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A Framework for the Design of Effective Learning Environments in the AI Era: Egyptian Students' Preferences from Humanities versus Engineering Disciplines

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Virtual Reality vs. Physical Classroom; Design of Learning Environments; Humanities vs. Engineering Disciplines Preferences; Learning styles; Design for Students' human-wellbeing

Abstract: The AI revolution has increased interest in the use of digital technologies and virtual reality learning environments (VRLEs) regardless of students' discipline and the design of these environments. This study investigates students' preferences from Humanities vs. Engineering disciplines towards diverse learning environments (LEs) and their design to enforce the design of effective LEs that promote the productivity and wellbeing for different disciplines. The research proposes a framework that integrates AI-driven technology-enhanced learning, learning and discipline-specific theories, in addition to architecture design for human-wellbeing theories to design effective learning environments based on interdisciplinary research. The methodology followed a cross-sectional, quantitative, non-experimental research design with 141 undergraduates from two private universities in Egypt. Results revealed that students of both disciplines preferred Physical classrooms. Following, Engineering students preferred Mixed LEs, but Humanities students preferred VRLEs over Online Learning. Furthermore, students from both disciplines rated "lighting" as the most important architectural design element in a physical and VR LEs, to enhance their focus and feeling comfortable, however, the ratings for the other two design elements differed between students of the two disciplines. Future research can make use of the proposed framework with larger samples. It is recommended to customize the design of LEs to adapt to students' different disciplines, learning styles and customize design elements that enhance students' wellbeing and productivity LEs. Using the proposed framework helps create well-designed LEs is recommended to promote quality education, green built-environments, and boost learners' overall well-being achieving the SDGs numbers 3, 4 and 11.

1. Introduction

Virtual Learning (VL) has made great strides in the previous decade, both domestically and internationally especially after the outbreak of Coronavirus. Researchers have been eagerly prompted to compare the effectiveness of the physical vs. the virtual classroom in various educational settings and across different disciplines in humanities, science and engineering (Chang et al., 2021). Immersive visual technology or Virtual reality (VR) is an exceptional computerized

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technology with unique features that allow several users to interact in a three-dimensional 3D "computer-made environment", simulating a real-world (RW) or an imaginary situation. Users interact using a set of devices other than the keyboard and mouse. They can use a body costume with sensors or a helmet with eye-sized screens that permit a change of view whenever it moves. Ever since VR has proved successful in-flight simulations, there has been a growing interest in examining the potential benefits of VR (Suryawinata and Mariana, 2022) and (Inoue, 2012).

VRLEs can provide users with simulated real-life circumstances that cannot be provided in regular FTF education (Ashley et al., 2020); (Pedram et al., 2020). Currently, some studies have shown the benefits of VR in green education, green architecture, and their integration in SMART cities using the Internet of Things (IoT) to fulfill the SDGs of "quality education", "sustainable cities and communities", and "good health and wellbeing". VR can save the environment and its resources by achieving the goals of COP27. It allows student users of different disciplines to experience being present in other places, seeing and avoiding RW hazards without being subjected to them, and seeing things in their true size. Architecture students can accurately study, edit details, and conduct virtual experiments with minimum costs (Suryawinata & Mariana, 2022). In learning languages, VR can enhance learning and ensure that foreign or second language learners or others, especially disabled people, are engaged (Hu, 2021).

The benefits of using VR and metaverse technology into architectural education were underscored in an article by (Cininta et al. (2024). The author explained that this technological development can greatly enhance the educational environment and process through making immersive learning environments such as the metaverse that minimizes students' tension and anxiety. This was according to quantitative data gathered through a User Experience questionnaire and qualitative structured interviews conducted. To create more innovative, effective learning environments, the study presented virtual space design standards, and encouraged greater ICT proficiency among adults and children and demonstrated how technology can revolutionise architectural education and support SDG #4.

Further, the architectural design of any environment (real or simulated such as VRLE) has a vital role in its impact on its users. In a simulated VRLE, such as a jungle, students are usually challenged to become active learners who see, feel, and touch things, and interact with others although this is an artificially simulated learning environment (LE) (Determan et al., 2019). This environment arouses students' creativity and cognitive abilities and reduces stress. Neuroarchitecture and cognitive emotional design theories stress that any built environment, whether indoor or outdoor, can positively influence individuals' well-being, emotions, mental abilities, motivation, and learning when designed in a successful multisensory way (Cininta et al., 2024; Moneim, 2005; Assem et al., 2023; de Paiva, 2018, Assem et al., 2020). Thus, research is ongoing to develop effective architecture designs for LEs that develop learners' skills, enhance the quality of their education and their wellbeing (Determan et al., 2019; Fink, 2021; Inoue, 2012; LAN, Sheng, Hsu, & Shiue, 2019; Moneim, 2005; Suryawinata & Mariana, 2022).

Building up on all the above, the research problem is represented in the fact that disciplines in higher education are an independent variable that "demarcates knowledge and academic identities" (Lau & Gardner, 2018). Choosing a specific discipline is based on individuals' preferred practices that they would like to pursue for their career. Little research has examined the disciplinary specificity within the area of learning styles, learning environments and their architecture design (Molineiro et al., 2022; Ezzat et al., 2021). Although artificial intelligence (AI) is being incorporated into higher education at a rapid pace, little is known about how students from different academic fields, specifically engineering and humanities, differ in how they use AI-driven learning tools, the kind of learning environments they would prefer (from physical to Fully VR), and how they would prefer the design of their learning environments to help them stay attentive (Morsi and Assem, 2021). Furthermore, established educational frameworks like Kolb's Experiential Learning Theory and Biglan's Typology of Discipline Classifications, which take individual learning styles and disciplinary learning characteristics into account, are rarely merged with architectural design theories like Neuroarchitecture and Cognitive Emotional Design, which study the impact of design on users, when analysing students' preferences (Molineiro et al, 2022). This disparity makes it more difficult to create effective, comprehensive, productive learning environments that meet the various needs of students from all disciplines (Abdous, 2024) and (Hill et al., 2016). Proposing a framework that guides teachers and designers to create effective learning environments through customizing pedagogical systems, LEs and their architecture design leads to achieving the SDGs: (3) good health and wellbeing; (4) quality education and (11) sustainable cities and communities from the sustainable development goals.

The aim of this interdisciplinary research work of technology-empowered digital learning and architectural design for human-wellbeing is to design effective AI-driven learning environments that foster students' wellbeing among students of different disciplines. This can be achieved through creating a framework that merges between AI -driven LEs types, learning theories, architectural design for wellbeing theories. To investigate and compare the use of AI-driven learning activities, preferred learning environments modalities (ranging from physical to fully virtual), and architectural design preferences of learning environments among higher education students from humanities vs. engineering.

2. Literature Review: Theoretical Framework

2.1 Kolb's experiential theory

This paper is based on five theories: Kolb's experiential learning theory (1986), Biglan's Typology of Discipline Classifications, Cognitivism Theory, The Cognitive Emotional Design Theory and Neuroarchitecture Theory. According to Kolb's experiential theory, learning explains as a cyclical process involving four stages: concrete experience (engaging in a new experience), reflective observation (reflecting on the experience), abstract conceptualization (developing new ideas or editing existing ones) and active experimentation (applying new ideas leading to other new ones). Kolb also proposed four learning styles, depending on individual preferences for the stages above; these styles are called: Diverging (prefers concrete experience and reflective observation), assimilating (prefers reflective observation and abstract conceptualization), converging (abstract conceptualization and active experimentation) and accommodating (active experimentation and concrete experience). It is proposed that Humanities students may prefer "diverging" (creative, reflective) or "assimilating" (theoretical, analytical) approaches, whereas engineering students may prefer "converging" (problem-solving, practical application) or "accommodating" (hands-on, action-oriented) styles based on Kolb's theory. During interactive activities, students transform knowledge into actual experiences and accommodate Kolb's proposed learning styles to complete assigned tasks: doing vs. watching; thinking vs feeling (Konak, Clark, & Nasereddin, 2014).

Adaptive competency, career choice, education specialization and personality type and diverse learning environments are other aspects that influence individuals' learning styles (Kolb, 1986). This theory has been investigated in physical and virtual LEs and across different disciplines. For instance, in learning languages or literature, it was found that students are mostly reflective observers who tend to carefully observe and analyse information before drawing conclusions (Reichard and Mokhtari, 2003). Students who study biology, architecture, or vocational programs always prefer concrete and hands-on experience. They are more interested in activities that involve practical applications. Some of these students are active experimenters who enjoy laboratory work and applying theoretical concepts to situations. Other students who study Mathematics, Computer Science or Philosophy usually have a high tendency towards abstract conceptualization which requires thinking and logical reasoning using abstract ideas and theories (Reichard and Mokhtari, 2003), (Hu and Chen, 2021).

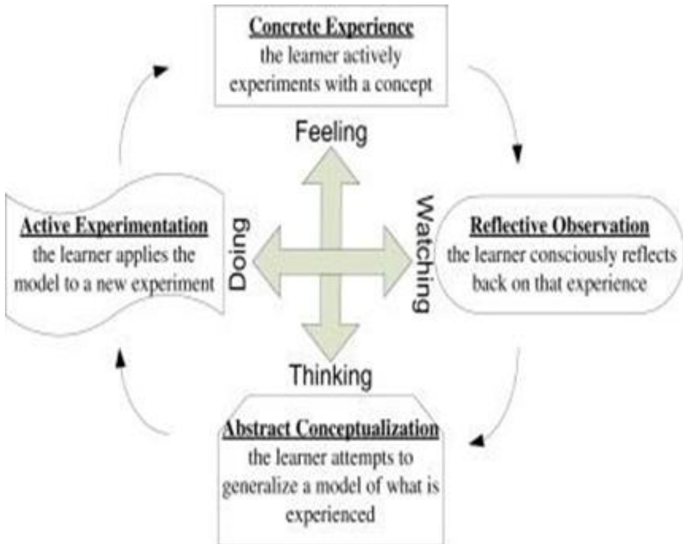

Figure1. Kolb's Experiential Theory [Konak et al., 2014]

2.2 Biglan's Typology of Discipline Classifications Framework

Analysis of disciplinary classification schemes has mainly focused on looking into different disciplines based on cognitive or social perspectives (Biglan, 1973), but the cognitive perspective is the principal disciplinary classification scheme that most studies tend to rely on, particularly Biglan's typology that classified disciplines into "hard vs. soft" or "pure vs. applied". Biglan's typology of distinguishing disciplines has received empirical validation (Alisen, 2008 as cited in Swarat et al., 2017). "Hard-applied" disciplines such as engineering and architecture are characterized as "concerned with mastery of the physical environment and geared towards products and techniques," whereas "soft applied" disciplines (e.g., education) care about "the enhancement of professional practice and aiming to yield protocols and procedures". On the other hand, the disciplines classified as "hard pure" adopt an atomistic perspective and rely on concrete facts, linear reasoning and abstract concepts, such as physics. On the other hand, "soft pure" disciplines such as humanities tend to embrace a holistic approach which emphasises a wider range of intellectual ideas, critical and creative thinking and effective expression forms of communication (Swarat et al., 2017).

2.3 Cognitivism Theory

Cognitivism is a learning theory proposed by Jean Piaget that is centered on individual's mental processes involved in learning; attention, memory and problem solving. The principles of cognitivism theory can be used in creating learning experiences which engage learners in active, valuable activities. Online discussions and collaborative projects are examples of such activities which enable students to build up knowledge and get involved in valuable social interactions and problem-solving activities. The theory calls for analyzing students' cognitive strategies—such as how they pay attention to, encode, and retrieve information—is made easier by cognitivism. While engineering students may concentrate on methodical problem-solving and formula application, humanities students may employ elaboration and critical analysis. It has been argued that cognitivism theory is focused only on individual learning processes which may disregard the social and cultural aspects of students' learning (Yilmaz, 2011).

2.4 Neuroarchitecture and Cognitive Emotional Design Theory

To improve the architecture design of environments, cognitive emotional design refers to the importance of embedding emotional and cognitive components in the creation of learning environments, resources, or systems. It is based on the knowledge that emotions have an obvious effect on motivation, attention, memory, and problem-solving. In addition, design elements, such as color and layout can either improve or harm the learning process (Higuera-Trujillo et al., 2021), (Arndt, 2012). Similarly, Neuroarchitecture is an interdisciplinary field. In order to create surroundings that have a favorable impact on human physiology (biological bodily systems), psychology (emotions and behavior) and cognition (cognitive functions), the interdisciplinary discipline of neuroarchitecture integrates neuroscience, psychology, and architecture. Physical surroundings have been found to have an impact on memory, attention, and general cognitive function. Light, color, acoustics, and spatial arrangement are all important aspects of how well people learn (Ezzat et al., 2021). It was observed that neuroarchitectural design concepts that call for natural lighting and ergonomic layouts in classrooms help students concentrate and feel less stressed (Assem et al., 2023) (de Pavia, 2018). The significance of designing learning environments that promote efficient learning and improve cognition and cognitive functions is highlighted by the convergence of cognitive emotional design, neuroarchitecture design and cognitivism learning theory in educational settings. Teachers and designers may collaborate to develop the best educational settings that promote attention and concentration, memory, knowledge retention by knowing how the design of the learning environments affect students physiologically, psychologically , behaviorally and influence their overall wellbeing.

2.5 Learning Environment Types and Learning Models

Over the past two decades, online learning (OL) has advanced significantly, with current 3D VRLE innovations introduced new levels. The following learning models: rotating, flex, enhanced virtual, and completely virtual models are now being used in education. It is argued that immersive 3D virtual technologies offer better learning engagement and skill training compared to traditional online 2D different learning models. In the rotational model, for instance, students follow a fixed timetable on campus, participate in group work and minimally use OL activities. In the flex model, the course content is mainly delivered online through computers that are available for almost every student on campus; sometimes certified teachers can meet learners (FTF) to supplement OL of certain subjects (Mansor & Ismail, 2012). The difference between the enriched virtual model and fully VL model is that the first allows students to complete their task online remotely; they seldom meet their teachers FTF – unlike the flipped classroom; many such programs started as fully-online schools but then had to shift to blended learning (Kustandi, Fadhillah, Situmorang, Prawiladilaga, & Hartati, 2020). Computer-generated scenes projected onto stereo high-tech screens and room-scale are the hallmark of IVR technology, with projected pictures constantly updating dependent on the user's location and perspective (Suryawinata & Mariana, 2022). The non-immersive VR uses devices like 3D keyboards, mouse, and desktop VR systems similar to those used in video games (Alahmadi & Muslim Alraddadi, 2020). Occasionally, hard simulators are used in IVR for a fully or partial immersive virtual experience (Schiavi, Havard, Beddiar, & Baudry, 2022). Figure 3 & 4 shows how different VRLEs relate to different learning models which can improve student engagement and retention (Vergara, Rubio, & Lorenzo, 2017).

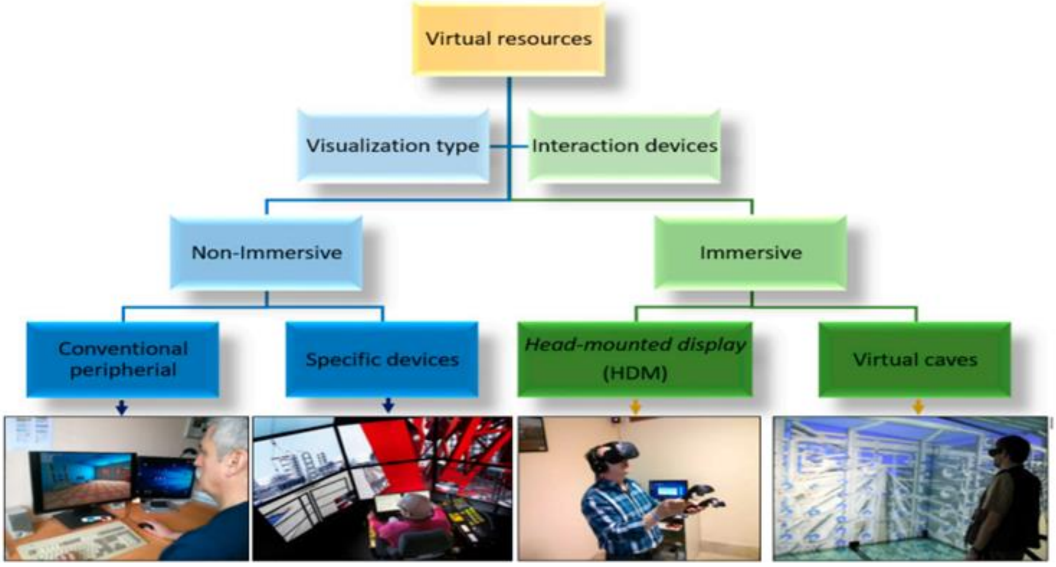

Fig2. Classification of VRLE [Vergara et al., 2017]

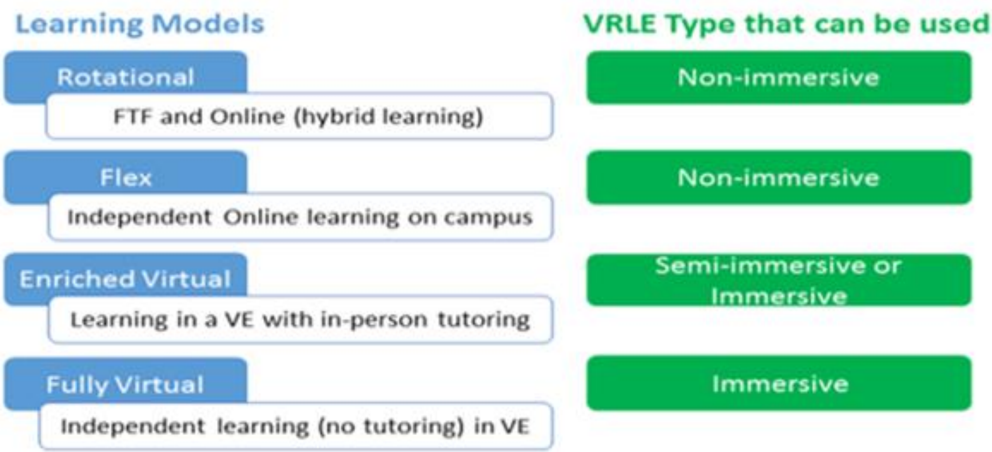

Fig 3. Link between Learning model and the related VRLE types [Authors, 2024]

2.6 Learning Activities

Different types of learning activities can be used in the different educational environments. Physical activities in classrooms involve hands-on activities or experiments. Digital/online activities include digital quizzes and e-books or engagement and interaction via platforms, such as Zoom. Semi-virtual activities provide partially virtual experience being completed with presence and connection to the RW in-person; students feel they are in a different reality. Fully Virtual activities are completed fully via the internet using digital devices simulating the RW without the need for connection to surroundings nor human communication (Akram, 2010).

2.6 "Design of Effective Learning Environments" Framework

Based on the literature sections above, the authors propose a framework that links all the theories and/or frameworks presented above and elucidates how they link together after explaining the definition, aim of each one, how the concept can be used or applied in learning environments, their architecture design and its application or use when applied to different academic disciplines (Humanities vs Engineering), see Table 0. The generated framework helps in understanding students' disciplinary specificity, their classification with regards to learning theories, their learning styles, preferred type of LEs, learning activities and their architectural design priorities and preferences to achieve human wellbeing in learning environments; this is based on linking different literature theories.

2.7 Students' Perceptions of Learning Environments: Engineering vs. Humanities Disciplines

Various methods and software tools are now being developed in VL to improve education through VWs, games, and simulations (Suryawinata & Mariana, 2022). The cognitive and emotional impact of these tools have been investigated in some studies (Liu et al., 2024). Mansor & Ismail (2012) analyzed 136 engineering students' perspectives on VLEs and how they preferred to learn. Students from different disciplines had generally favorable impressions of online education, but no connections were found between learning styles and those impressions in the data. Students may act as architects and take customers on a virtual tour of their work to simulate an RW design process. This method excels over computer-generated (CG) animations because it does not force users to follow a certain route while exploring the design, thus it improved students' spatial abilities (Hussain Al-Qahtani, 2019). In addition, it allows for simple design adjustments (Vergara, Rubio, & Lorenzo, 2017).

Seifan, Robertson, & Berenjian (2020) looked into how chemistry is taught and learned in virtual and physical labs for third-year engineering students. The use of VR technology allowed for more cost-effective, time-efficient, and engaging learning experiences for students and the opportunity to investigate previously inaccessible phenomena. These benefits align with those of green development, green education, green architecture, and SMART cities. Notably, 90% of students saw VR models and virtual laboratories in science majors vital for efficiently and securely doing "hands-on experiments," illustrating the significance of VR in hands-on learning.

Thus, aligning with cognitivism theory, recent research has shown that AI educational technologies can provide cognitive, emotional support to enhance students' performance, cognitive development, reduce fatigue and improve their emotional learning experience. Alahamdi & Alraddadi (2020) looked at how OL is used by elementary and intermediate university students in Saudi Arabia to acquire L2 (second language). Students' L2 learning was found to be greatly facilitated by instruction in full virtual courses, which provided many possibilities for engagement and conversation. Several students noted feeling less nervous in the online forum. In an Iranian EFL context, OL was well-received when used to teach English to speakers of other languages and provide valuable opportunities for EFL teachers (Fallah et. al., 2024). Despite the need for IT training to handle technical challenges in private and public schools, students and teachers had good impressions of using multimedia technologies in OLEs (Derakhshan & Shakki, 2024).

In second-language education, AI has been used in the past two decades for language tutoring systems. The use of voice functions, robots, and applications for improving translation skills has become a common part of AI integration in teaching and learning foreign languages using AI and

Chat GPT has proved to support both teachers and students' effective development (Andujar & Spratt, 2023). Exploring the design features of 3D (VRLEs) artificial setting showed significant signs of students' motivation and engagement. (Kösa & Karakuş, 2018). For instance, interactivity, immersion, simplicity of use, and efficacy were identified as crucial characteristics of VREs in a poll of 200 engineering students (Vergara, Rubio, & Lorenzo, 2017). By helping them add value and exceed customer expectations while reducing costs, risks, and turnaround times; VRE supported engineering students in meeting industry standards. To conclude, employing VR in education was highly recommended for educators in teaching and giving feedback as it showed significant improvements on students' language and communication skills, and cognitive knowledge (Lin & Lan, 2015; Chen, Chang & Kuo, 2016).

2.8 Significance of the Study

Research is ongoing to investigate students' perceptions of VRLEs and their design. Limited studies have examined how students' prior knowledge/disciplines and individual characteristics/skills impact their preferences for the different learning environments including PE, OLE and VRLEs. Therefore, it is crucial to investigate whether generation Z -who are familiar with using technology (Alahmadi & Muslim Alraddadi, 2020; Ummihusna & Zairul, 2022) - from different disciplines have the same preferences for LEs. The research investigates the interrelationship between LEs' types or modalities, learning activities, learning styles, the influence architectural design in learning environments and prioritizing students' well-being through exploring preferences of students from disciplinary differences. This is to enhance LEs, teaching strategies, engagement, motivation, cognitive abilities, and psychological responses because poor environmental stimulation causes negative impacts on students (Assem et al., 2023; Fajardo, Higuera-Trujillo, & Llinares, 2023; Makransky, Terkildsen, & Mayer, 2019).

2.9 Research Questions

Accordingly, the research questions are as follows:

1. Are there significant differences between students of humanities versus engineering disciplines in their preferences towards the learning environments (LEs) namely: full VR using avatars, semi-VEs, and OL vs. the physical environment?
2. Do students of different theoretical and practical disciplines (humanities vs. engineering) share the same preferences towards different learning activities (regardless of the learning environment)? Which type of activities do students of humanities vs. engineering prefer, and which learning mode (individual or group work?
3. Do students of different disciplines (humanities vs. engineering) share the same preferences towards the "important architecture design elements" for them to be productive, comfortable and attentive in an effective learning environment (physical classroom/virtual classroom)?

2.10 Hypotheses

For Q1, statistically significant differences are expected between the two groups regarding their "preference for each LE" because of their different disciplines, individual learning styles and educational background.

For Q2, significant differences are expected between the two groups regarding their "preference for learning activities" are expected.

For Q3, significant differences are expected between the two groups regarding their "important design elements in a comfortable classroom" in physical vs. VLE.

Table 0. A Framework linking Learning Theories, Types of Learning Environments, Learning Activities and Architecture Design theories for Designing for Students Wellbeing [Authors, 2024, after the authors stated in the literature]

Framework/ Theory	Definition	Aim	Application to Learning Environments (physical/ virtual)	Use for different disciplines: Humanities Vs. Engineering
Biglan's Typology	A classification of the different academic disciplines	Classifies disciplines into: "hard/soft" and "pure/applied" dimensions	Dictates the requirements/setting of the environment: traditional classroom, lecture halls, labs, studios, seminar rooms	Engineering: Hard-Applied; Humanities: Soft-Pure
Kolb's Experiential Theory	Experiential theory that defines learning as in a cyclic model	States that learning integrates concrete experience, reflective observation, conceptualization, and experimentation	Ensure that the learning environment supports all stages of Kolb's cyclical model	Engineering including architecture are more active/experiential learners and Humanities are more reflective/conceptual learners
Cognitivism	Learning theory that highlights internal mental processes	Focuses on mental processes, such as: attention, memory, and information processing	Encourages creating environments that decrease cognitive fatigue, support attention, concentration and memory.	Environments should cater for students' cognitive strategies. Engineering students may use methodical problem-solving and formula applications, humanities students may use elaboration and critical analysis
Cognitive Emotional Design	Design approach that considers how the design of environments arouses and governs emotional regulation and cognitive processes	Designing environments that cater for positive emotions and effective cognitive processes	Use different design elements such as colors, lighting, spatial layout, and sensory stimuli to positively impact mood, attention, concentration, and productivity in physical/virtual environments	Emotional and cognitive needs may vary across different disciplines as students may be differently affected by design.
Neuroarchi-tecture	Studies on how the architecture design of environments impacts the body, brain, cognitive functions, emotions and even behavior	Understanding how the physical/virtual environment affects the brain, cognition, body, emotions, and behavior	Using the different design elements and multisensory design to evaluate and ensure a positive human experience and design influence on users based on all stages of the neuroarchitecture model	Analyze how space design and the design elements affect (supports or hinders) students from different disciplines physiologically, psychologically, and cognitively.
Types of Learning Environments in the era of AI	Different types of learning environments and learning modalities	Includes: Physical, online, semi virtual, virtual, mix between physical and virtual	Each type of learning environment provides different affordances and learning experience	Discover discipline-specific preferences for LE and why. Students' preferences may differ.
Learning Activities	The tools and techniques that can be used in the different learning environments and modalities	Includes: physical activities, digital (online) activities, semi-virtual, fully virtual	Integrating suitable activities in designing educational spaces of physical/virtual environments	Discover discipline-specific preferences for activities and why. Students from different disciplines may have different preferences.

3. Research Methodology

This study follows a cross-sectional, non-experimental, quantitative research method to compare the preferences of students from different disciplines. Data was collected through a structured online questionnaire distributed to 141 randomly selected undergraduate students from two private universities in Egypt. The questionnaire was sent to all students of the two different disciplines through their university email during their academic semester, so every student had the opportunity to participate in the study if they fulfilled the criteria for selection: 1) undergraduate student, 2)studies Humanities- or Engineering discipline, and 3) familiar with and experienced all types of VRLEs before. The two universities were selected from a list of private Egyptian universities in Cairo because 1) they applied different types of VLEs in addition to PE with undergraduate students, 2) had faculties for the two different disciplines targeted in this study, 3) had a large number of undergraduates compared to other private universities, 4) allowed the researchers to contact the students by email. To compare between the preferences for the design of effective learning environments for different disciplines, students were chosen from two distinct disciplines who were categorized following the most widely used typology devised by Biglan as: "hard vs. soft; "pure vs. applied". Engineering and Architectural Engineering are classified as "hard and applied" discipline, while humanities is classified as "soft and pure" (Hu, et al., 2021). Additionally, the study followed the classification of the two disciplines according to Kolb's theory as follows: humanities students prefer "diverging" (creative, reflective) or "assimilating" (theoretical, analytical) approaches, whereas engineering including architecture students prefer "converging" (problem-solving, practical application) or "accommodating" (hands-on, action-oriented) styles. This point was also linked to other investigated points in the discussion of preferences of different disciplines for the design of effective LEs. Eighty-nine students were from the Faculty of Engineering (FOE) and 53 from the Faculty of Arts and Humanities (FOAH). Participants from all majors in the faculty of Engineering contributed to the study. All students signed a consent form. Notebook gifts were distributed to participants to complete the questionnaire.

The questionnaire consisted of four main sections that were formulated based on questions from similar literature studies. The researchers made sure that the questions cover all the sub-sections of the literature review, such as: discussing preferences for the different LEs (from physical to FVE), learning activities, and the preferred/important design elements that affect students in LEs in relation to cognitivism, cognitive emotional design and neuroarchitecture. Section one covered the student's demographic data: name, gender, year of study, college, and email. Section two covered the student's university discipline, and the student's secondary (high) school discipline, familiarity, and previous experience with the different types of physical and VLEs, and preferred learning mode. Section three examined the students' preferred learning environments and type of learning activities regardless of their preferred LE. Finally, section four investigated student's preference for the important design elements that create a comfortable physical/virtual learning environment for effective learning. For questions in sections three and four, the students answered MCQ on a 5-point Likert scale ranging from "Not at all preferred/important" to "extremely preferred/important".

Data was then quantitatively analyzed using SPSS. To compare the results between the two groups "humanities" vs. "engineering" disciplines, the Independent T-test and Z-test were conducted after checking the normality, validity, reliability and internal consistency of the study tools through the required statistical tests: the Kolmogorov-Smirnov normality test, Cronbach's Alpha and Pearson Correlation test. The respondents enrolled in the FOE represented (62.4%) and from the FOAH represented (37.6%). Analysis of the sample's responses for the gender variable showed there were 45.5% male, and 54.5% female students enrolled in FOE, whereas 24.5% male and 75.5% female students enrolled in FOAH. It was noticeable that the number of students enrolled in the FOAH is less than that enrolled in the FOE, this is because, culture wise, engineering and science majors are usually favored by families than humanities, specifically in private universities in the Egyptian context which allow a higher opportunity for reserving a place and being accepted.

3.1 Limitations

A larger sample size was expected, but the final number of participants yielded to a much smaller sample size. Concerning disciplines, eleven completed questionnaires were disregarded from the data collected from FOAH students because they were enrolled in science or mathematics tracks in their Egyptian secondary education then enrolled in humanities in higher education. Therefore, the researchers ensured that the 141 participants were students who have chosen their preferred discipline in both their secondary education, whether following the national or international system, and in their university undergraduate majors. Moreover, although the researchers targeted universities that used VLEs, they had to exclude all participants who were not familiar with VLEs or did not try them before participating in the questionnaire. VR devices are a burden on Egyptian universities, specifically public universities, because of their high costs. Due to technical constraints, technological infrastructure limitations of finding semi and fully VRLEs applied in the Egyptian context, as well as the limited timeframe of the study, the researchers couldn't expand the sample size. It is also worth mentioning that students from private universities usually come from the upper middle to upper economic status, so it is recommended that the research is repeated with a wider scope of the community.

4. Results

The following section presents the results of the study.

Results of the questionnaire: This section presents the results of the survey instrument designed to elucidate research questions. Table.1 shows the frequency distribution of the student participants from each discipline (humanities vs. engineering).

Table 1. Frequency distribution of the sample population [Authors, 2024]

Number	Items	Frequency	Percentage
1	Arts and Humanities	53	37.6
2	Engineering/ Computer Science (architecture, electrical, other)	88	62.4
Total		141	100

Table 2. Preferred learning Environment: Frequency distribution for (FOAH / FOE) disciplines [Authors, 2024]

No.	Dimensions	FOAH, n= 53			FOE, n= 88		
		Frequency	%	Rank	Frequency	%	Rank
1	Physical Environment only - attending classes on campus and interacting,	40	75.5	1	57	64.8	1
2	Online learning (audio/video)- interact	3	5.7	4	27	30.7	3
3	Semi-virtual- doing tasks virtually using tools ALONE except for one time interaction with DR for online feedback	5	9.4	3	22	25	4
4	Fully Virtual-like metaverse using your avatar (3D) - go online & learn at any time without your voice or appearance. Avatars are programmed to act like you when u are not online to keep the class going.	5	9.4	3	17	19.3	5
5	Mix between physical and virtual	20	37.7	2	50	56.8	2

The participants rated their preference for five different LEs on a scale from (1) not at all preferred to (5) extremely preferred. Afterwards, a Z-test was performed to show if there are statistically significant differences between the groups of the two disciplines (FOAH) and (FOE) according to their choices of their preferred LEs. By exploring the students' choices for their preferred different LEs, Table 3 showed that the students' preferences towards OLE, SVE and Mixed showed that there were statistically significant differences between the two groups (FOAH and FOE) in each of these three LEs, at (Z) values equal to (4.28, 2.54, 2.25) respectively and P-value less than (0.01). The significant difference was for the benefit of FOE students in all cases. The statistical difference between the two groups was "highly significant" for the choices OLE and SVE, and "significant" for "mix between physical and virtual environments".

Based on Table 3, there were no statistically significant differences between the groups FOAH/FOE with regards to "physical hands-on activities" and "virtual activities using your avatar (like met averse)" where the values of (t) ="0.943" and (t) ="1.263" respectively, at a significance level of more than (0.05).

Table 3. Preferred learning environment types: Z-test results between (FOAH / FOE) disciplines [Authors, 2024]

Dimensions	FOAH			FOE			Z value	p-value	Result
	N 53	%	Rank	N 88	%	Rank			
Physical Environment only - attending classes on campus and interacting,	40	75.5	1	57	64.8	1	1.37	0.17	N.Sig.
Online learning (audio/video)- interact	3	5.7	4	27	30.7	3	4.28	0.01**	H.Sig.
Semi-virtual- doing tasks virtually using tools ALONE except for one-time interaction with DR for online feedback	5	9.4	3	22	25	4	2.54	0.01**	H.Sig.
Fully Virtual-like metaverse using your avatar (3D) - go online & learn at any time without your voice or appearance. Avatars are programmed to act like you when you are not online to keep the class going.	5	9.4	3	17	19.3	5	1.70	0.08	N.Sig.
The mix between physical and virtual	20	37.7	2	50	56.8	2	2.25	0.02*	Sig.

Secondly, students in different disciplines (FOE & FOAH) yielded almost the same findings when they were asked to rate on a scale from (1) not at all preferred to (5) extremely preferred, the way they would like to perform their coursework assignments in their field of study regardless of their chosen LE. Table.4 shows the results and Table 5 explains there were no statistically significant differences between the groups FOAH/FOE with regards to "physical hands-on activities" and "virtual activities using your avatar (like met averse)" where the values of (t)="0.943" and (t) ="1.263" respectively, at a significance level of more than (0.05).

Moreover, in Table.5, there was a highly statistically significant difference between the groups (FOAH /FOE) regarding "digital activities on computer" where the value of (t)="2.847" at a significance level of less than (.01), in favor of the (FOE) group, with a mean of (3.36), compared to a mean of (2.79) for the (FOAH) group.

Table 4. Preferred Learning Activities: Descriptive Statistics [Authors, 2024]

Dimensions	FOAH, n= 53			FOE, n= 88		
	Mean	Std. Dev.	Relative importance%	Mean	Std. Dev.	Relative importance%
1-virtual learning environment using your avatar (like metaverse)	2.28	1.06	45.60	2.55	1.26	51
2-physical hands-on activities	3.72	1.26	74.40	3.90	0.99	78

Dimensions	FOAH, n= 53			FOE, n= 88		
	Mean	**Std. Dev.**	**Relative importance%**	**Mean**	**Std. Dev.**	**Relative importance%**
3-digital activities on computer	2.79	1.02	55.80	3.36	1.22	67.20
Mean Average: Prefer each of these learning activities	**2.93**	**0.72**	**58.62%**	**3.26**	**0.69**	**65.38%**

Table 5. Results of Independent T -test Results between FOE / FOAH for Preference of Learning Activities [Authors, 2024]

Dimensions	FOE N=88		FOAH N=53		t-value	p-value	result
	Mean	**St. dev.**	**Mean**	**St. dev.**			
1- Virtual activities using your avatar (like met averse	2.55	1.26	2.28	1.06	1.263	0.20	N.sig
2-Physical hands-on activities	3.90	0.99	3.72	1.26	0.943	0.34	N.sig
3-Digital activities on computer	3.36	1.22	2.79	1.02	2.847	0.01**	H.sig
Total: prefer each of these learning activities	3.26	0.69	2.93	0.72	2.739	0.01**	H.sig

In Table 6, the general trend of the study sample toward “Individual work vs. group work learning preferences” for the group of FOAH students indicates that the majority of the answers were toward the (neutral), with a mean of (2.83), Std. Deviation (1.15), with Relative importance (56.60%). Similarly, the general trend of the study sample of FOE students indicated (neutral), with a mean of (2.88), Std. Deviation (1.26), with Relative importance (57.50%). Both samples (FOE and FOAH) marked that they liked both options equally (individual work in a quiet space vs. group work in a gathering area).

Table 6. Independent T-test results between groups (FOE / FOAH) according to their Learning Preference (individual vs group work) [Authors, 2024]

Dimension	FOE			FOAH			t-value	p-value	Result
	Mean	**Std**	**Relative importance**	**Mean**	**Std**	**Relative importance**			
Learning preferences (Individual vs. Group work)	2.88	1.26	57.50	2.83	1.15	56.60	0.210	0.83	N.Sig

Further, to discover the effect of the design elements of the different learning environments on student users, the participants were asked to rate on a semantic scale the importance of three design elements for them in a physical classroom environment vs. virtual classroom. The researchers made sure that all the participants were familiar with a virtual classroom environment and experienced different VREs before contributing to the study. Table 7 reveals the results of the Independent T-test between FOAH and FOE students for their response of the importance of the design elements listed for them in a PE. There were highly significant statistical differences between FOAH and FOE with respect to “comfortable space design” (t-value =3.097, p-value = 0.01) and “comfortable colour tones” (t-value=2.643, p-value=0.01) for the benefit of FOE students. Further, there were significant statistical differences between the two groups for “comfortable lighting” with (t-value=2.22 and p-value=0.02).

Table 7. Independent T-test results between groups (FOAH /FOE) for the important design elements to students in the physical classroom) [Authors, 2024].

Design Elements in a physical classroom	FOE n= 88			FOAH n= 53			t-value	p-value	result
	Mean	Std.	Rank	Mean	Std.	Rank			
Comfortable lighting	4.51	0.93	1	4.11	1.17	1	2.224	0.02*	Sig.
Comfortable Space Design	4.20	0.98	2	3.60	1.30	3	3.097	0.01**	H .Sig.
Comfortable colour tones/ temperatures	4.13	0.98	3	3.62	1.25	2	2.643	0.01**	H .Sig.

In addition, the participants were asked to rate on semantic scale the importance of two design elements for them in a virtual classroom. Table 8 reveals the results of the Independent T-test between FOAH and FOE students. There were highly significant statistical differences between FOAH and FOE with respect to "comfortable lighting" (t-value =2.445, p-value = 0.01), "comfortable space design" (t-value =3.505, p-value = 0.01) for the benefit of FOE students. However, there were no significant differences between the two groups for "comfortable colour tones" (t-value=0.631, p-value=0.52).

Table 8. Independent T-test results between (FOAH / FOE) for the important design elements to students in the virtual classroom [Authors, 2024]

Design Elements in a virtual classroom	FOE n= 88			FOAH n= 53			t-value	p-value	result
	Mean	Std.	Rank	Mean	Std.	Rank			
Comfortable lighting	4.72	64.	1	4.40	0.90	1	2.445	0.01**	H .Sig.
Comfortable Space Design	4.40	0.79	2	3.83	1.12	3	3.505	0.01**	H .Sig.
Comfortable colour tones/ temperatures: warm colors like red, or cold colors like blue	4.14	0.97	3	4.02	1.21	2	0.631	0.52	N .Sig.

5. Discussion

5.1 Discussion of RQ1

FOE, Physical and Mixed E: These results revealed in Table.2 corroborate earlier studies that found FOE students who are classified as "hard and applied" discipline (Hu, et al., 2021) usually prefer non-virtual settings or those that combine both physical and (online or VE-based components), (Makransky et al., 2019). The necessity of FTF interaction for feedback and conversations and the hands-on nature of their projects may account for this inclination. That is because OL through a computer screen only deprives them of FTF interaction and does not mimic the RW sensory environment, which is important in science disciplines.

OLE: Similar dissatisfaction with online education was documented by Al-Salman & Haider in 2021, who looked at university students in Jordan. They found that students enrolled in scientific hard disciplines were less satisfied with online education than their soft humanities counterparts. **VRLEs:** In a study, students in VRLEs in architecture and engineering valued interactive activities (Schiavi et al., 2022; Vergara et al., 2017) and the advantages of VREs for drawing and feedback because of its simplicity and adaptability. However, they also recognized the necessity of hands-on engagement and applying knowledge in RW situations through interaction (Seifan et al., 2020). The degree of interactivity and realism in a VR encounter was considered a secondary consideration (Vergara et al., 2017). Further, recent research emphasised the beneficial effects of VR environments on architectural students' projects praising the adaptability and simplicity of VRLEs (Schiavi et al., 2022).

FOAH, PE and Mixed E- Students of FOAH likewise overwhelmingly preferred the PE (75.5%), followed by a Mixed (37.7%). While OLE received the fewest votes (5.7%), FVE and SVE tied for third place (9.4%). FOAH are the representatives of the “soft pure” discipline; according to soft-pure discipline students most likely prefer the individual mode of study; most of them work independently to enhance their language abilities through reading, analysis and writing creatively and writing reflections as assignments of different course subjects (Lau & Gardener, 2019; Williamson, n.d.). Students usually enroll in language centers to improve their skills (Obeidat & Al-Share, 2012), and this choice may derive from the belief that language acquisition involves student and instructor communication to achieve fluency through speaking practices, but they understand gaining vocabulary and improving fluency requires working independently and individually. **VRLEs**- Previous studies highlighted the potential advantages of VR, emphasizing the motivating component and the utilization of simulated gaming settings for immersive language practice; therefore, our findings align with those findings in (Holden & Sykes, 2011).

The VRE is less frightening than RW interactions, which is why it came in third place for FOAH students; hence, it helps reduce "foreign language anxiety" and negative emotional responses in language learners (Thrasher, 2022). VR technologies, such as Google Cardboard, have been demonstrated to boost confidence among EFL students and decrease nervousness among Chinese students giving oral presentations. Another study found that VRE facilitates vocabulary acquisition, speaking, writing, and listening, as well as cultural competence which language learners need to improve individually and the VRE allows for this for soft pure disciplines whose assessments are mostly essay writing, critical reflection, oral presentations of covered concepts. Even instructors revealed a positive experience of using VR in teaching languages. Taiwanese students who performed authentic listening in an immersive VE were able to activate their prior knowledge and make adequate inferences. Learners’ presence in VR “brought learner involvement from the fringe to the center, prevented cognitive overload, reduced anxiety and thus aided comprehension” (Yillmaz, 2011; Hua & Wang, 2023). That is why FOAH students chose VRE before the OLE. **OLE-** Although the OLE were the least preferred by humanities, Foreign Language Programs in higher education are usually supported by ebooks and interactive activities on eLearning for enhancing learners’ individual work (Morsi & Seoud, 2022; Morsi, 2023). In Morsi & Elseoud (2022), students perceived online discussion forums on eLearning as an effective tool that allows them enough time to express their viewpoints after checking their sources and editing their posts. Similarly, in Morsi (2023), students appreciated the use of ebooks for independent learning of academic EFL by reading texts, watching tutorials on essay genres and structures, doing interactive quizzes and receiving instant feedback with illustrations that can help them improve their reading and writing. That is why FOAH students are interested in OL, FVE and SVE online interactive activities that usually help them study at their speed without interruptions besides the FTF in-person instruction (Obeidat & Al-Share, 2012).

Moreover, a student's choice for physical or mixed LEs may also be influenced by their background in conventional classroom settings (Mansor & Ismail, 2012). For instance, during the pandemic, dental students perceived their OL experience as effective, timesaving and some reported feeling less shy to speak their opinion online via ZOOM compared to the physical classroom. However, they reported their preference for the “convenience and fairness” of the physical classroom examinations compared to the online one (Chang, Wang, Cheng & Chiang, 2021). This confirms that students from hard disciplines appreciate life experience and collaborative work. Another explanation for FOAH preference could be that they appreciate FTF interaction that they were used to during school years and university years before the pandemic.

5.1.2 Discussion of Significant Differences

The results of the Z-test in Table.3 confirm previous findings that students in soft pure discipline prefer online activities which prompts individual independent learning whereas students enrolled in hard applied disciplines tend to prefer activities that simulate life experience and collaborative work with team members and seniors to gain professional experience needed for their career; that is why, they tend to be interested in semi-virtual environments. To clarify the comparison, Table 2 and 3 also show the percentage of students who chose each LE in each discipline. It clarifies that a significantly higher percentage of FOE students voted for the stated choices than the percentage of FOAH students. Thus, the hypothesis of RQ1 was confirmed for the Mixed, OLE and SVEs but rejected for the rest of the environments.

5.2 Discussion of RQ2

In reply to hypothesis of RQ2, Table.4 indicates that the preference ranking of both disciplines engineering “hard-applied” and humanities “soft-pure” was almost equal regarding the options of “physical hands-on activities” followed by "virtual learning activities using your avatar (like metaverse)" which came in the least place for FOE and FOAH students’ preferences. An interpretation for the latter result is that most students have rarely had the opportunity to experience much simulation of VLE using their avatar in education in the Egyptian context.

Concerning choices of both FOE and FOAH for digital activities that has come in the 2nd place, there was a statistically significant difference between the groups (FOAH /FOE) regarding "digital activities on computer" where the value of (t) ="2.847" at a significance level of less than (.01), in favor of the (FOE) group, with a mean of (3.36), compared to a mean of (2.79) for the (FOAH) group. This explains that a greater percentage of FOE students ranked digital activities in the third place than the percentage of FOAH students. The preference of FOAH students for digital activities is confirmed in Morsi (2023) and Morsi & Elseoud (2022). Further, Holden & Sykes (2011) confirmed this by highlighting the value of interactive digital activities that increased the academic achievement of secondary school students. Students felt motivated and more engaged in using mobile devices and technological tools to solve problems, finish quizzes, complete their tasks and receive instant feedback besides scores. These activities also facilitate independent learning. Finally, virtual activities using avatars, which came in the least preference, indicated how students in both disciplines “hard-applied” and “soft-pure” are aware that despite the revolution in technology, genuine and effective communication with their instructors while working on tasks with their peers or individually, would only be guaranteed while interacting physically or at least online through conversations on digital platforms like zoom. They can pose whatever questions they have and get responses, whether verbally or through gestures.

For soft-pure discipline, online learning using digital activities is highly beneficial for improving their reading, writing, listening, speaking, and improving their grammar and pronunciation. In addition, the fact that a larger percentage of students of both disciplines did not favor using virtual activities may refer to their eagerness to communicate with others and interact in reality to finish practical tasks that require real fieldwork or laboratories (for FOE) or finish written assignments with tutors' FTF feedback (for FOAH) rather than independently. This applies in specific for "hard applied" disciplines who truly need to gain practical life experience before graduation as they are converging, accommodating learners within Kolb's classification. Costley 2021, for instance, found that collaboration in an online environment where students solve problems and receive prompt feedback is engaging. Interaction in OL environments significantly improved individual learners' cognitive abilities through "germane cognitive load", i.e., greater learning capabilities whether team members in the online groups were active members or were just observers contributing little to group work (Liu et al., 2024; Morsi & Elseoud, 2022; Morsi & Assem, 2021).

Another interpretation for this is the tendency of students to prefer sensory FTF interaction in the RW. They actually indicated a high percentage of "Not at all" for "VR activities using avatars" but not for using "digital computer activities". This was affirmed by Lan (2019), who stressed that multisensory PEs that trigger the senses develop the users' cognition and creativity, and consequently their wellbeing as stated in Neuroarchitecture (de Paiva, 2018; Assem, Khodeir & Fathy, 2023). Thus, they are usually preferred. In Senthil Kumar et al. (2023), the 3D animation helped learners retain information, understand complex concepts by simplifying it in various ways and make learning more interactive as it acts as an efficient, cost-effective medium for communication across cultures and languages. However, results of students' survey and educators in Tamil college in India showed that there was lack of awareness among educators about how to use VR and 3D animation efficiently in education.

Therefore, in reply to the hypothesis of RQ2, Table 3 results indicate that the preference ranking of both disciplines was almost equal regarding the options of "physical hands-on activities" followed by "virtual learning environment using your avatar (like met averse)," which came in the least place for FOE and FOAH students' preferences. On the contrary, Table 4. explains that a greater percentage from students of FOE ranked digital activities in third place than the percentage of students which voted for it from the sample of students in FOAH. Thus, hypothesis RQ2 was rejected because there were no significant differences between the two groups in their preferred learning activities as shown in Table 5.

The similarity between Biglan's typology of disciplines and Kolb's classifications of the experiential learning styles that have been developed based on the extensive research in cognitive development and cognitive style is worth noting in this study. Students in FOE who are enrolled in mechanical engineering, civil engineering, computer science, nuclear engineering and architectural engineering prefer active experimentation, concrete experimentation and abstract conceptualization as these students are interested in making decisions relevant to problem solution would like to be involved in real experiences without any bias (Concrete Experience); engineering students are expected to use theories to make decisions and solve problems (Active Experimentation). They also need to create concepts that integrate their observations logically into acceptable theories (Abstract Conceptualization). On the other hand, students who study foreign languages, English literature, sociology, psychology, and anthropology in FOAH prefer reflective observation (Reflective Observation) and (Concrete Experience). Students in the humanities would like to observe and reflect on their experiences. Students in psychology department are interested in observing and analyzing motivations behind human behavior and link their findings logically to existing theories (Concrete Experience). The results of this present research are confirmed in Kolb’s (1981) that showed how disciplinary differences suggested by Biglan (1973) relate to Kolb’s proposed learning styles. Recognizing disciplinary differences can help educators and learners consider the learning styles that are more or less compatible with different fields of study and in turn the convenient learning environment for delivery of its subject matter (Lau & Gardenr, 2018; Reichard & Mokhtari, 2003; Hu, Peng, Cheng & Yu, 2021). This awareness can inform instructional strategies, curriculum design, and assessment methods to better cater to the diverse learning needs and preferences of students across different disciplines.

Results of Table 6., the independent t-test showed that there were no statistically significant differences between the two groups FOE and FOAH according to their "Learning Preference (individual vs. groupwork) with (T-value =0.210) at a significance level of more than (0.05) as illustrated in Table 6. This affirms that students of both disciplines almost agreed about their opinion for preference of both individual and group work.

Most FOE students (57.5%) and FOAH students (56.6%) preferred individual and group work equally. This shows that most students appreciate cooperative work as much as individual work, regardless of the nature of their studies. An interpretation for this could be that majority of students in FOAH probably favour “concrete experience” or “abstract conceptualization” like students who are enrolled in “hard applied” disciplines besides “Reflective Observations”. This is because not only do students in humanities study literature, culture and philosophy, but they also study applied linguistics and basic and applied psychology in their courses, such as teaching methodology, educational administration, professional editing, teaching foreign languages (e.g., TESOL), sociolinguistics, and translation with all its genres “screen translation, sight translation”. Moreover, it is believed that most students in the psychology department appreciate real-life experience of examining and coaching patients who need psychological therapy or counselling according to Kolb’s classification of learning styles. Students in both disciplines also understand that their future career requires having communication skills to work cooperatively with their co-workers, so they value the experience of working on group projects with their colleagues. This is confirmed in Morsi & Assem (2021).

Another interpretation could be that students in both disciplines “hard applied” and “soft-pure” understand that both strategies serve specific learning purposes and positively impact their performance. In the second place, 33.8% of FOE students chose only or more individual work, versus 22.6% chose only or more group work; yet there were no significant differences. Insert the other table here. On the other hand, 22.1% of FOAH students chose only or more individual work versus 22.6% chose only or more group work. This slight difference although not significant but is confirmed in Chiriac 2014 as 97% of the 210 students who participated in the study perceived working in groups positively for its effective impact on their “academic work” and improvement of their “collaborative abilities” or both. Further, students help each other understand concepts or learn different skills (Kolb, 1981). They feel affiliated with a group when working cooperatively with confirmation of who they are and what they are capable of. Understanding group structure, tasks, and contributions would enhance their competence and communication skills in their future careers (Morsi & Assem, 2021; Chiriac, 2014).

5.3 Discussion of RQ3

Research about neuroarchitecture and cognitive emotional design – including multisensory design - of learning environments in Physical or VR environments contribute to the development of leaners' brains/cognition, the efficacy of their learning processes, such as attention & memory, and impact their feelings (Ezzat et al., 2021; Zhang, 2024; Assem et al., 2023). For example, in the physical environment, **PE**, it was worth noting that students of both disciplines (**humanities & engineering**) rated "lighting" as the most important architectural design element that preserves their attention, productivity and comfort in both physical and virtual learning environments. These results confirmed the results of a study that explored the role of architectural elements like "lighting" and "color" in causing emotional responses among humanities students in a physical and virtual environment. These components could improve emotional resonance and well-being in learning environments according to Zhang (2024). Natural light and appropriate artificial lighting can boost mood, feelings and productivity. According to studies, lighting quality and variation (such as dynamic or adjustable lighting) allow students to customize their surroundings, which improves comfort and facilitates a variety of learning activities, such as group discussions and concentrated reading (Assem et al., 2023; Obeidat et al, 2020; Ezzat et al, 2021). In "soft-pure" disciplines such as "humanities", where emotional engagement is essential to learning as they are diverging, assimilating learners within Kolb's classification; poor lighting or a lack of natural light can have a detrimental impact on mood, increase eye strain, and lower motivation (López-Chao et al., 2024). A study in the field of "engineering" concluded that effective lighting, specifically natural and adaptable lighting, improves concentration, alertness, and information processing in engineering fields (Al-Enezi & Al-Saleh, 2020). A key component of engineering education is complicated problem-solving as they are converging, accommodating learners according to Kolb's theory (Assem et al., 2023). Thus, this should be supported by adequate lighting or natural lighting to lessen cognitive overload, fatigue, stress and inattention that can be brought on by poor illumination making it difficult to do technical tasks or intricate hands-on work (de Pavia, 2018; Determan et al. 2019; Assem et al, 2020;). Engineering students who use laboratories and work collaboratively benefit from lighting that encourages both individual concentration and group engagement. Lighting conditions that are too harsh or uncomfortable can minimize motivation and cause anxiety, especially for hard activities conducted by students of the "hard-applied" engineering discipline (Al-Enezi & Al-Saleh, 2020).

FOAH students, who are in a "soft-pure" discipline opted "colour tones/temperature' in the second place, followed by "space design". The varied demands of students studying arts and humanities can be met by flexible, adaptable spaces that facilitate adjustments to lighting and colour schemes. These spaces can improve individual and group learning in addition to cognitive and emotional health. According to a study conducted on "humanities" students in learning environments, colour complexity and excitement are crucial. Cool, soothing tones like blues and greens encourage attention and introspection, while warm, exciting colors like reds and yellows can foster creativity and social interaction (López-Chao, 2024). Their choice can also be attributed to the fact that humanities students are "diverging" (creative, reflective) students or "assimilating" (theoretical, analytical) who need customized design elements that help them develop these characteristics. This is also supported by Higuera-Trujillo (2021) who stated how the built environment affects cognition and emotions based on the cognitive emotional design theory.

FOE students, who fall within the “hard-applied” discipline, chose “space design”, in the second place, followed by “colour tones/temperature”. This could be because engineering students have "converging" (problem-solving, practical application) or "accommodating" (hands-on, action-oriented) styles according to Kolb’s classification of learners, which makes them need more space to conduct their experiments or work on their large drawing sheets or work collaboratively on models which require good spatial organization. Moreover, architecture and civil engineering students usually pay more attention to space design since they usually design space; therefore, space design is an important factor for them than their FOAH counterparts. On the other hand, for FOAH students “space design” came the least among the three elements as they are less knowledgeable about the possibilities of “space design” and less expecting its effect on their overall comfort in the classroom than engineers. Moreover, FOAH students use "diverging" (creative, reflective) or "assimilating" (theoretical, analytical) approaches according to Kolb’s classification. Thus, they do not need large spaces in their learning environment. Flexible classroom layouts promote active learning and teamwork, which are critical for engineering fields. Diverse learning needs are met, and cognitive and emotional wellbeing is enhanced by incorporating various zones (active, reflective, and relaxing), (Molineiro et al., 2022; Ezzat et al., 2021; Barret et al., 2015). It was also stated that the choice of the learning styles is crucial for setting the classroom’s arrangement and layout. For open forms of self-organized learning, multipurpose rooms with spaces designated for particular kinds of work are helpful. Rows encourage concentrating with the teacher. It is also noteworthy that circles or semicircles arouse discussion and can facilitate exchanges with the teacher (Arndt, 2012).

Our interpretation for the significant differences between FOE and FOAH in the three design elements which was for the benefit of “FOE” in both physical and virtual environments reflects that more percentage of FOE students voted for the “high” importance of the design elements for them than the percentage of FOAH students. This was expressed in the analysis of the results which showed that the FOE’s answers were toward the (High) trend, while FOAH were towards (Moderate/High). FOE students included a percentage of architecture and civil engineering students who may be more aware of the effect of the architectural design of learning environments on students’ wellbeing and the importance of each design element in their learning environment based on neuroarchitecture.

VRLEs- Similar to what took place in the student's choices for the PE, it was clear that students of both disciplines (**humanities & engineering**) prioritized “lighting” in the first place. Following, engineering students of the **FOE** chose “Space design” followed by “Colour tones/temperature”. On the other hand, **FOAH** student's first choice was followed by “Colour tones/temperature”, then “Space design”. It can be inferred that these three design elements “lighting”, “colour” and “space design” are important in both PE and VRLE equally because students of both disciplines gave them the same rank (order) of importance in VRLE as they did in the PE, Fink (2021) and (Maher et al., 2000) agreed. In their VR created environment, Maher et al. (2000) defined a virtual office environment as exhibiting active behaviour, whereas a physical office is inactive. A physical office is composed of tangible materials, whereas a virtual office is composed of digital representations. While both have the same role, for instance, VR should facilitate navigation in space through an easy and aesthetically clear layout. Molineiro et al. (2022) who called for “different colours for furniture and walls”, and “flexible class layouts” within his proposal for guidelines for diverse-learning, technological, comfortable flexible LEs also supported the importance of these elements and created a VRLE model. Significant differences were found between FOE and FOAH in Table 8, for the two elements "lighting" and "space design", and was also for the benefit of FOE. This could be attributed to the fact that FOE's answers were toward the (High) trend while FOAH were towards (Moderate/High) like the answers in the PE. However, there were no significant differences found between the two groups for their answers to "colour tones/temperature" element, which means that both groups gave very similar rating trend to the importance of "colour tones/temperature" as an element of the VLE.

Maintaining student interest and attention requires an engaging VRLE, which can be reached through suitable lighting and colour tones/temperature. Simulated lighting (brightness, contrast, and colour temperature) has a high impact on mood and emotional stimulation in VEs (Moneim, 2005, Higuera-Trujillo et al., 2021). In a similar study, results revealed that the most important factor in a virtual classroom environment was "lighting", which had a large impact on both genders' preferences, males' memory and females' attentiveness. Geometry was the least powerful feature, while colour also had a major impact on girls' attention (Fajardo et al., 2023). This states that gender may also be a factor that needs to be considered. For instance, many females than males study "humanities", while more males than females study "engineering".

For humanities students, who frequently participate in analytical and discussion-based activities, warm and tunable virtual lighting can boost comfort, lower anxiety, and enforce students' sense of presence. Virtual lighting that is set correctly improves visual clarity, lessens cognitive fatigue, and encourages prolonged attention when reading, analyzing, and creating. Bad virtual lighting, such as sharp contrasts or glare, can make it harder to understand and retain information (Abbas, 2024; Moneim, 2005; Ezzat et al, 2021). For humanities students who value social communication and identification in their LE, the use of soothing or culturally relevant colour schemes in virtual platforms can enhance emotional well-being, lower stress levels, and create a sense of belonging. Colors that are too bright or badly coordinated can divert attention and make it more difficult to reflect and think critically. Proposing clear organization and easy navigation, well-structured virtual spaces, such as: interactive galleries, lessen cognitive overload . This encourages more in-depth interaction with difficult texts and concepts, supporting Kolb's experiential learning cycle. With regards to space design, it was found that students are more inclined to participate in conversations when they feel free and at ease, which is facilitated by open areas and high classrooms (Saleeb & Dafoulas, 2010).

For engineering students, who face intricate problem-solving and technical jobs, VE are very important specifically when studying the details of hazardous materials. Students of engineering who are action-oriented, problem solvers appreciated the involvement, ease of use, motivation, and realism (including immersion) of the VRLE (Vergara et al., 2017; Fink, 2021). Simulated lighting of VE can help in all of that by greatly boosting a clear vision and thus decreasing cognitive strain. Similarly, VE's colors are therefore very crucial. Bright VE colors can cause distractions particularly when working on technical exercises or group design projects. Soothing colour hues in VE like blue and green help lower tension and foster a sense of order, which are required for engineers. When used strategically, accent colors can inspire creativity in tasks involving design. Effective learning strategies and cognitive load management are supported by engineering students for virtual environment designs that offer distinct zones for various activities (e.g., labs, group work, presentations), organization, and way finding (Fajardo et al., 2023), (Zhang, 2024). Experimentation, reflection, and conceptualization are all made possible by well-organized virtual environments that support the cyclic experiential learning processes. Myung & Jun, (2020) revealed similar findings in their study about VR environments and distinct spatial configurations, where the results marked great evidence that a plan spatial configuration can highly impact the quality of space for the user's wellbeing. They also suggested that designers should opt for suitable layouts for each use because spatial configuration is impactful in reducing stress that can worsen the psychological state.

Fajardo et al. (2023) affirmed closely similar findings clarifying that the three top essential elements in a VC were: lighting, followed by colors, followed by geometry (i.e., ceiling height/width) in their study about the impact of these design elements on students' preference and cognitive functions as these elements are the main ones that affect main cognitive functions of learning. The top two choices for FOAH and the top two for FOE students in our study were among the same three elements listed by (Fajardo at al., 2023). Moreover, Sattarzade and Tahmasebi (2021) also affirmed our results stressing the importance of colour as a design element in the VW and its effects on short-term memory in their quasi-experimental study on 24 male and female student participants of the Faculty of Physical Education from the University of Tehran. Thus, the hypothesis of RQ3 was confirmed for significant differences between the two groups with regards to importance of the design elements mentioned in the physical and virtual LEs, except for "colour tones/temperature" in the VE which showed no significant differences.

To wrap up, lighting, colour, and spatial design are used in effective design of VE to support wellbeing, lessen cognitive load, improve emotional health, and facilitate the entire learning cycle (experience, reflection, conceptualization, and experimentation). In addition, when carefully combined, these design elements support both neuroarchitectural and cognitivism theories, maximizing virtual learning to meet the diverging, assimilative nature of humanities education, as well as, the converging, accommodating nature of engineering. In a study, students' satisfaction levels were correlated with the architecture design features of their virtual educational environment, indicating that careful planning and designing for wellbeing can result in improved learning results (Saleeb et al., 2016). To achieve effective learning environments in higher education, Molineiro et al (2022) proposed a VR learning environment model that consists of three learning zones: the flexible zone which represents the active area; the introspection zone, and the relaxing zone On the other hand, although architectural design is important, he along with some other researchers contend that pedagogical techniques and the caliber of the information offered also have a significant impact on how effective virtual learning environments are. Overall, this research has shown a reciprocal relationship between cognition and emotions leading to human wellbeing and generated based on the architectural design of the learning LEs, the AI-driven different LE's type and the learning tools and activities used. Therefore, it is recommended to create effective learning environments through integrating both learning methods and architecture design as proposed in this research.

6. Conclusion and Recommendations

This research aimed to design effective AI-driven learning environments that foster students' wellbeing among students of different disciplines through interdisciplinary research work of technology-enhanced digital learning and architectural design for human-wellbeing. Little research has examined the disciplinary specificity within the area of learning styles, learning environments and their architecture design. This was fulfilled through creating a framework that merges between AI -driven LEs types, learning theories, architectural design for wellbeing theories. The research investigated the preferred AI-driven learning activities, preferred learning environments modalities (ranging from physical to fully virtual), and architectural design preferences for learning environments among higher education students from humanities vs. engineering disciplines. The methodology followed a cross-sectional, quantitative, non-experimental research design with 141 undergraduates from two private universities in Cairo, Egypt. Data was collected using a questionnaire formulated based on the framework and disseminated to university students through their university email. Data was quantitatively analyzed using the statistical analysis tool SPSS. The generated framework helps in understanding students' disciplinary specificity, their classification with regards to learning theories, their learning styles, preferred type of LEs, learning activities and their design priorities and preferences to achieve human wellbeing; this is based on literature theories. Results revealed that students of both disciplines preferred Physical classrooms. Following, engineering students preferred Mixed LEs, but Humanities students preferred VRLEs over Online Learning. The findings indicate that students from both faculties value interaction and learning in Physical Environments (PEs) for effective learning, while also showing acceptance of Virtual Reality Learning Environments (VRLEs). FOAH students prefer VRLEs; they address individual differences and provide practice opportunities, particularly for speaking skills. Engineering students prioritize PEs for the hands-on-practical nature of their discipline. Additionally, VR technology is seen as a valuable tool for language learning, engineering education, and overall education. Furthermore, students from both disciplines rated "lighting" as the most important architectural design element in a physical and VR LEs, to enhance their attention and comfort, however, the ratings for the other two design elements differed between students of the two disciplines. Humanities students followed light by "colour tone/temperature" and "space design", whereas Engineering students chose "space design" followed by "colour tone/temperature". The study highlights the importance of "light" as the most important design elements for students of both disciplines in physical and virtual environments.

Future research can make use of the proposed framework with larger samples or conduct similar study with mixed-methods approach and different categories of universities. The study emphasises the importance of recognizing disciplinary differences to customize the design of LEs to adapt to students of different disciplines' learning styles and customize design elements that enhance students' wellbeing, attention, comfort, and productivity LEs. Moreover, the study underscores the importance of Mixed Physical and Virtual Environments to enhance learning experiences. Furthermore, the study also highlights the need to design LEs that boost human-wellbeing boosting student's attention, concentration, motivation, and comfort. Further investigation is suggested to examine the impact of other architectural design of LEs, such as ceiling height, nature on user's satisfaction, attention and productivity. Using a framework that guides teachers and designers to create effective learning environments through customizing pedagogical systems, LEs and their architecture design leads to achieving the SDGs: (3) good health and wellbeing; (4) quality education and (11) sustainable cities and communities from the sustainable development goals. Teachers, designers, and policy makers should work collaboratively to create healthier and more effective LEs.

List of Acronyms
AI – Artificial Intelligence
FOE – Faculty of Engineering
FOAH - Faculty of Arts and Humanities
FVE – Fully Virtual Environment
LE – Learning Environment
ME-Mixed Environment
OLE – Online Learning Environment
PE – Physical Environment
RW– Real World
SDGs – Sustainable Development Goals
SVE – Semi-virtual Environment
VLE- Virtual Learning Environment
VR – Virtual Reality
VRLEs - Virtual Reality Learning Environments

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