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Exploring the Relationship Between Learning Styles and Architectural Design Education (Systematic Review)

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Abstract

In most architectural design teaching methods, students are typically considered to be at the same level, and educational steps are presented uniformly . However, this approach often overlooks the individual abilities and tendencies of students. Learning style refers to the personal approach learners have toward learning, problem-solving, and information processing. It provides a valuable framework for recognizing and addressing the differences among students in architectural design education. This research aims to systematically examine the studies on the relationship between learning styles and architectural design education. The study seeks to answer the following question: What are the different types of relationships between learning styles and architectural design education, based on existing research? Four categories of research purposes emerged from the reviewed articles: the impact of learning style on architecture design (product), the impact of learning style on architecture design (process), the benefits of different types of architecture education on various learning styles and preferences, and the impact of different types of architecture education on learning style. The methods and results of articles within these four categories were evaluated and analyzed.

***Keywords*:** Learning style; Learning preference; Architectural design; Design studio; Education; Design process

1. Introduction

The concept of learning can be defined in different ways. Learning covers a very broad field. Hergenhahn and Olson considered learning as one of the most important fields in today's psychology and one of the most difficult concepts for define at the same time. Learning means the process of creating a relatively stable change in behavior or behavioral ability resulting from experience and cannot be attributed to temporary body conditions (Hergenhahn & Olson ,2005).

Education in the field of architecture is one of the most controversial issues in architectural education centers. The structure of architecture education is formed around a nucleus, which is called design, and the most important mission of architecture education is to form an all-round thinking that provides the ability to step into the architectural design process for architecture students. The importance of architectural design in the process of architectural education is so much that many consider it the most important topic in architectural topics (Cikis and Cil,2009). Orbasli and Worthington's comparative research on architecture education and urban planning showed that in the five famous architecture schools in Europe, the average time devoted to exercises and design courses is more than 44% of the total time of the academic course (Orbasli and Worthington,1995).

Heidegger considers teaching to be much more difficult than learning, not because the teacher must have a large store of information and be always ready, but because teaching requires the creation of learning conditions for the learner. In fact, a real teacher lets nothing else be learned than—learning. (Pallasmaa,2010). In most architectural design teaching methods, students are considered to be at the same level and educational steps are presented in a coordinated manner. Part of the educational errors is caused by ignoring the abilities and tendencies of the student. The existence of these differences is a fact considering the multidimensional nature of human beings. But in most architectural education programs, the students are considered to be of the same level and the same education programs are implemented for all of them. The characteristics of design learners, like the characteristics of all human beings, have individual differences and they differ in their ability, knowledge, insight and transfer in design activities.

There are different components in evaluating the individual differences of learners, such as the difference in the general learning ability; knowledge; motivation; gender, age, socio-economic status, culture and differences in learning style. Learning style can be defined as the learners' personal approach to learning, problem-solving and information processing or the way the learner prefers to other methods in his/her learning. (Eggen & Kauchak, 2009) Therefore, in some texts, the term “learning preference” is used instead of “learning style”. (Woolfolk, 2013) Learning style refers to how the learner learns, not how well they learn . Ormord (2012) says about this: that

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students with the same intelligence often have different approaches to homework. Some of these differences are due to their cognitive styles over which they have no conscious control. (Ormord, 2012)

People have different levels of creativity and different learning styles, each of that requires a different approach and instruction. The selection of suitable methods and programs by the teacher has a significant effect on its improvement and the student's success rate. Each student needs a different amount of attention and a different way of guiding in the design process. It is important that each person needs support and guidance in which step of the steps he takes towards the desired design product, and more importantly, that the teacher has sufficient and necessary knowledge to deal with these differences. The individual differences of students in learning styles require different paths for teaching-learning in the multidimensional architectural design process .

In recent decades of research, the issue of learning styles has been investigated in various disciplines. in architecture, some of articles have been written about the learning styles of architecture students too. Paying attention to individual differences in the subject of learning style is a subject that makes education researchers interested in this subject. By studying the historical path of dealing with the issue of learning style in architecture, it can be seen that at first, the studies identified the learning styles of architecture students or comparison of learning styles of architecture students with other disciplines, and then the relationship between learning styles and human characteristics or different educational dimensions of students was investigated. More limited studies have also addressed the issue of the relationship between learning style theory and architectural design education. The current research has tried to systematically review and discussed studies on the relationship between learning styles and architectural design education. The systematic literature review (SLR) was formed based on PICO concept. (Population, Intervention, Comparison, Outcome measures) The initial codes were defined by adapting the PICO concept (Aromataris and Riitano.2014) as a framework (1) level of study (2) Number (3) Academic field (4) Type of learning style (5) Research approach for learning style (6) Base design theory (7) Research approach for architectural design (8) Area of study in architectural design (9) Research purpose (10) Research outcome.

After addressing each of these sections, discussion and analysis was done at the end, suggestions for future research were presented to the researchers according to the review of the studies conducted in this field, which can be useful for the researchers of this field.

2. Literature Review

To deal with the subject of relationship between learning styles and architecture design education, first a brief introduction of various theories related to this discussion is given.

2.1. Learning styles

There are different types of learning styles or learning preferences. They can be divided into three categories: cognitive, emotional and physiological learning styles. Cognitive learning styles are the ways in which a person perceives subjects, remembers information, thinks about subjects, and solves problems. Emotional learning styles include the learner's personality and emotional characteristics such as persistence, working alone or working with others, accepting or rejecting external boosters. Physiological learning styles have a biological aspect and include a person's reaction to the physical environment affecting his learning. Like preferring to study at night or day or preferring to study in hot or cold environments. Among these three categories of learning styles, cognitive learning styles have been discussed more than others. In the following, we briefly review their types:

2.2. Cognitive learning styles

2.2.1 Field dependence and field independence learning styles

Field dependence learners have internal motivation, organize their learning by themselves and define their own study strategies. In contrast, field independence learners are extrinsically motivated, respond better to material organized by others, and need guidance from the teacher. (Cassidy, 2004)

2.2.2. Impulsive and Reflective learning styles

Another classification of cognitive learning styles is impulsive style as opposed to reflective style. Impulsive learners work fast but make many mistakes, reflective learners work slowly but make fewer mistakes. (Kagan, 1964)

2.2.3.Converging, Diverging, Assimilating and Accommodating learning styles

Another type of classification of learning styles is done by David Kolb. This classification is based on a four-stage cycle called the experiential learning cycle. According to Kolb's theory, which was proposed in his famous book entitled “Experiential Learning” in 1984, experience plays an important role in learning. In this book, Kolb defined learning as a process by which knowledge is created by changing the form of experience. What he means by experience is the interaction between the learner and her/his environment. (Kolb,1984)

David Kolb's four learning styles are created based on a four-step cycle called the experiential learning cycle. In fact, this theory considers learning as a cycle that begins with experience, continues with reflection, and ultimately leads to action, and this cycle can continue likewise (Kolb,1984).

According to this learning model, Kolb and Fry (1975) have introduced two dimensions and four learning methods. The first dimension includes two ways of learning, **Concrete experience** as opposed to **abstract conceptualization**. The second dimension also includes

two ways of learning: **active experimentation** as opposed to **reflective observation**. (Kolb & Fry. 1975)
Kolb and Fry (1975) have named four learning styles by combining the above four learning methods. These four learning styles include: **Converging, Diverging, Assimilating and Accommodating learning styles**
Kolb and Fry say that each of the above learning styles has its own strengths and weaknesses, and therefore a learner who only uses one particular style is not a complete learner. To become a complete learner, he/she must be able to use the appropriate learning styles in different situations (Kolb & Fry,1975). Describing perfect learners, Kolb and Fry argue that perfect learners are very flexible and relativist in dealing with the world and their experiences and they can easily resolve dialectical contradictions between four main learning styles namely concrete experience (CE), reflective observation (RO), abstract conceptualization (AC), and active experimentation (AE) by their integration (Mirmoradi,2018). Kolb's learning style measurement tool is a questionnaire called "Learning Style Inventory (LSI) "

- Honey and Mumford (1986) summarized Kolb and Fry's learning styles and presented four styles with different names from that, each of which includes one learning style instead of two styles. These styles are: **Activist – Reflector – Theorist – Pragmatist**
- **Environmental, emotional, sociological, physiological and psychological styles** are another famous classification of learning styles by Dunn, Dunn and Price. This model contains 21 elements that are categorized into 5 variables. These variables include: environmental - emotional - sociological - physiological - psychological variables (Dunn, Dunn, & Price,1997).
- Felder and Silverman (1988) have classified learning styles into four categories: **Sensory – Intuitive, Visual – Verbal, Actively – Reflectively, Sequentially – Globally**, according to the following four questions:
    - What kind of information does the learner receive? Sensory or intuitive
    - What kind of sensory information does the learner receive? Visual or verbal
    - How does the learner process information? Actively or Reflectively
    - How does the learner move towards understanding? Sequentially or in Globally (Felder & Silverman, 1988).

Felder and Silverman's eight styles measurement tool is a 44-question questionnaire that was created by these two researchers in 1991. This tool is called "The Index of Learning Styles (LSI) "

2.3. The experiential learning theory

ELT is a dynamic view of learning based on a learning cycle driven by the resolution of the dual dialectics of action/reflection and experience/abstraction. Learning is defined as "the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience." (Kolb, 1984, p. 41). David Kolb's four learning styles are created based on a four-step cycle called experiential learning cycle. In fact, this theory considers learning as a cycle that begins with experience, continues with reflection, and ultimately leads to action, and this cycle can continue likewise (Kolb,1984).
"Experiential Learning Theory (ELT) draws on the work of prominent 20th-century scholars who gave experience a central role in their theories of human learning and development— notably John Dewey, Kurt Lewin, Jean Piaget, Lev Vygotsky, William James, Carl Jung, Paulo Freire, Carl Rogers and Mary Parker Follett" (Kolb & Kolb,2021:5). This theory is built on six propositions that are shared by these scholars:
Learning is best conceived as a process, not in terms of outcomes. Although punctuated by knowledge milestones, learning does not end at an outcome, nor is it always evidenced in performance. Rather, learning occurs through the course of connected experiences in which knowledge is modified and re-formed. To improve learning in higher education, the primary focus should be on engaging students in a process that best enhances their learning – a process that includes feedback on the effectiveness of their learning efforts (Kolb & Kolb,2021:5). Conflict, differences, and disagreement are what drive the learning process. These tensions are resolved in iterations of movement back and forth between opposing modes of reflection and action and feeling and thinking (Kolb & Kolb,2021:6).

2.4. Learning styles in architecture

The topic of learning styles started in the field of education around the 80s, and interdisciplinary studies that tried to identify learning styles in their students also started from the same time. In the field of architecture, early studies identified the learning styles of architecture students or compared the learning styles of these students with other fields. But with the passage of time, the studies of this field in architecture also dealt with deeper aspects and the relationship between learning styles and various educational subjects related to this field were discussed and investigated. In general, the studies conducted in this field can be divided into several categories:

2.4.1. Identifying the learning styles of architecture student

In the initial studies that have been done in this field, the learning styles of the students of different fields, including architecture, have been identified, or the learning styles of the students of different fields have been compared. Among the various studies conducted in this category, these studies can be mentioned: (Albadi & Zollinger ,2021), (Maturakan & Moorapun, 2017), (Kaba and Abdou, 2022).

2.4.2. The connection of learning styles theory with human characteristics

Further, studies have been conducted that have investigated the relationship between learning styles and human characteristics of students. Among the many studies that have been done in this field, we can mention these cases: (Mirmoradi,2018), (Akinyode & Khan, 2016), (Kvan & Yunyan,2005).
These studies have examined the relationship between the theory of learning styles and subjects such as field of study, level of study, gender, etc.

2.4.3. The relationship between the theory of learning styles and different educational dimensions

Some researches, including (Dermirkan,2016), (Mostafa&Mostafa,2010), (Demirkan& Demirbas,2010), (Mirmoradi,2018), (Al Maani,2022), (Nussbumere & Guerin,2000), (Gilfilen,2012), (Ozdemir and Akalin,2022), (Khaleghimoghaddam, 2023), (Ummihusna and Zairul, 2022), have studied the relationship between the theory of learning styles and different aspects of students' education. In this researches, students' different learning styles have been examined and their relationship with students' academic performance, or important topics in architecture education such as thinking style, visual ability, autonomy, mimetic approaches, reflective thinking, spatial experience, have been examined.

2.4.4. The relationship between the theory of learning styles and architectural design education

Some researchers have studied the relationship between the theory of learning styles and student's performance in architecture studios. The focus of this research has been on individual differences, i.e. different learning styles, and the different abilities of each of these styles in different parts of design (design product or design process) are reported. *This is the category that present research deals with.*

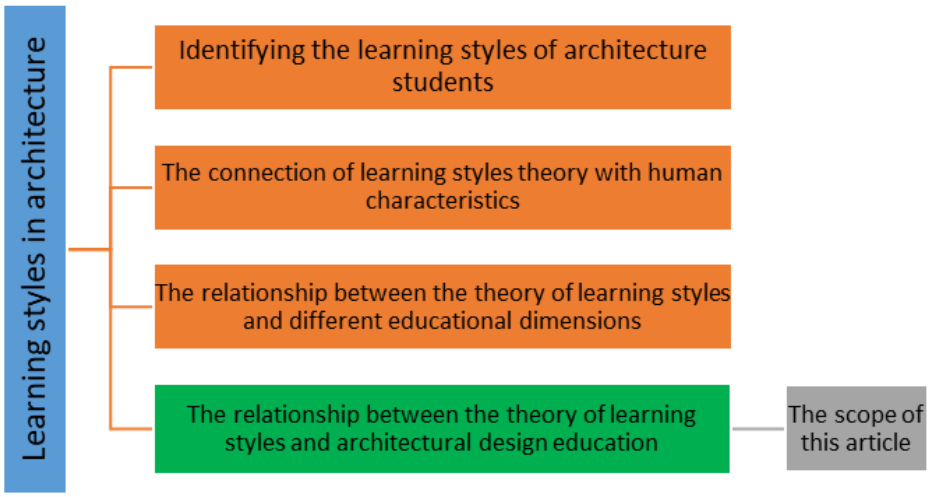

Fig.1. Several categories in the field of "learning style in architecture" in literature review and the scope of this article

3. Methods

This research systematically examines the studies in the field of communication between learning styles and architectural design education. Tranfield (2003), states that a reasonable consensus has emerged as to the systematic review desirable methodological characteristics (Davies and Crombie, 1998). A systematic literature review (SLR) based on Tranfield et al, (2003) comprised three stages: (1) planning the review, (2) conducting the review and (3) reporting and dissemination. These three stages have several phases that in the following, these different stages are explained:

3.1. planning the review

The main research question for the systematic literature review (SLR) was formed based on PICO concept. (**P**opulation, **I**ntervention, **C**omparison, **O**utcome measures) (Aromataris and Riitano.2014)

The study tries to answer to the following question: Based on existing studies, what are the different types of relationship between learning styles and architectural design education?

3.2. Conducting the review

The search was conducted using the key search string from the keywords as follows: "Learning style" OR "Learning preference" AND "architecture" OR "architect" OR "design" "architecture design "OR "design studio" OR "architecture studio". "Learning" AND "architecture" OR "architect" OR "design" "architecture design "OR "design studio" OR "architecture studio". "education" AND "architecture" OR "architect" OR "design" "architecture design "OR "design studio" OR "architecture studio".
The final list of search strings was filtered for 6 months after examining these databases: Web of science, Google scholar, Scopus. The first restriction applied was that only articles from 2000 onwards were selected. By July 2022,

the search resulted in the identification of two hundred and thirty-eight articles. The reason for choosing this period time was that The topic of different learning styles has been discussed since the year 1980 and in the beginning, the articles that have dealt with this issue have only studied the learning style of students of different fields. But they have not linked the topic of learning style to the specialized fields related to different disciplines. Therefore, the selected period for dealing with the articles was from 2000 onwards.

Then the title and abstract of these 238 articles were thoroughly evaluated. The data complied with the following criteria: journal articles (articles from the conference were omitted), peer-reviewed articles, written in English, and published in the last 22 years (from 2000 to 2022). And most importantly, they must have established the connection between students' learning styles and architectural design. Most of those articles only identified the learning style of the students or related the learning styles with the grades of the students or their gender or academic year. But among the articles, only those were selected in which the topic of learning styles was related to the topic of architectural design or the activities in architectural studios. The articles were evaluated to validate the selection based on a set of inclusion and exclusion criteria according to table 1 and 12 articles were selected finally.

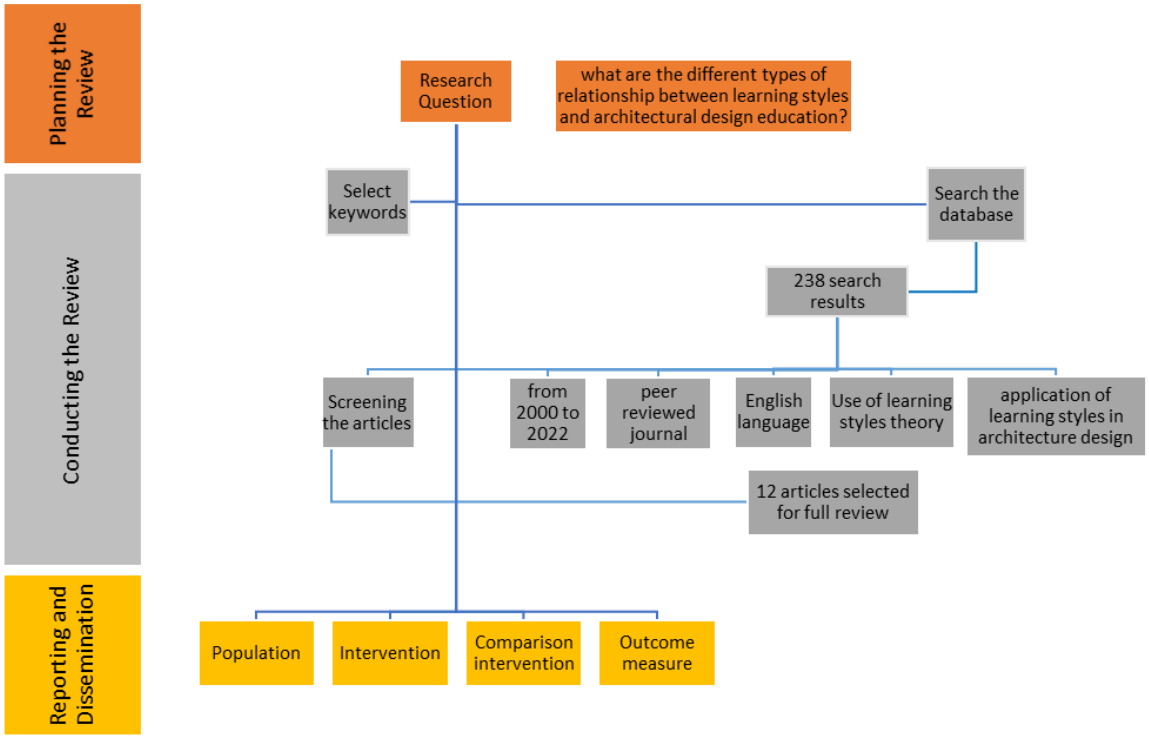

Fig. 2. Theoretical framework and operating model, The systematic review methodology

Table 1
inclusion and exclusion criteria

Inclusion criteria	**Exclusion criteria**
Published between 2000 and 2022	Published < 2000
Indexed journal, peer-reviewed journal articles	Non indexed journals, review journals, chapter in book, conferences articles, dissertation
English language	Non-English
Use of learning styles theory	Not used of learning styles theory
Described application of learning styles in architecture design	Not used learning styles in architecture design

3.3. Reporting and dissemination

The initial codes were defined by adapting the PICO concept (Aromataris and Riitano.2014) as a framework (table 2) (1) level of study (2) Number (3) Academic field (4) Type of learning style (5) Research approach for learning style (6) Base design theory (7) Research approach for architectural design (8) Area of study in architectural design (9) Research purpose (10) Research outcome.

Table 2
initial codes according to concept

	Review component	codes
P-Population	Architecture student (all levels and fields)	(1) Level of study (2) Number (3) Academic field
I-Intervention	Learning styles theory	(4) Type of learning style (5) Research approach for learning style
C-Comparison intervention	Architecture design	(6) Base design theory (7) Research approach for architecture design (8) Area of study in architecture design
O-Outcome measure		(9) Research purpose (10) Research outcome

4. Result

4.1. Characteristic of a population

4.1.1. Level of study

The selected articles that have addressed the issue of the relationship between learning styles and architectural design have investigated this issue in various levels among students. Eight studies,66 % of articles had examined in bachelor students and evaluated in different levels from freshman to senior students. And in 4 articles, the review there was no mention of the educational level of the students.

4.1.2. Number of a population

The maximum number of students examined in the articles was 245, and the minimum number of students was 17. The average range of the examined number was 90 students.

Table 3
Characteristics pf population in reviewed studies

Author	Level of study	Number	Academic field
Demirbas & Demirkan,2003	Freshman students	88	Interior Architecture
Kvan & Yunyan, 2005	undergraduates in Years Two and Three	91	Architecture
Chawla,2017	1st, 2nd and 3rd years of B.Arch	30	Architecture
Iavarone, 2021			
Maghool, et al, 2018		82	Architecture
Tezel & Casakin, 2010	two consecutive academic years	90	Interior Architecture
Kolsal & Kandemir, 2021	first-year students	17	Architecture
Wang, et al, 2015	over two years	245	architecture and construction students
Casakin & Miller, 2008	-	-	-
Khan & Thilagam, 2021	-	-	Architecture
Guler,2022	3rd year	59	Interior Architecture
Gilfilen, 2012	Sophomore, junior, senior	139	Architecture and interior design

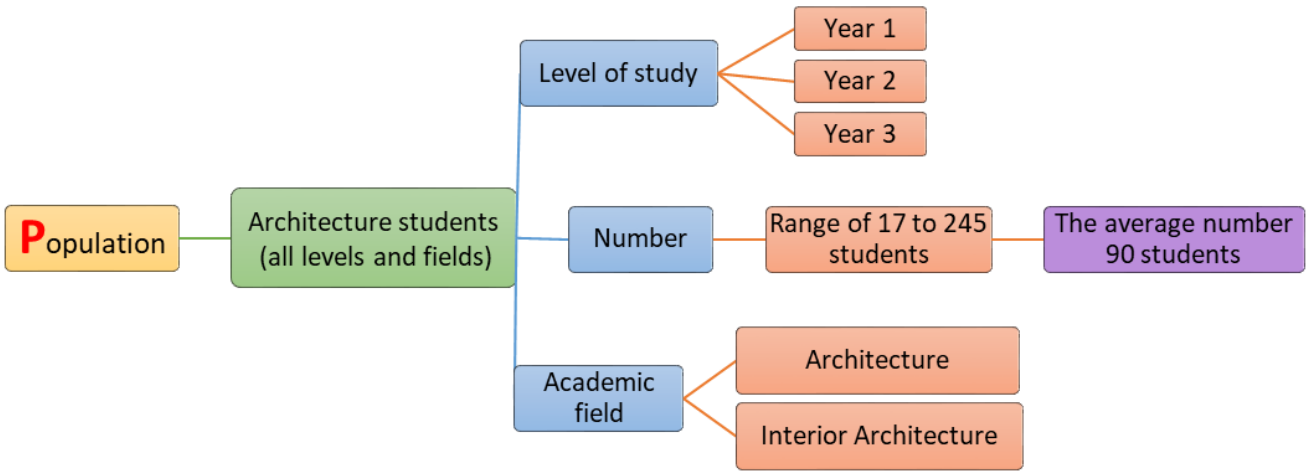

Fig. 3. Thematic framework of Phase 1 (population) of stage 3 (Reporting and Dissemination) of operating model

4.2. Evaluation of intervention

4.2.1. Type of learning style

One of the tools most used in architecture is the Kolb's Learning Style Inventory (K-LSI). Among the different types of theories related to learning style, the largest number of articles have evaluated learning styles through Kolb's learning style. 8 articles, i.e. 66% of the reviewed articles, used Kolb's experiential learning theory(LSI) and Kolb's learning styles in their articles (Demirbas & Demirkan,2003), (Kvan & Yunyan, 2005), (Iavarone, 2021), (Tezel & Casakin, 2010), (Kolsal & Kandemir, 2021), (Wang, et al, 2015), (Casakin & Miller, 2008), (Gilfilen, 2012). Also Felder and Solomon's Index of Learning Style Questionnaire (ILS) is the tool for study learning styles in engineering education. Two of reviewed articles used Felder's learning style (Maghool, et al, 2018), (Guler,2022). And another one used Honey and Mumford Learning styles(LSQ) (Chawla,2017). The last one had analyzed several different learning styles (Kolb's learning style inventory based LSI- Honey and Mumford learning style based LSQ- Herrmann's brain dominance theory based HBDI- Allinson and Hayes' cognitive theory-based CSI) (Khan & Thilagam, 2021).

4.2.2. Research approach for learning style

Considering that the reviewed articles had two main sections (learning styles - architectural design). In learning styles part, 50% of the reviewed articles have identified students' learning styles quantitatively with learning style questionnaire.one study implemented both a pre-test and a post-test Before and after students encounter virtual training. But the other five studies used only a pre-test. 4 articles, have qualitatively investigated the characteristics of each learning style. And one article has studied with the combined quantitative and qualitative method. That is, they have expressed the percentage of students belonging to each learning style with used of questionnaires and descriptive statistics, and have analyzed the characteristics of each learning style qualitatively and analytically.

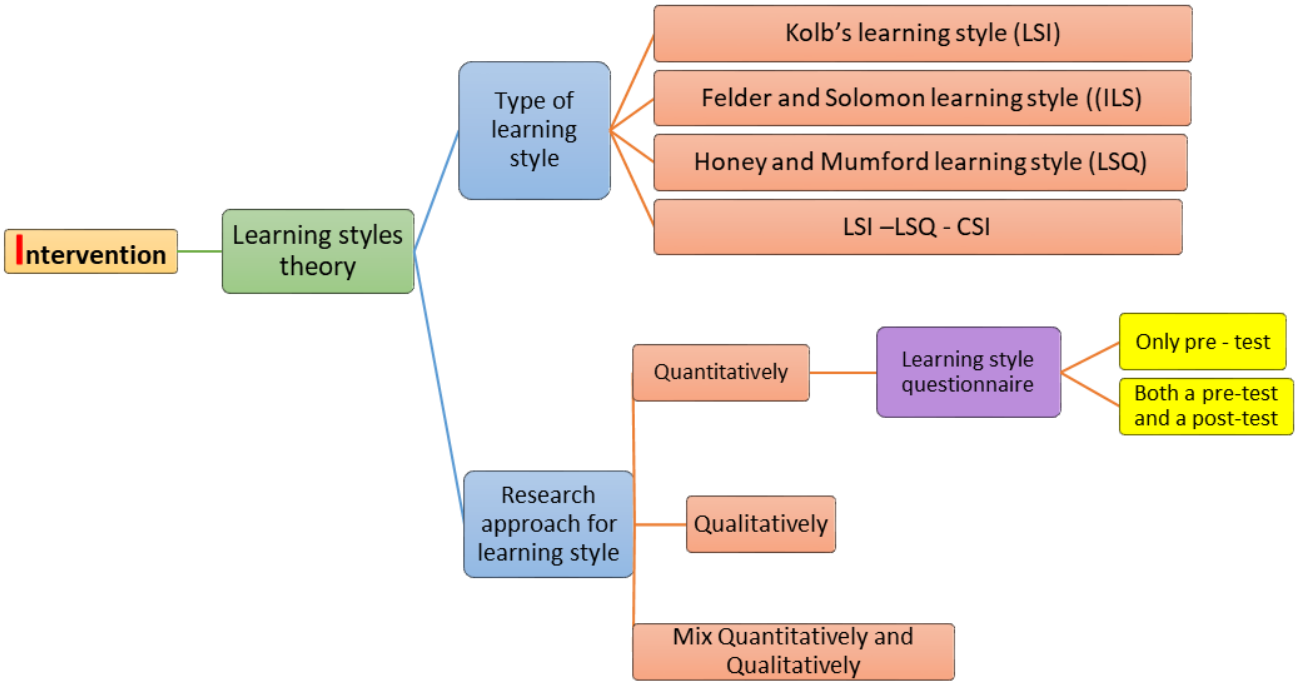

Fig. 4. Thematic framework of Phase 2 (intervention) of stage 3 (Reporting and Dissemination) of operating model

4.2.3. Area of study in architecture design

four articles have focused on architecture design (Demirbas & Demirkan,2003 - Kvan & Yunyan, 2005 - Kolsal & Kandemir, 2021 - Tezel & Casakin, 2010). These articles had raised a topic as design in the studios and had evaluated the final product designed by the students. The focus of these articles has been on the final product designed in design studios, and the design process has not been investigated.

Four other articles focused on virtual architecture studios (Khan & Thilagam, 2021 - Wang, et al, 2015 - Maghool, et al, 2018 - Iavarone, 2021). One of them focused on Different kind of virtual design studios based on learning style (Iavarone, 2021). Another one focused on effectiveness of an application based on VR (LADUVR)as a response to different learning styles (Maghool, et al, 2018). One article focused on Virtual design studio based on the experiential learning cycle (Khan & Thilagam, 2021). And another focused on whether student learning

style preferences changes with exposure to VR technology in architecture education (Wang, et al, 2015).

Four other articles focused on design process (Chawla,2017 - Casakin & Miller, 2008): One of them focused on different phases of metaphorical thinking in design process (Casakin & Miller, 2008). Another study in this area focused on how the learning and thinking styles of an individual effect students design process in the architecture studio (Chawla,2017). Another one investigated a guideline for design studio program based on student experience during an online design course emphasizing different learning styles and preferences (Guler,2022). And the last one in this category focused on thought development, consist of students overall thinking (MID) and design thinking (MOD) with deferent learning styles and preferences of students (Gilfilen, 2012).

Table 4
Evaluation of intervention in reviewed studies

Author	Type of learning style	Research approach for learning style	Base design theory	Research approach for architecture design	Area of study in architecture design
Demirbas & Demirkan,2003	Kolb's Experiential Learning Theory (LSI)	Quantitative	-	Mix method	Architecture design Design products
Kvan & Yunyan, 2005	Kolb's Experiential Learning Theory (LSI)	Quantitative	-	Mix method	Architecture design Design product
Chawla,2017	Honey and Mumford Learning styles(LSQ)	Quantitative	Rasmussen design process	Mix method	Design process
Iavarone, 2021	Kolb's learning styles	Qualitative	Internet-based design studios	Qualitative	**Virtual design studio** Different type of virtual design studios based on learning style
Maghool, et al, 2018	Felder & Soloman learning style	Mix method	VR technology	Qualitative	**Virtual design studio** effectiveness of an application based on VR (LADUVR)as a response to different learning styles
Tezel & Casakin, 2010	Kolb's Experiential Learning Theory (LSI)	Quantitative	-	Mix method	Architecture design Design product
Kolsal & Kandemir, 2021	Kolb's Experiential Learning Theory (LSI)	Quantitative	multiphase design problem spatial-visual perception test	Mix method	Architecture design Design product
Wang, et al, 2015	Kolb's Experiential Learning Theory (LSI)	Quantitative	VR technology	Quantitative	**Virtual design studio** whether student learning style preferences changes with exposure to VR technology in architecture education
Casakin & Miller, 2008	Kolb's Experiential Learning Theory (LSI)	Qualitative	Metaphorical thinking	Qualitative	**Design process** The effect of learning styles on metaphorical thinking in design studio
Khan & Thilagam, 2021	LSI – LSQ – HBDI - CSI	Qualitative	Virtual design studio	Qualitative	**Virtual design studio** Virtual design studio based on experiential learning cycle
Guler,2022	Felder & Soloman learning style	Qualitative	Canvas learning management system	Mix method	**Design process** a guideline for design studio program based on student experience in online design course with emphasis on different learning preferences
Gilfilen, 2012	Kolb's Experiential Learning Theory (LSI)	Quantitative	Perry scheme	Mix method	**Design process** Relationship between students overall thinking (MID), design thinking (MOD) and learning styles

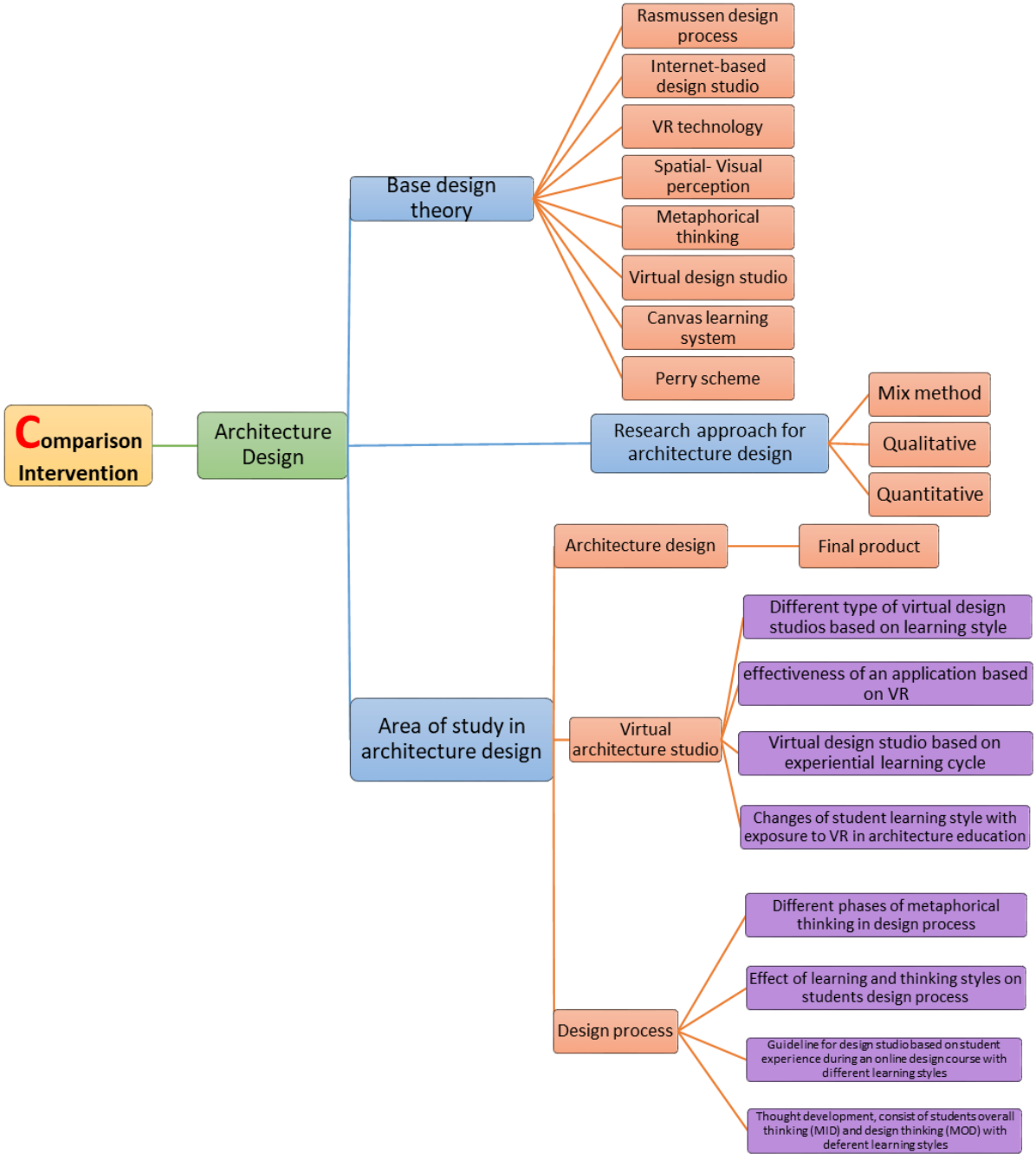

Fig. 5. Thematic framework of Phase 3 (comparison intervention) of stage 3 (Reporting and Dissemination) of operating model

4.3. Outcome measure
4.3.1. Research purpose

The following four categories of research purpose emerged from the reviewed articles:

(1) Impact of learning style on architecture design (product) (four studies) (Demirbas & Demirkan,2003 - Kvan & Yunyan, 2005 - Tezel & Casakin, 2010 - Kolsal & Kandemir, 2021)

These four articles have identified students' learning styles. They presented a topic for architectural design to students and evaluated the results of students' design. And then they have investigated the relationship between the type of student's learning style and the degree of success in the final product of architectural design.

(2) Impact of learning style on architecture design (process) (three studies)

One article investigated Impact of the different learning styles on each phase of the metaphorical thinking in design studio (Casakin & Miller, 2008). And one other studied how the learning and thinking styles of an individual effect students design process in the architecture studio (Chawla,2017).and the last one studied

impact of learning styles on design thinking (Gilfilen, 2012).

(3) Benefits of type of architecture education on different learning styles and preferences. (four studies)

These four articles have addressed the virtual and online topic. One of them investigated Benefits of Virtual design studio based on experiential learning cycle (Maghool, et al, 2018). Another one evaluated different types of virtual design studios based on the learning styles theory (Iavarone, 2021). Another one investigated Capacities of VR (virtual reality) Technology as a Response to Learning styles theories (Khan & Thilagam, 2021). And the last one investigated a set of guidelines targeting design knowledge-building, based on student experience during an online design course emphasizing different learning styles and preferences (Guler,2022).

(4) Impact of type of architecture education on learning style (one study)

In this case, an educational method is adopted for teaching architecture, and students' learning styles are evaluated before implementing the method and after that. Then, impact of that type of educational method on student's learning style preferences and its possible changes is examined. In one reviewed article investigated Impact of architecture education based on VR on students learning styles preferences during the time (Wang, et al, 2015).

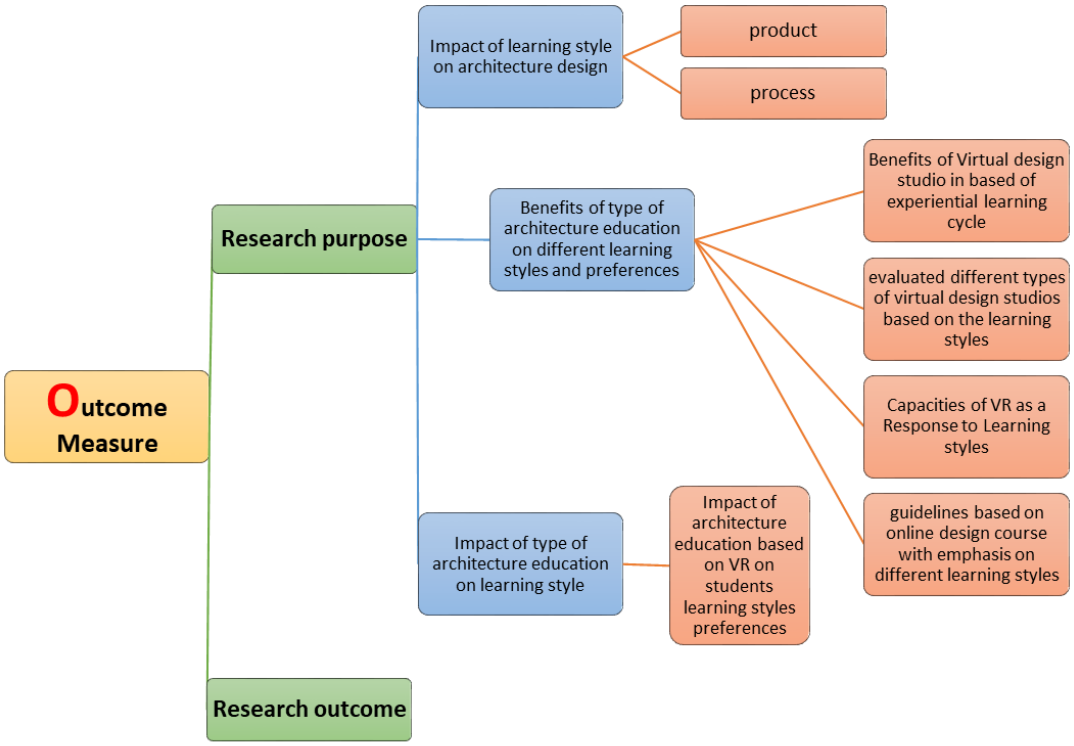

Fig. 6. Thematic framework of Phase 4 (outcome measure) of stage 3 (Reporting and Dissemination) of operating model

4.3.2. Researche outcome

- The results of Demirbas & Demirkan' study (2003) showed that different learning styles were effective on the performance scores of students in different stages of a design problem through the studio process. In this study, the emphasis was on the final product designed by the students and scores were based on the final product. But it is stated as a hypothesis that in based of results there is a relation between learning style types and different stages of the design process. Looking at results separately, assimilating learners had the highest progress where the increase in the performance scores of accommodating learners were the lowest. But as architecture design is a combination major, its education should be containing all of the stages of the experiential learning cycle. Finally, they conclude that different stages of design education should be associated with different learning styles instead of concluded that education in based of one of learning style are more suitable for design studios.

- The findings of Kvan & Yunyan' research (2005) showed significant correlation between learning style and students' academic performance in design studios. This study suggested a test of learning style from students in beginning of the design studio program the teacher can design a program that can cover all the different learning styles of the students.

- Chawla' study (2017) indicated that first-year students are mostly Reflectors in learning styles. The performance of the students was correlated with their learning and thinking abilities but there appears to be No clear connection of learning style and thinking styles. Certain learning and thinking types design in a certain way and this is reflected in their design process. From 1st year to 3rd year architecture students of a

certain combination of learning and thinking types; design in a certain way. Most students are judicial in thinking when they enter college but become executive in thinking by the third year.

- Iavarone' study (2021) explored the Internet-based design studios in two main axes: the terminological classification and supported learning styles. each design studio model was classified according to the learning methods that can support and matched with Kolb's learning styles. The results showed that Internet-based design studios have more potential to support different learning styles, nevertheless an Internet-based studio does not entirely replace face-to-face communication in the design studio, but only can create opportunities to develop the learning process of the studio.
- In output of Maghool, et al' study (2018) had been designed and developed an educational application based on VR technology called LADUVR. This application was based on new education theories in architecture such as PBL, EL, FL and learning styles theory. This application can be a supplemental tool for architecture education.
- Tezel & Casakin' study (2010) explored the performance of interior architectural students in relation to their learning styles in based of Kolb's Experiential Learning Theory. Results showed that in some design conditions certain learners are more successful than others. Hence, teachers should try to adapt the transference of design knowledge according to the particular needs and requirements of each student.
- According to Kolsal & Kandemir' study (2021) there is difference between performance of students with various learning styles. it is observed that the students with the learning style of "assimilation" had the highest grades in the design process. In other words, the students with assimilating learning styles are accepted as more promising for this design exercise compared to the other students with other learning styles. the study showed that in an era the production of knowledge is very crucial, a fertile field such as design should be primarily considered as many erase of education as in architectural education.it is important to create course content, syllables and thus specific exercise according to abilities and learning tendencies od design student which can be adapted to their personal preference and aptitudes. It is necessary to adapt new methods for design teaching-learning and evaluation to reach the full potential of creativity and production of knowledge.
- In Wang, et al' study (2015) some experiments were done to show the impact of increasing exposure to virtual reality education on learning style preferences of students. The results showed that when virtual reality applications are used in teaching and learning, learning preferences of students shifts to Accommodate learning style that is more concrete experiential mode of learning. Also the results of that study showed that individual architecture students don't have any particular learning style preferences and they have all modes of learning styles.
- In study of Casakin & Miller (2008) discussed the role of metaphorical thinking in design studio and education in based of Kolb's experiential learning models. the effect of different learning styles on each phase of the metaphorical process were proposed. The purpose of this study was identification the relationship between learning styles and metaphor. Strength and weakness of each learning style and the way of each of them in metaphorical process in design was discussed.

  At the end was showed that assimilators, followed by converging learners, hold learning preferences most advantageous for the successful use of metaphor. assimilators will need training in the last phases of the design process to develop skills for the application of metaphorical knowledge to concrete design situations. Converging learners, on the other hand, are expected to require assistance to develop reflective observation skills in the earlier phases of the process. diverging learners and accommodators are considered to be the most disadvantaged learners with regard to metaphorical reasoning. Both of them are expected to need training to perceive and integrate information by means of abstract conceptualization which is essential to the earlier stages of the metaphorical process.

- Khan & Thilagam' study (2021) introduced a rational directive with a focus on student-centric pedagogy using a web-based learning environment. This learning environment is virtual design studio using e-learning mode that was inevitably in Covid pandemic situation.
- Guler' study (2022) investigated a guideline a guideline targeting design knowledge-building, based on student experience during an online design course emphasizing different learning styles and preferences. This guideline emphasized on (1) flexibility and handling stress, (2) managing self-pacing issues (3) formal conversation platform, (4) content variety and access options.
- Results of Gilfilen' study (2012) indicated no association between learning style and global or discipline-specific thought development level; however, qualitative data provide insights into the ways design students approach thinking and learning. It was determined that design students learn in diverse ways, as learners were found in every region of the learning style type grid. Both these findings support the need for diverse instruction to accommodate the varying perspectives and approaches apparent within design.

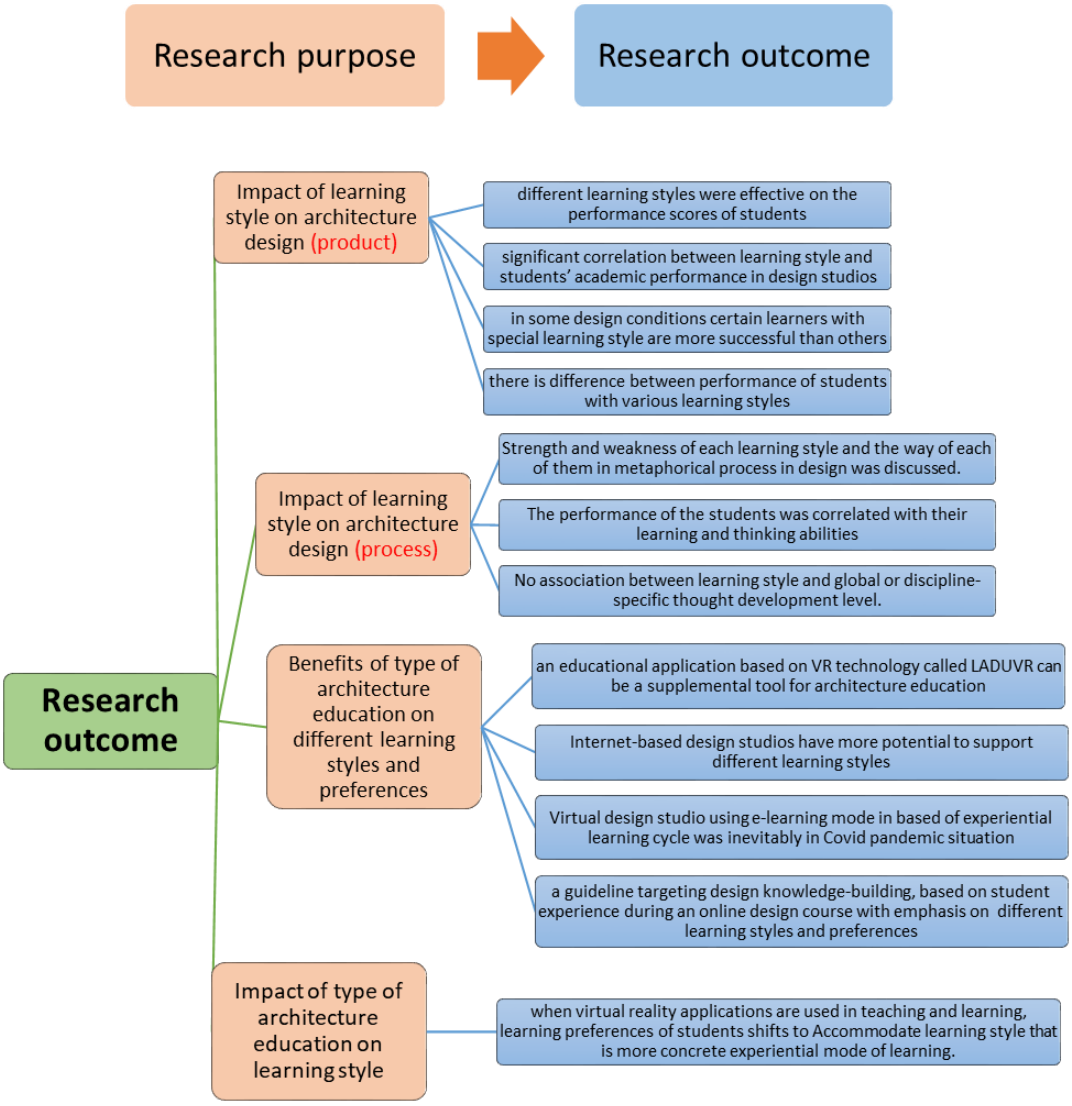

Fig. 7. Diagram of researches outcome

5. Discussion

Learning style is the learners personal approach to learning, problem-solving and information processing or the way the learners prefers to other methods in learning (Eggen & Kauchak,2009). Attention to different learning styles of architecture students and awareness about that help educator to understand the difference in students' learning abilities and tendencies and can be useful. It Design educators must be conscious of the role of learning preferences in the design studio, as well as to develop an awareness of individual differences with respect to how information is perceived and processed (Tezel & Casakin, 2010). But what can be obtained from the study conducted in the last three decades in this field is that one or two styles cannot be introduced as the dominant style of architecture students. This issue depends on various factors and the results of studies have identified various styles in architecture students. Wang's study showed that architecture students don't have any particular learning style preferences and they may have all modes of learning styles (Wang, et al, 2015). Gilfilen's study was determined that design students learn in diverse ways (Gilfilen, 2012). Also, various studies that have recognized a dominant style for architecture students have not agreed with each other and various styles have been introduced as the dominant style of architecture students (Demirbas&Demirkan,2003), (Demirbas&Demirkan,2007), (Mirmoradi,2018), (Kolb,1984), (Kvan & Yunyan,2005), (Maturakarn& Moorapun, 2017), (Newland, et al,1987).

This issue is especially more important in the multifaceted architectural design process and the issues raised in this field cannot be reduced to only one of these styles. The main structure of architecture education is around architecture design (Cikis & Cil, 2009). Despite the fact that designing is divergent in its entirety (Lawson,2006), There are many steps which require convergence in any designing process. The design process has many steps and designing clearly includes both convergent and divergent types of thinking (Lawson,2006), (Guilford,1962). According to Cross, design process is a convergent activity including a number of divergent stages and selecting the most appropriate and feasible solution from different

options according to objectives of design(Cross,1989). Architecture design education contains all of the stages of the experiential learning cycle and all of the four learning styles occur in the design studio process (Demirbas & Demirkan, 2003). Therefore, knowing the dominant learning styles of students with the aim of adapting the curriculum to one style in the field of architecture and the subject of architectural design is not very effective.

Another noteworthy point was that fifty percent of the studies that investigated the relationship between architectural design and learning styles had given students a design topic and scored the students' final designed product based on quantitative criteria and the relationship between the scores obtained had been investigated by students with different learning styles, but the important point is that , according to Kolb & Kolb (2021) Learning is best conceived as a process, not in terms of outcomes. Leaning does not end at an outcome, nor is it always evidenced in performance. Rather learning occurs through the experience that knowledge is modified and reformed (Kolb & Kolb, 2021). One of the most frequently mentioned problems in design education is that studio evaluation focuses on the final product rather than the process (Bashier, 2014). Many traditional forms of evaluation, including design project criteria, often test a limited range of skills, abilities, and knowledge and products rather than processes (Brown,1999). Therefore, it can be said that in teaching architectural design, the design process and correct modification is more important than the final design product, and instead of focusing on the evaluation of the final design product, it is better to focus more on the design process.

Kolb and Fry indicated that each of learning styles has its own strength and weakness and a learner who only uses one particular style is not a complete learner. To become a complete learner, they must be able to use the appropriate learning styles in different situations (Kolb & Fry, 1975). And because of the

it is necessary for instructors to challenge strengths and weaknesses of each learning style, Ignoring and not strengthening weaknesses can put the learner in serious failure if he relies on a particular style and ignores other styles. the formulation of the design program and presentation requirements can disadvantage certain learning styles (Kvan & Yunyan, 2005). Therefore, teachers should provide conditions for each of the learners to pass the four stages of learning successfully and each of them, while having the characteristics of one of the styles, should not neglect the skills and capabilities of other styles. Therefore, the awareness of the students' learning styles leads to the teacher's awareness of the students' abilities and weaknesses. And teachers can know at which stage of the design process their students need more help. Knowing the students' learning style can help teachers to help students overcome their weaknesses in counseling and individual corrections. Increasing teachers' awareness of learning styles leads to an increase in the flexibility of teachers' teaching styles and strengthens the relationship between teachers and students and leads to a better understanding of the professors about the characteristics of students and their abilities and weaknesses of students.

What most of the studies emphasized was to provide a diverse curriculum that includes the priorities of different learning styles for students, so that each group of them can, according to their preferences, choose parts in harmony with themselves and parts as a challenge considered for training in the way of improving the features in which they are not so strong. Teacher can design a program that can cover all the different learning styles of the students. Teachers should try to adapt the transference of design knowledge according to the particular needs and requirements of each student (Tezel & Casakin, 2010). Considering individual differences among students, and applying the Experiential Learning Theory, which is basically a theoretical framework for understanding learning abilities, can contribute to the enhancement of individual skills and abilities under different design situations (Tezel & Casakin, 2010). It is important to create course content, syllables and specific exercises according to abilities and learning tendencies of design students which can be adapted to their personal preferences and aptitudes (Kolsal & Kandemir, 2021). In teaching as a process, it is best to use compilation methods to help learning become useful for different learning styles. It can be said that a successful learner in the multifaceted field of architecture should also be able to strengthen the ability to move in the entire learning cycle and use different learning styles at different stages of design.

Learning style information is also valuable to the instructor in planning team projects or group work. studies in learning style theory recommend teaching that provides a balance between all learning styles. Providing a balance of support and challenge for the student can promote intellectual development and facilitate independent learning. Educators should create a learning environment where all students regardless of developmental level and/or learning preferences are respected and feel safe moving into unfamiliar and even intimidating waters. Previous research has indicated that a supportive classroom environment can enhance academic achievement and intellectual development (Felder & Brent, 2004). People who have balanced learning profiles in both dimensions of the LSI are more adaptively flexible learners (Kolb and Kolb, 2005). In balancing learning style, it balances concrete experience, abstract conceptualization, active experimentation and reflective observation. Kolb and Kolb (2017) identify the balancing style as: "adapting by weighing the pros and cons of acting versus reflecting and experiencing versus thinking." (Kolb and Kolb, 2017: p.24).

At the same time, instructors must challenge a student's beliefs to stimulate them to move to higher levels of thinking. Since students are found at various developmental levels and with varying preferences for learning, instruction appropriate for students at one level or style might be unsuccessful or counterproductive for other students (Felder & Brent, 2004). The solution is to allow various challenges for all students. This targets a balanced approach to the design process that allows students to learn

by doing, feeling, reflecting, and thinking (Gilfilen, 2012). Educators can strategically place students with different dominant learning styles together to facilitate discussion and enhance operation (Gilfilen, 2012). The individual differences of students in learning styles require different paths for teaching-learning in the multidimensional process of architecture design.

Another issue that can be seen in this field in the studies of the last three years is the category that we discussed in this article in the third category of research objectives: (Benefits of type of architecture education on different learning styles and preferences).The four articles that were reviewed in this category all discussed the type of virtual education and its various capabilities according to the conditions of the Corona pandemic in recent years, and even though these educations were not considered a complete substitute for face-to-face architecture education, but The many capabilities that these virtual tools provide to educators were emphasized. One of the points that is mentioned earlier is that the possibility of diversity of educational content for all the different learning styles in a class can be provided with the help of these virtual educational aids. Results of Iavarone' study (2021) showed that internet-based design studios have more potential to support different learning styles, nevertheless an internet-based studio does not entirely replace face-to-face communication in the design studio. But can create opportunities to develop the learning process of the studio. Because of the fact that not everyone learns with the same methods, as Kolb mentions, different aspects of Internet-based studio methodologies may help us build infrastructures that support different learning styles in the design studio (Iavarone,2021).

6. Conclusion

The concept of learning styles emerged in the field of education during the 1980s, leading to interdisciplinary studies aimed at identifying learning styles among students. In the field of architecture, early research focused on understanding the learning styles of architecture students and comparing them with students in other disciplines. Over time, studies in architecture delved deeper into the subject, exploring the relationship between learning styles and various educational aspects related to the field. Broadly speaking, research in this field can be categorized as follows:

- Identifying the learning styles of architecture students.
- Exploring the connection between learning styles theory and human characteristics.
- Investigating the relationship between learning styles theory and different educational dimensions.
- Examining the relationship between learning styles theory and architectural design education.

This research specifically focuses on the relationship between learning styles and architectural design education, utilizing a systematic literature review (SLR) based on the PICO concept: Population, Intervention, Comparison, Outcome measures. The review considers factors such as the level of study, the number of participants, the academic field, types of learning styles, research approaches for learning styles, base design theory, research approaches for architectural design, area of study in architectural design, research purpose, and research outcomes.

From the reviewed articles, four categories of research purposes were identified: the impact of learning style on architectural design (product), the impact of learning style on architectural design (process), the benefits of different types of architecture education on various learning styles and preferences, and the impact of different types of architecture education on learning style. The methods and results of articles within these four categories were evaluated and analyzed.

Based on the discussion section, the following conclusions can be drawn:

Given that the design process involves both convergent and divergent thinking and includes multiple steps, adapting the curriculum to a single learning style in the field of architecture and architectural design may not be highly effective. However, design educators should still be aware of the role of learning preferences in the design studio. Understanding students' learning styles can assist teachers in addressing their weaknesses, providing guidance, and offering individualized feedback. Most studies emphasized the importance of offering a diverse curriculum that incorporates different learning style preferences, allowing students to choose parts that resonate with their preferences while also challenging them to improve in areas where they may be less strong.

Teachers can design programs that cover all the various learning styles of students. Additionally, when teaching architectural design, emphasis should be placed on the design process and appropriate modifications rather than solely evaluating the final design product. This aspect deserves more attention in research studies when comparing and evaluating projects.

Information about learning styles is also valuable for instructors when planning team projects or group work. Another recent development in this field is the exploration of the benefits of virtual education and its various capabilities, particularly in the pandemic conditions (e.g., COVID-19). While virtual education is not considered a complete substitute for face-to-face instruction in architecture, its numerous capabilities in accommodating diverse learning styles have been highlighted.

7. Suggestions for future studies

According to what was stated in the discussion and conclusion part of the review of the studies conducted in the field of the relationship between learning styles and architectural design education, the following suggestions can be made for future researches:

- It is not recommended to conduct new studies only to identify the learning styles of architecture students in general.

- Identifying students' learning styles at the beginning of the curriculum can be appropriate to decide on the appropriate educational program for that group.
- It cannot be expected that the architectural design curriculum will match the dominant learning style of the students of a study group, because the nature of the design process requires various capabilities and, as a result, various learning styles.
- In studies that deal with the relationship between architectural design and learning styles, it is better to emphasize the design process instead of the final design product.
- There is still a need for more studies to know the strengths and weaknesses of each learning style in different stages of the architectural design process.
- Identifying students' learning styles at the beginning of education with the aim of being aware of students' strengths and weaknesses can be useful, and a teacher with knowledge can provide more support to students in stages where they are weak.
- Studies that examine the effect of doing group projects in architectural design with members who complement each other's learning styles can be useful.
- Developing architectural design curricula that can cover students' diverse learning styles and checking their effectiveness can be useful.
- One of the things that can be seen in the studies of the last three years in this field is the capabilities of internet-based and virtual design training and the possibility they can have to cover diverse learning styles. It seems that more studies can be done in this field with the aim of checking the effectiveness of different educational methods and tools.
- Among the types of learning styles, what has been assigned a high percentage of studies is the studies according to Kolb's experimental learning style, it seems that the studies that can examine another different type of learning styles which are discussed in the first part of this article and the useful capabilities of each on architectural design education can be useful too.

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