual environments and real life. Therefore, virtual reality can provide learners with such a virtual environment, in which students carry out the same learning activities in virtual reality as in real life (Lamb & Etopio, 2020). Compared with traditional multimedia learning, the unique characteristics of virtual reality (i.e. immersion, interactivity, imagination) provide a novel virtual learning experience. Its visual and auditory effects create an immersive and imaginative environment in which users operate as if they were in the actual environment (Moro, Štromberga, Raikos, & Stirling, 2017). According to current research results, virtual technology can deliver learning benefits and has great potential to improve educational outcomes (Southgate et al., 2019; Wu, Yu, & Gu, 2020). The integration of virtual technology with the traditional classroom is accelerating globally, so improving the application rate of virtual technology in education is necessary (Di & Zheng, 2022).

The contents of the digital camera experimental course in practical teaching enable students to master all kinds of shooting methods and digital camera skills, with the cooperation of professional lighting (Taylor, Hallett, Lowe, & Sanders, 2015). Examples include technology to control exposure, clear performance, depth of field, colour, and camera positioning (Raskar & Tumblin, 2009). Students can learn scene shooting, according to the film and television scene-scheduling principle and the contents, plots and characters the script provides. Therefore, this study creates three experimental steps—i.e. actor scheduling, lens scheduling and lighting design— for a digital camera virtual reality lab course. The main teaching content of this experiment is the teaching demonstration and manual operation guide of the virtual reality lab in that course. The teacher first operates the demonstration, then the students manually operate the experiment and submit the assignment.

Although a virtual reality lab has great advantages in multimedia teaching, the teaching design of a virtual reality lab also has many problems. Recent research indicates that virtual reality curriculum design must consider the potential cognitive load (Skulmowski & Rey, 2021). Skulmowski and Xu (2022) found that interactivity, immersion, nonfluency, realism and redundancy in the virtual reality lab induce task-independent cognitive load.

According to cognitive load theory (CLT), the elements of human cognitive structure include long-term memory and working memory (Mousavi, Low, & Sweller, 1995; Sweller, 2008). Working memory first processes new information before it can accumulate in long-term memory (Sweller, Van Merriënboer, & Paas, 1998). However, overloading the working memory with limited capacity due to information and processing requirements makes acquiring new knowledge more difficult (Greer, Crutchfield, & Woods, 2013). Designing teaching materials should include reducing unnecessary load on working memory (Mutlu-Bayraktar, Cosgun, & Altsan, 2019).

Therefore, the teaching design of the digital camera experimental course requires reducing the cognitive load that the virtual reality lab produces. For example, Lee, Donkers, Jarodzka, Sellenraad, and Van Merriënboer (2020) investigated the effects of computer simulation games on emergency medicine training. As a result of putting a pause-based learning control in a simulation game, this design reduced the overall cognitive load on learners, thereby increasing their performance. The results suggest that designing pause simulations to regulate cognitive load can improve student performance and learning. In other words, teaching designers can reduce cognitive load in the learning process through design. Research has also shown that in the teaching process, dividing educational videos into smaller segments and presenting them as video playlists through teaching design can not only reduce the cognitive burden on learners but also improve their satisfaction and, finally, achieve the goal of improving academic performance (Altinpulluk, Kilinc, Firat, & Yumurtaci, 2020). Kim, Yang, Choi, Kim and Ryu (2020) studied how adding auditory feedback design to virtual reality teaching training affected cognitive load. The results suggest that as a design element, auditory feedback can affect cognitive load by interacting with task difficulty. As a result, previous research shows that design may influence cognitive load. Therefore, the teaching design elements of virtual reality laboratories must focus on minimising unnecessary cognitive load on students.

In addition, learners must identify many objects, and the psychological amount with which learners deal will increase as they identify more objects, so cognitive load will increase (Ali & Ullah, 2020). Therefore, increasing cognitive load will seriously affect learners' performance (Ullah, Ali, & Rahman, 2016). Analysis shows that the virtual reality lab with complex information will lead to high levels of cognitive load, and at the same time, the virtual reality lab will promote students' enthusiasm for learning and affect their academic performance (Su & Cheng, 2019). Therefore, analysis shows that reducing the psychological amount of object recognition in the virtual reality lab—that is, the unnecessary content in working memory—can reduce the cognitive load on it. The teaching design of the virtual reality lab can realise all of these learning improvements and, thus, in this study, focuses on adding attention guidance.

Attention guidance refers to guiding learners' attention to specific positions and information in multimedia, often important information useful for understanding principles and constructing psychological representations. In experiments, researchers test a variety of clues (e.g. guides, connectives, coarsening, italics), largely find a guiding effect on attention and the clue group achieves better academic performance. As a result, Betrancourt (2005) proposed an attention-guidance principle, to emphasise the important role that clues play in multimedia learning, and suggested using clues to guide learners' attention to the important content in the learning materials. In numerous studies, attention guidance has improved learners' performance in multimedia environments (Alpizar, Adesope, & Wong, 2020; Luo, Koszalka, & Zuo, 2016; Moon & Ryu, 2021; Sidhu, 2014).

To sum up, attention guidance can promote learning effects in two important ways. First, as a salient stimulus, it can direct attention to the most important information. A study by Ozcelik (2010) used colour as an attention guide, to record subjects' eye movements during learning. He found those subjects more likely to maintain focus on relevant information for a longer period. That is, learners gazed more times at the attention guidance domain, and their gaze time was longer.

Other researchers have observed more eye movements in task-related interest areas in the attention-guidance group (Boucheix & Lowe, 2010). Also, attention guidance reduces the processing of irrelevant information by directing learners to focus on learning relevant information and ignoring irrelevant information (Kalyuga, Chandler, & Sweller, 1999). As an example, multimedia eye-tracking research indicates that attention guidance can enhance search efficiency and reduce search time for task-related information (Ozcelik et al., 2010). Boucheixand Lowe (2010) found that using dynamic colour as a clue showed subjects tending to focus on regions of interest with low visual salience but high relevance to the learning topic, for increasingly longer periods, indicating that learners may ignore high visual prominence and pay more attention to information associated with the learning topic. In the virtual reality lab, the yellow arrow guides attention. Because the experiment took place in a virtual reality setting, the arrows’ design made them look to be 3D instead of 2D.

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CLT is the most cited and best theoretical explanation of attention guidance. Individual cognitive resources are limited; searching, organising and integrating relevant multimedia information are additional tasks that consume cognitive resources. On this basis, adding attention guidance will reduce resource consumption by subjects searching, organising and integrating information, releasing more resources for learning-related activities or deep processing. The multimedia teaching design can reduce the extraneous load on the individual, thus promoting the learning effect (Paas, Renkl, & Sweller, 2003). In the multimedia learning environment, individuals must process multichannel information reaching them through vision or hearing and integrate multilevel information from such sources as pictures, graphics, diagrams, words or explanations. Therefore, some researchers have recognised the idea that attention guidance can effectively reduce cognitive load. However, some recent empirical studies (e.g. Tabbers, Martens, & Van Merriënboer, 2004) did not support that hypothesis. Those studies found that adding attention guidance did not reduce the cognitive load and psychological effort of learners in the process of learning—or, at least, the expected assumption of the subjectively judged cognitive load was not found. Therefore, this study focuses on attention in virtual reality labs in the context of cognitive load.

Interestingly, recent studies of adding attention guidance in virtual reality labs have found that it generally reduced cognitive load, and students perform better (Liu, Lin, & Kuo, 2019). Using arrow-line cueing as an attention cue and simulating the ordinary classroom in a virtual classroom as an experimental platform for classroom situations, tests found that students who adopt the arrow-line cueing method showed better academic performance and teaching efficiency. Castro-Alonso, De Koning, Fiorella, and Paas (2021) found that optimising teaching materials through teaching design in multimedia learning can reduce cognitive load, also the purpose of adding attention guidance in the virtual reality lab where all experimental contents are teaching materials.

1.3 Problem Statement

Although the virtual reality lab has many applications in education and has brought it many benefits, the interactive, immersive and imaginative nature of a multimedia learning virtual reality lab makes it more likely to cause extra cognitive load than traditional lab learning (Juliano, Schweighofer, & Liew, 2022; Makransky, Terkildsen, & Mayer, 2019). The characteristics of a virtual reality lab determine that too many factors affect the focus of attention in the visual scene. Excessive focus of attention will lead to storing excessive contents in the working memory, affecting learners' cognitive load and, finally, their learning results (Frederiksen et al., 2020; Parong & Mayer, 2021). The design is the main influence on cognitive load (Albus, Vogt, & Seufert, 2021; Du et al., 2022; Kehrwald & Bentley, 2020; Skulmowski & Xu, 2022). Reasonable and effective teaching design of virtual reality labs is the primary way to address this problem (Pellas, Mystakidis, & Kazanidis, 2021). However, incorporating attention guidance into the teaching design solves the problem of adjusting the excessive distraction of attention (De Koning, Tabbers, Rikers, & Paas, 2009; Jamet, Gavota, & Quaireau, 2008). Therefore, this research proposes that the teaching design that adds attention guidance can reduce students' cognitive load. In addition, further research on the influence of adding attention guidance on students' academic performance and the time to complete the experiment will contribute to solving the issue. Finally, with no definitive research on the regression analysis of cognitive load, students' academic performance and time to complete an experiment calls for practical research and experimental analysis to solve the problems.

1.4 Significance of the Study

With the development of science and technology, the continuous change and progress of teaching methods also influence the development of multimedia teaching (Jaafar & Nur, 2009). Virtual reality technology belongs to artificial intelligence. Introducing its advantages into the experimental teaching of traditional digital camera courses can enrich the relevant teaching contents and improve the overall teaching experimental level. It is a new teaching vehicle to cultivate students' practical ability and makes traditional digital photography courses 'intelligent' and 'systematic' (Hofstein & Lunetta, 2004).

Applying a virtual reality lab to a digital camera course is an innovative and practical part of research and teaching (Senthamarai, 2018). It includes artificial intelligence, experience of virtual reality technology, practice and application development. The project environment will reside on the Unity virtual reality development platform, based on open-source architecture and versatile. Moreover, users in real time can develop the platform a second time. The actual teaching of the digital photography course can add specific 3D digital scenes to the platform, and many 3D data come into being, beneficial for summarising and further optimising the experiment.

The digital camera course is the core course for students majoring in digital media. At present, the experimental teaching of this course is relatively weak. Adoption of the virtual reality lab includes abundant configurable scenes, various kinds of materials changeable at will and lighting and camera positioning that can be scheduled at any time. The actual effect of simulation can be obtained in a short time, so students can have the experience in the real environment and grasp the basic methods of integrated application of scene design and lenses, lighting and performer scheduling. The design of the digital camera virtual reality lab course has established a new teaching research direction in which to develop teaching digital media art. Therefore, the results of this study are useful for the teaching design of virtual reality lab courses.

With the wide application of network and portable device clients in teaching, multimedia learning using words and pictures to present materials is occurring more widely. However, compared with traditional teaching, a large amount of information and complex spatial changes of elements are among the features of multimedia teaching. They may impose a great cognitive burden on learners and not be conducive to realising efficient learning (Ayres & Paas, 2007). As a result, multimedia learning researchers focus on how to use instructional design to improve learning effectiveness (Clark & Mayer, 2016). As an important form of instructional teaching design, adding attention guidance has attracted many researchers in recent years (Boucheix, Lowe, Putri, & Groff, 2013; De Koning, Tabbers, Rikers, & Paas, 2011).

The mechanism of attention guidance for learning is a very complex problem, and opinions differ among multimedia teaching studies. This research mainly studies attention guidance in the virtual reality lab, and currently, where the research is still a blank. This study can provide a reference for the attention guidance design of the future virtual reality lab.

1.5 Theoretical Framework

The theoretical framework of this research is based on capacity limitation theory, cognitive load theory (CLT in this study) and biased competition theory.

In his book *Attention and Effort*, Kahneman (1973), an American psychologist, proposed capacity limitation theory, also called resource allocation theory. The resources here refer to psychological resources, including cognitive resources mainly reflected in working-memory capacity, and attention resources. Thus, it is also a cognitive resource theory in cognitive psychology. The basic assumption of this theory is that each task requires the use of psychological resources; they can be shared while performing several tasks, but the total amount of human psychological resources is limited. These processes produce a specific amount of output, allocated to the operation of several tasks based on the amount available and the quality of output resulting from people operating them. It is possible to Performing two tasks simultaneously is possible, provided that the sum of the resources they require does not exceed the total amount of human psychological resources. An individual may suffer cognitive overload if the cognitive resources that processing certain information requires exceed the available total, negatively impacting the effectiveness and efficiency of the learning process.

The virtual reality lab of the digital camera course has many visual elements, such as characters, cameras, lighting equipment and indoor scenery. Based on the capacity limitation theory, we know the limited capacity of working memory. Therefore, adding attention guidance in the virtual reality lab enables selecting visual elements, making storing visual-element information in the working memory unnecessary. Only the visual elements of the current operation require extraction for attention guidance.

Sweller (1988) conducted a systematic study on cognitive load and established a theoretical hypothesis. In his opinion, cognitive load refers to the total amount of psychological activity imposed on the individual's cognitive system during a specific working time. On the basis of resource limitation theory and schema theory, he investigated cognitive load from the perspective of resource allocation and discussed CLT systematically. Paas and Van Merriënboer (1994) define multidimensional cognitive load as the load on an individual's cognitive system when performing a specific task.

CLT involves three types of cognitive load (Paas, Tabbers, & Van Gerven, 2003; Sweller, Van Merriënboer, & Paas, 1998; van Merriënboer & Sweller, 2005). First, the interaction between the learner and the learning material generates the intrinsic cognitive load, influenced by how complex the content is, compared to the learner's prior knowledge—particularly how many elements the working memory simultaneously processes. A second type of cognitive load is extraneous cognitive load, which imposed cognitive demands due to improper teaching design cause—for example, if the visual search process must occur in a virtual 3D environment (Plewan & Rinkenauer, 2021). Third, the germane cognitive load results from activities that promote prior knowledge integration as well as schema construction in learners, as when learners must explain how they solve their problems (Wilson, 2015). These three cognitive loads are cumulative, so learning should improve when external loads decrease, and released cognitive abilities can be devoted to associated cognitive loads (Sweller, 2011).

According to some articles, signals and cues also express the attention guidance this article describes, guiding students to focus on the key elements of the course and building the connection among them. That is, inserting signals into the course to bring students' attention to noteworthy knowledge reduces unnecessary processing, by guiding students' attention (Mayer, 2002). Not only sending verbal guidance but also marking specific parts of the graphics attract students' attention, so visual signal delivery involves adding visual guidance, such as arrows, unique colour flashes, pointing gestures or unnecessary grey displays. The study of common features of visual signals by Mayer appears in Table 1.1.

Table 1.1

Common Features of Visual Signalling (Mayer, 2002).

Feature	**Example**
Arrows	Arrows point to the bottom and top of the wing in the animation as the voice says, “how air pressure on the top of the wing compares to that on the bottom of the wing.”
Distinctive colors	In an animation on air flight, the airplane is drawn with black lines but arrows representing airflow are drawn in red(below the wing)

(continue)

Table 1.1 *(continue)*

Feature	**Example**
	and blue (above the wing).
Flashing	A particular component on the system flashes, such as the bottom of the wing.
Pointing gestures	An onscreen agent points to a part of the system, such as the bottom of the wing.
Graying out	When a particular component is being described, it isshown in a “magnifying glass” and the rest of the picture is grayed out.

According to CLT, guiding students’ attention reduces the number of visual searches and the resulting additional load, leaving more resources for key learning (Chandler & Sweller, 1991; Van Merriënboer & Ayres, 2005). Multimedia research usually operates attention guidance by inserting additional graphic elements that make certain parts of the presentation more prominent. This type of guidance is explicit visual guidance; it adds additional, clearly visible symbolic information layers (Glaser & Schwan, 2020). This study added attention guidance to the virtual reality experiments and selected the yellow 3D arrows as the attention guidance.

Above all, the theoretical framework combines these theories via models with documents, as Figure 1.1 shows.

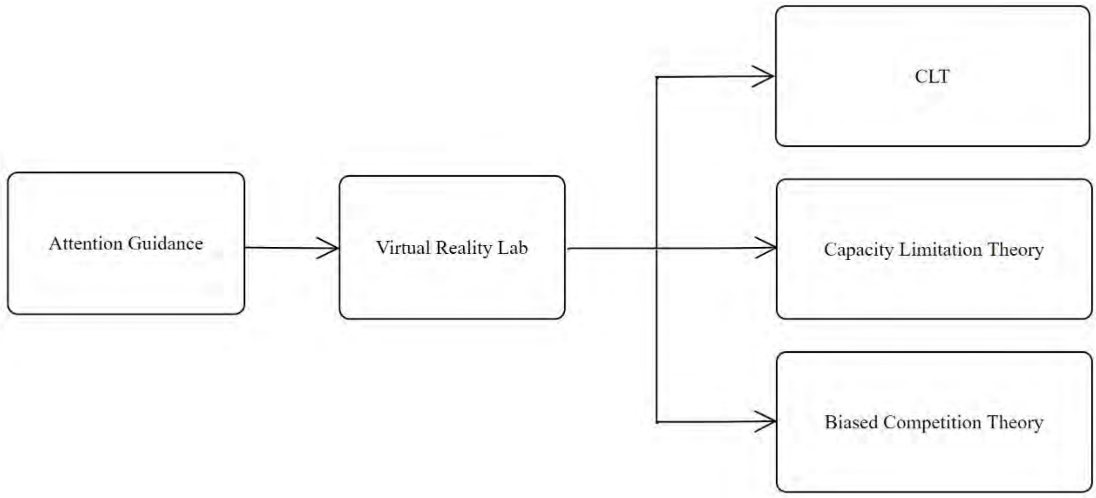

Figure 1.1. Theoretical Framework

During the students' operation of the virtual reality lab, the control group displays the attention guidance on the target, while the experimental group does not. The measurements of the respective groups reflect the impact of attention guidance on cognitive load and learning effects.

1.6 Research Objectives

In a word, on the basis of the discussion, the feasibility of the virtual reality lab course of digital camera is explored, at the same time, the course is designed according to the theory of multimedia design, and the influence of attention guidance on students' cognitive load is analyzed.

Development:

1. To design and develop a virtual reality lab for the digital camera course.

2. User Experience (UX) study on the virtual reality lab for the digital camera course developed.

The specific objectives of the study are as follows:

1. To analyze if there is any significant difference between virtual reality lab for digital camera course with and without attention guidance on students' cognitive load.

2. To analyze if there is any significant difference between virtual reality lab for digital camera course with and without attention guidance on students' learning performance.

3. To analyze if there is any significant difference between virtual reality lab for digital camera course with and without attention guidance on students' time consumed in completing the lab.

4. To analyze if there is any significant regression between cognitive load and learning performance.

5. To analyze if there is any significant regression between cognitive load and time consumed in completing virtual reality lab.

1.7 Research Questions

The specific research questions derived for the study are as follows:

1. Is there any significant difference between virtual reality lab for digital camera course with and without attention guidance on students' cognitive load?

2. Is there any significant difference between virtual reality lab for digital camera course with and without attention guidance on students' learning performance?

3. Is there any significant difference between virtual reality lab for digital camera course with and without attention guidance on students' time consumed in completing the lab?

4. Is there any significant regression between cognitive load and learning performance?

5. Is there any significant regression between cognitive load and time consumed in completing virtual reality lab?

1.8 Hypothesis

The research hypotheses predicted are as follows:

H1. There is significant difference between virtual reality lab for digital camera course with and without attention guidance on students' cognitive load.

H2. There is significant difference between virtual reality lab for digital camera course with and without attention guidance on students' learning performance.

H3. There is significant difference between virtual reality lab for digital camera course with and without attention guidance on students' time consumed in completing the lab.

H4. There is significant regression between cognitive load and learning performance.

H5. There is significant regression between cognitive load and time consumed in completing virtual reality lab.

1.9 Limitations

This research was limited to a few areas, mainly the respondents, the content of the study and the device used.

1.9.1 The respondent

In this research, Chinese college students are made subjects, and their major isDigital Media Art. The research only focuses on the college-level students in China, aged from 19 to 25, generally excluding any nationality.

1.9.2 The content

The digital camera virtual reality lab is only available to the students in Digital Media Arts in the fourth semester, and these students have completed the basic theory in digital camera course. Through virtual reality experiment courses, students can improve their abilities of operation and learn lens scheduling, light scheduling, actor scheduling and other basic practical operations. It is a very important experimental course for students majoring in Digital Media Art. In previous digital camera experimental courses, students are asked to do operations in the studio. While with the virtual reality lab, students are allowed to complete their experiments in the virtual environment of the computer.

Only visual guidance is studied when attention guidance is added to the design of virtual reality lab, and the audio guidance is not studied.

According to the cognitive load measurement model, cognitive load can be assessed by measuring mental load, mental effort, and performance. In this study, students' cognitive load is measured only by subjective assessment and performance measurement, excluding physiological measurement.

1.9.3 The Device Used

The equipment used in the quasi-experimental study will only be virtual reality laptops, as the labs at the research sites are easy to get.

1.9.4 The System and Software Used

The operating system for the equipment will only be Windows 10, and the virtual reality lab will be designed using Unity, 3DMax, and Adobe Photoshop.

1.10 Operational Definition

1. Virtual reality lab

Virtual reality lab, which is set up on the basis of advanced technologies such as web, virtual reality, etc. is an open and internet-based virtual experiment teaching system.

2. Digital camera course

In China, digital camera is a core course for the students who major in digital media technology, digital media art, animation, photography, broadcast, film and television program production, etc.

3. Cognitive Load Theory (CLT)

According to cognitive load theory（CLT）, humans are able to cope with complex problems effectively and get knowledge and skills of a higher degree due to the limitations of working memory while learning new tasks and its ability to work with infinite long memory for achieving familiar tasks (Paas & Ayres, 2014).

4. Attention guidance

In multimedia learning, attention guidance is divided into two parts, i.e. visual attention guidance and auditory attention guidance. Visual attention guidance include arrows, colors, spotlights and gestures, etc.

5. UEQ (User Experience Questionnaire)

UEQ, which is a questionnaireto measure the user experienceof interactive products.

6. NASA-TLX

NASA-TLXis a sensitive and validated measuring tool used to quantify the subjective workload during or after a mission.

1.11 Summary

With technology, virtual reality makes something that exists objectively or is abstract in a virtual environment, and people may feel as if they were there. Virtual reality technology can help us to build a realistic experimental teaching environment and provide an innovative and integrated interdisciplinary practical teaching system, professional learning and innovative design. In recent years, with the progress of technology, education has widely used virtual reality labs with good teaching results. Various factors in practical teaching will influence the digital camera experimental course in the digital media major, but solving these problems can occur in the virtual reality lab. Therefore, the focus of this study was to design digital camera experimental courses in a virtual reality environment, to which attention guidance would be added. Finally, the teaching effect was evaluated with CLT, by testing the students'learning effect. The results of this study set up a new teaching research direction for digital media art teaching; at the same time, it also provided a useful guide for the teaching design of a virtual reality lab course.