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RESEARCH ARTICLE/ARAŞTIRMA MAKALESİ

A Study on the use of diagrams as a form of representation (expression) in architectural education

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Abstract

This study examines the development of architectural education in the information age, particularly concerning the representation and expression of knowledge. Considering that architecture is a visual medium that aims to construct tangible structures, it remains in constant flux due to changing environmental conditions, architects, and technology. Interdisciplinary studies have revealed that visual tools like diagrams effectively transfer knowledge and practice. This study focuses explicitly on the role of architectural diagrams in facilitating communication and enabling architecture students to express their design knowledge. It examines diagrams' characteristics, functions, and potential for representing architectural designs. Within the scope of the study, the transfer of architectural knowledge, the means through which it is communicated, the effectiveness of diagrams as a means of expression in the field of architecture, how they are used in the educational environment, and the competencies of understanding and using diagrams were questioned through a survey conducted with architecture students in the city of Kayseri. Students' attitudes in three universities in Kayseri are evaluated to understand how architectural education adapts to the current environment.

Keywords: Architectural Diagrams, Architectural Knowledge, Architectural Education, Architectural Expression Tools

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1. INTRODUCTION

The discipline of architecture can be classified into two categories: the field of practice, as the area where the production of the architectural discipline at the building scale turns into the final product, and the theoretical field, as the area where questions about how all kinds of products are made or their meaning are carried out. The results of the changes experienced in the practice field can be seen relatively faster and more clearly than the results obtained from the field of education, which can be said to operate theoretically. While advancing technology quickly finds a place in practice or technology develops upon a need arising in the field of practice, it can be said that in the educational environment, this situation is in the form of adaptation to the changing technology by following the opposite path. During its functioning, education takes in information from outside, expands it, educates the architect with this information, and leaves it outside. The transfer of architectural knowledge, whose educational environment is dialogue-based, occurs between the educator and the student, whose perception styles, capacities, experiences, and cognitive awareness differ. While the educator selects and presents the knowledge from the contexts in his/her mind, the student tries to place this knowledge in a context in the totality of thoughts in his/her mind. During the positioning of architectural knowledge in a mental environment, a unique interpretation possibility may be encountered each time. The fact that these unique situations follow specific rules both in the way they are expressed and in the way they are evaluated crystallizes the attitude of the perceiving subject towards the situation. The ambiguous and unclear rules create uncertainties in the attitude of the subject.

In recent years, diagrammatic approaches have become more and more prominent in both the practice and education of architecture. Due to its structure, the diagram can be used as a representation/expression technique as both a traditional and digital tool. Production has always followed specific rules and flow sequences by nature. On the other hand, diagrams have become a tool for reproducing information by visualizing all situations with the quality of information in this process, managing information, establishing relationships between them, and communicating with information through analysis.

The extent to which diagrams guide and express architectural design varies in practice and education. By its nature, the educational environment primarily prefers traditional media (paper, pencil, t-ruler, miter, etc.) to transfer architectural knowledge and later shifts towards digital media. Although the mediums through which the transfer of thought takes place change, what does not change is that the architectural thought, which would eventually turn into a solid object, needs lines, graphical expressions, and visuals.

2. DEFINITION

The development of technology changes the subjects and environments that produce and use knowledge. One of the environments affected by the preferences of the information user is the educational environment. Our age has created different generations with the development of technology. One of these generations is the "digital natives," who communicate visually instead of textually. This situation is essential for architectural education, where visual communication is advanced.

2.1. Problem definition and Purpose of the Study

Knowledge is inherently explicit and implicit and is produced a priori and a posteriori. Explicit knowledge can easily express itself through any language and can be symbolized. The same is not valid for tacit knowledge. The fact that the structure of architectural knowledge is currently largely implicit and that the act of knowledge is based on experience makes its visualization-inclined language difficult. However, its boundaries are indeterminate and expanding, making it challenging to determine which knowledge is to be used in design and how to organize it. First of all, to manage information, thought needs to be represented. There is not a complete overlap between the represented knowledge and the representation. This situation makes the transfer of knowledge and the

evaluation of knowledge difficult in architectural education.

This study aims to determine the capabilities of diagrams in terms of their ability to express architectural knowledge and thought, their effectiveness in education, and the extent to which students utilize diagrams in their designs.

2.2. Scope and Methodology of the Study

Within the scope of the study, by deciphering what the information structures subject to architectural design can be, it was tried to make inquiries on how to transfer them and communicate with information. In the present study, diagrams were selected as an interdisciplinary means of expression by considering how the problematic information is transferred and communicated. Moreover, by looking at the effectiveness of diagrams in architecture, it was tried to determine the level of this effectiveness in the educational environment. Erciyes University, Faculty of Architecture, Department of Architecture, Abdullah Gül University, Faculty of Architecture, Department of Architecture, and Nuh Naci Yazgan University, Faculty of Fine Arts and Design, Department of Architecture were chosen as the field of investigation. A survey study on students in the selected educational institutions was deemed appropriate.

2.3. Reason for Addressing the Issue

Architectural diagrams are a traditional expression technique and tool dating back to ancient and primitive times. Although its use has risen to an important position, especially with modernism, it experiences the value it deserves due to the development of computer technologies and the emergence of personal computers after the 1990s. In Turkey, studies on diagrams, production with architectural diagrams, and using diagrams as a productive design tool rather than an expression technique are on the agenda, and the widespread opinion is that diagrams are still believed to have many unexplored aspects. Written publications in Turkey are extremely few. When the thesis studies are examined, the lack of a study on how diagrams are handled in the field of education in the design studio has caused the study to proceed in this direction. The article's main idea is based on the hypothesis that diagrams facilitate the comprehension, association, organization, transfer, and expression of design knowledge when used in architectural education.

3. THEORETICAL KNOWLEDGE

The basis of the study is the questioning of the place of diagrams, which are used to transfer knowledge in architectural design and its education. The theoretical knowledge of this study includes the use of diagrams in transferring architectural thought. It covers what a diagram is, its history, what it aims to achieve, and the current situation of diagrams. The study also explores the use of diagrams in architectural education, which is the main focus of this field study.

3.1. Diagrams in Architectural Design

Architecture has always had the opportunity to feed itself from branches of science and art. It can be said that this situation can be realized at the stage of creating the design or better explaining the design. Architecture, which necessitates interdisciplinary work, performs its tasks such as organizing, analyzing, transforming, establishing relationships, and producing, which are brought about by the ability to include all kinds of data in its design process through the diagram as a tool. Moreover, the diagram is instrumentalized as a decision mechanism in determining the form in the early stages of the design. Another purpose of using the diagram in architectural design is that it is used as a representation/expression tool that explains the idea of the design. Another use is to be encountered in the implementation phase, such as site organization and workflow diagram, which is one of the production phases of architecture. Just like in a factory, process design is done, and diagrams can be established when defining actions, such as the timing of actions, the order in which they will take place, and by whom each item will be loaded.

3.2. Diagram Definition

Diagrams find their place in philosophy, art, mathematics, architecture, and all other

disciplines that require design and planning, such as architecture. Therefore, different definitions have been made according to the missions they undertake in each discipline. The definitions of diagrams, in general, are not sufficiently descriptive to define diagrams within the architectural discipline. As a word, the early 17th century Latin 'diagramma' entered English from the Greek 'diagraphein'. It means a simplified drawing showing the appearance, structure, or functioning of something and a schematic representation. A Turkish diagram, which means 'çizenek', shows any event or situation's general change or structural details (URL-1). The second definition of the diagram in the Turkish Language Society is related to plant science and is defined as "a sketch showing the details of a flower" (URL-2). In the definition in the Oxford dictionary, diagrams are defined with the word "showing" as the appearance of the physical conditions of the object subject to the diagram or with the word "functioning" as the deciphering of the working logic of the object. Since the word "showing" is again in the foreground in the Turkish dictionary, it can be concluded that the primary task of the diagram is to represent/express visually. It can be said that these definitions have expanded over time within the discipline of architecture; architectural diagrams have added new meanings and new tasks and can be used in many different ways, fields, and stages.

Ceylan mentioned the etymological origin of the Greek word 'diagramma' and stated that the word means 'through something written'. He revealed that the prefix 'dia', which carries the meaning of mediation, and the word 'gramma', which refers to any coding that finds expression through lines, basically have the task of mediation and that the state of being in between in this analysis stems from the fact that it represents everything other than itself. According to him, every representation expressed by lines (sign, map, language, pictogram, ideogram, index, icon, sketch, sign system, etc.) is a diagram. For this reason, every simplified drawing, from cave paintings produced under primitive conditions to subway maps, can be exemplified as a diagram (Ceylan, 2010). Marc Garcia, in his book The Diagrams of Architecture written for the AD Reader series, gives the following definition for architectural diagrams in his introduction: "A diagram is the spatialization of a selective abstraction and/or reduction of a concept or phenomenon. In other words, a diagram is the architecture of an idea or entity." (Garcia, 2010).

On the other hand, Vidler mentions that the diagram, unlike traditional drawing tools, communicates the information it contains through geometric forms and is therefore referred to with other terms related to drawing (Vidler, 2000). According to Pai, the diagram is not an invention of scientific management but part of it. It is a mechanism that controls the object of knowledge during the separation and subsequent unification of subject and object. Discourse perceives, thinks, and represents the distance between the object and the mind. The diagram is a modern form of representation, and its genius lies in the invention of a discursive code of reality that makes it visible and usable. Therefore, the main criterion defining the diagram is not similarity but instrumentality (Pai, 2002).

According to Stan Allen, architects throughout history have used diagrammatic techniques to express, visualize, calculate, and implement their work. Unlike classical theories based on imitation, they do not map or represent existing objects and systems. Diagrams are not simply a reduction from the existing order; the potential for interpretation is high. Content is not attached or structured but outlined and reproduced. They determine the relationships between activities and forms and organize the structure and distribution of functions on a graph. Diagrams are; therefore, the best tool architecture can use to deal with the complexity of reality. The knowledge from the history of architecture and the knowledge from different disciplines is transformed into a graphic narrative with the diagram's structure and objectified and brought into architecture (Allen, 2009). Jormakka states that the two designers of UNStudio, Caroline Bos and Ben Van Berkel, were influenced by Deleuze's views on the diagram. According to Bos and Berkel, the diagram is defined as an abstract tool

that provides the opportunity to think about the organization of space, its relationships, and all their possibilities. This tool is not a representation tool; it represents neither the schematic order nor the abstract order. It does not represent any object or the state of the object that is the subject of the diagram, but it enables the generation of new objects or object states through its mediation (Jormakka, 2012). According to Eisenman, a diagram is a graphic language that enables the representation of an idea, not an abstraction. It has two tasks: to explain and to produce. While it explains the content of the architectural product, the meaning, and the essence of the idea, it is a productive tool that is not synonymous with it. It evaluates possibilities and allows interpretation. Therefore, it acts as a bridge between the inner space of architecture and its product (Eisenman, 2005). Jormakka quotes Douglas Graf's interpretation of the diagram as follows: "It is a tool that mediates between typologies that define the components of an architectural composition; between qualities specific to a particular building and general qualities that constitute a particular architectural discourse; between the stasis of organization and the dynamism of functioning" (Jormakka, 2012). Diagrams are based on a mathematical foundation and can be logically likened to machines with reductive properties. According to Corbellini, Deleuze, along with the concept of an "abstract machine" with which he characterizes diagrams, thinks this machine works conceptually, away from materiality (Corbellini, 2006). The architect becomes the manager of these fields of knowledge as the design activity shifts from approaches that deal with static objects and their interrelationships to approaches that deal with the relationships between processes and flows that need to be managed in many different and multiple ways (Jacobus, 2014). As it is understood from the definitions, the meaning of diagram changes in different disciplines. Even within architecture, it acquires different characteristics according to the interpreter's point of view. This is an indication that the diagram is a highly personalized tool. A diagram can meet almost all of the meanings such as abstraction, reduction, mediation, organizing, planning, producing, deforming, relating, analyzing, selecting, visual representation, representing the final product one-to-one or overlapping with the content rather than the final product, or it can also contain a single meaning. However, having different definitions of a diagram indicates that there may be different assumptions. Occasionally, a visual representation in a sketch, diagram, or graphic expression may need more precise differentiation from a diagram.

In the research on architectural diagrams, the word 'diagrammatic' was encountered a lot. Diagrammatic is defined in the Cambridge dictionary as "a form of a diagram or in the form of a diagram" (URL-3). Thus, when it is called diagrammatic design, it can be thought that not only is the method of producing with diagrams used, but the characterized design behaves like a diagram.

3.3. Diagrams Used in Architectural Design in Historical Process

Although the diagram is an old tool, it has become imperative in architectural design, especially since the mid-20th century. Despite the development of the computerized environment, especially in the 90s, very few architects still adopt a diagrammatic design approach. This problem is also seen in the theoretical field that studies the diagram and its potential (Garcia, 2010). Diagrams differentiate themselves from other disciplines and find new adjectives and tasks within architecture. Garcia cites Stonehenge in England, the rock carvings and reliefs of ancient Native Americans, and the map of Konya / Çatalhöyük from 6200 BC as the first examples of diagrams in history (Garcia, 2010). For instance, the mural found at Çatalhöyük depicts a village in front of a volcano. The purpose of this painting is to warn the village against the danger of the nearby Mount Hasan (URL-4). This painting, which depicts the settlement like a map, can also be considered a diagram in terms of its semantic content, as it reports an event, a dangerous condition.

Figure 1. Wall painting found in the settlement of Çatalhöyük, which can be considered one of the first diagrams in history (URL-5), (URL-6)

The use of diagrams in architectural texts indicates the knowledge and competence of the author or architect on the subject he or she is writing about. For instance, Vitruvius' "Ten Books on Architecture" contains several basic diagrams (Garcia, 2010). In his book, Vitruvius also touched upon the subjects of many disciplines other than architecture. They emphasized how architecture interprets and uses this knowledge in practice by giving information about them (Vitruvius, 2005). This shows us that architecture has brought knowledge from different disciplines to its borders since ancient and classical times.

Moreover, diagrams from other disciplines have inevitably been used within architecture, transferred to design, built structures, theories, and texts. The chapter titled "Truth From Diagram" in Le Corbusier's book La Ville Radieuse", there are diagrams such as the paths of the sun's rays and basic diagrams describing the city's layout. Although most of the diagrams in this book are about proportions, the body's relationship with space, and life cycles, Le Corbusier says very little about diagrams (Garcia, 2010).

Conversely, Pai argues that scientific management is essential because of rationalism, the dominant discourse in early 20th-century America. Therefore, the diagram is related to it. Scientific management primarily separates and then unites subject and object. At this point, it is argued that the diagram is the tool that controls the connections of the object of knowledge with the subject (Pai, 2002). In his doctoral dissertation on diagrams as a modern representation and performance tool, Ceylan categorizes diagrams according to their historical uses. This classification is;

• The diagram between the Enlightenment and Modernism: Analytical/Analysis Diagram,

• The diagram in the Modernism Period: Synthesis (Synthetic/Synthesis) Diagram

• Today's Diagram: Dissolution (Conceptual-Mechanical) Diagram.

The first of these three diagrams (Analytic/Analytical Diagram) aims to analyze by moving from existing knowledge, the second (Synthetic Diagram) aims to combine by moving towards the knowledge that may exist, and the third one (Conceptual Machinic Diagram) aims to obtain the in-between-uncertain by moving from the virtual (Ceylan, 2010).

A recent example is UNStudio's approach to diagrams. UNStudio designers need a tool to use an overarching principle and to make it visible by providing intense coherence during design (URL-7). By adapting this tool to linear drawing methods, Van Berkel developed a deconstructive approach away from representation and formalism. In this way, he moved away from an abstractive architectural approach dominated by individual discourses and moved into practice. The reason for this effort is that the projects produced after the 1990s are produced in a complex environment. This complexity cannot be handled with the limited nature of traditional representation systems. As a conceptual project, the final product of deconstructive architecture is difficult to understand for the sub-designer, the investor, and the building user. The interdisciplinary nature of the production mechanisms of our century also necessitates responsible and rational behavior by decision-makers and collaborators. Hence, they prefer

diagrams as an effective visualization tool to control complexity, make design understandable, and manage the process (Bun, 2009).

All this shows us that diagrams have gained more and more features and functions within the boundaries of the architectural discipline and, over time, beyond being a simple representation. Although there are still unexplored aspects of diagrams today, it can be predicted that they will take on new features and missions in an environment where science and technology constantly evolve.

3.4. Functions or Tasks of the Diagram

The widespread use of diagrams as a graphical tool is particularly evident within architecture, which utilizes visual ways of thinking (Corbellini, 2006). With or without a graphical representation, the architectural diagram can exist anywhere. The diagram has encompassed almost every design aspect, expanding its meaning as a concept (Teyssot, 2012). According to Corbellini, the word diagram refers to many possibilities in Greek etymology. Diagrams, which are usually defined with the help of points and lines on a two-dimensional plane, also provide the opportunity to create models in a third dimension in architecture (Corbellini, 2006).

As mentioned earlier, Deleuze described diagrams as an 'abstract machine' instead of an approach that materializes thought into flesh and blood. This tool, whose working method is conceptual, can determine lines, films, images, storyboards, etc., as extensions for itself, provided it works with the same method. Therefore, for Corbellini, diagrams are an easy-to-read planning and thinking tool with meaningful relationships between realities (Corbellini, 2006). According to Jacobus, Sanford Kwinter, based on Deleuze and Corbellini's ideas, considers the diagram as an "engine of innovation" by characterizing the objects he defines as a result of the "unification event" as a "combination of forces" (Jacobus, 2014).

As can be seen, the architecture uses diagrams basically in two ways. The first is to use it for communication purposes, and the second is to try to create a product by using it to reveal new possibilities and new situations. The most significant advantage of the diagram is its easy readability. The diagram seeks an answer to the design problem, incorporates explicit and implicit information into the design process through visualization, i.e., objectification, and relates them. Thus, the idea's accuracy and manufacturability can be realized and discussed. In addition, evaluating the existing situations and revealing the relationships between possible situations are among the main tasks of the diagram. Therefore, its working mechanism is generally future-oriented. Diagrams were analyzed under four headings according to their information management styles, i.e., their functions. While classifying these functions, especially Corbellini's (2006) classifications were used. Corbellini identified the diagram functions as reduction, relationship building, multiplication, abstraction, and ideology. Kürtüncü, on the other hand, considered them as relationship-building, reduction, abstraction, and ideology (Kürtüncü, 2011). Ceylan (2010) did not make a classification of the functions of the diagram and emphasized the "mediating" feature in the part he mentioned as its tasks, and expressed its other tasks as representing the essence, revealing the structure of thought, being the representation of abstractions, and being double-referential. Although Ceylan's (2010) views on the "mediating" function of diagrams and Corbellini's (2006) views on the "relationship building" function of diagrams are close to each other, a distinction was made between the two, and definitions were made for both. Although communication is a common denominator in both categories, the former refers to the diagram's mission as a "mediator" between subject-object or object-object, and the second refers to the potential relations that the object can establish with the object, that is, the mission of "organizing, connecting, correlating and relativizing ". Unlike the above classifications, "deformation" has been defined as a function that disrupts the structure of established ideas, types of form production, and form (Ceylan, 2010; Corbellini, 2006). Intermediation, relationship creation, reduction, abstraction, and deformation are the main reasons for using diagrams.

3.5. Current Environments for the Transfer of Architectural Knowledge

Societies are in a constant state of transformation and change with the knowledge in circulation. Every environment where architectural knowledge can be produced also points to the environments where it is transferred. These can be physical environments as well as virtual environments. With globalization and the development of technology, the easy dissemination or accessibility of all kinds of information and the fact that it can be experienced when appropriate cause radical changes in ways of thinking. Architectural knowledge is shaped by the representation tools and environments it possesses. At the top of the physical spaces where architectural knowledge is produced is the field of practice and education of architecture, which performs real architectural knowledge and produces theoretical knowledge. Virtual environments are digital media tools that are widely used today. These are the environments where information is transferred fastest and easiest. The environments where knowledge is produced have also changed the scientific environment by affecting the people who are the consumers of knowledge. Within the discipline of architecture, digital media and digital design environments are used to transfer information, as a source of production, and as a means of production. Today, social platforms such as Instagram, Facebook, Twitter, Pinterest, etc., appeal to a general audience and are used by architects, architectural offices, schools, or students to promote their work, share their thoughts, and interact with others. These platforms are open to everyone and have allowed information transfer and interaction within and outside the discipline. Information is predominantly based on visuals, and detailed information about the project is often ignored. A preferred photograph, renderings, sometimes short animations, sometimes diagrams, or other drawings of the final product or model are shared. Besides, anyone can share in these environments. At this point, information is thought to be shared without a control mechanism. Although it can be thought that people with a certain amount of knowledge have the cognitive competence to distinguish between right and wrong, it is unthinkable that architecture students still studying have reached the competence to make this distinction. Other mediums through which architectural knowledge is transferred are the websites of the offices themselves, which are considered to be more focused, blogs, and virtual architectural platforms open to collective sharing, such as Arkitera, Colloquium, Mimarizm, Mimarimedya, Archdaily, Dezeen, Awwwards, Archinect, and Designboom, in addition to these, various architectural journals that serve as printed publications also share some or all of their resources through their websites.

In this context, technological and scientific developments have been aimed at making people's lives easier. The necessity of looking at this change from within the boundaries of architecture has made the education of the architect and the production of architecture questionable. The rise in the importance of the process of obtaining the product rather than obtaining the final product and the necessity of designing this process requires new updates in the educational environment. Besides, the conditions of the subjects receiving education in institutional areas shape this process by affecting how they perceive and consume information.

In today's world, where digital media are widely used, a new generation is growing in opportunities, such as the Internet, computers, and cell phones. Dividing this new generation into two groups as, "digital natives" and "digital immigrants", Prensky stated that the first group constantly uses these digital connections to access information quickly, they prefer visuals and graphics instead of text, and they prefer to skip any part of the text rather than reading the whole text. Although digital natives can do many things simultaneously, they prefer digital games more. Assuming that most educators constitute the digital immigrant group, it can be assumed that this group shows behaviors contrary to the natives. Although some digital immigrants adapt to the new generation, they retain their general characteristics. The primary source of information for this group is printed publications. Therefore, these two groups are

considered to process information differently. They also differ in searching for, using, and creating information (Prensky, 2001, a, b.).

The preferences of these two different groups are reflected in their preferences for space and, therefore in their approaches to producing it. While the first group expects a building program where they can have fun and socialize in addition to any function, the second group finds a program that completes the process of acquiring sufficient knowledge by focusing more on the main function. Thus, the potential of expression/representation tools used effectively to facilitate communication and information transfer between the educational environment, the instructor, and the subjects receiving educational services should be re-evaluated.

4. ARCHITECTURE EDUCATION

The transfer of architectural and design knowledge is essential in architectural education. The primary purpose of education is to transfer knowledge and skills to new generations on the focused subjects and to ensure upbringing and development (URL-2). The realization of education is possible in every institutional and non-institutional environment. Individuals can be trained by others as well as to train themselves. The structure of education can be formal or informal. Today, however, the breadth of the boundaries of knowledge, how to think about specific issues to distinguish between correct and incorrect information, and which information and methods to teach in educational institutions are of great importance for knowledge to gain scientific quality. The differences between generations mentioned in the previous section and the need to adapt to changing parameters make it necessary to update educational programs constantly.

Architectural education requires a holistic approach in which a significant part of theoretical and practical knowledge is transferred. Knowledge acquisition is always based on mental and experiential processes. Hence, theoretical and practical workshop courses always have a place in architectural education. Architectural students develop themselves through theoretical courses that follow certain rules and by following and adopting their personal knowledge and the experiences of the workshop instructor. The most crucial course where experiences are transferred is architectural design studios/workshops or project courses. Design-based disciplines always use qualitative as well as quantitative information. According to Gökmen and Süer (2003), architectural education is a design-oriented education, and other courses in traditional learning styles, where theoretical knowledge is learned, support these studio courses. The central course in the architectural education curriculum is the studio course, and each architectural school creates its program. The primary purpose of architectural design is to transfer qualitative information, and the implicit nature of this qualitative information makes the evaluation criteria difficult. Although specific rules are tried to be determined to clarify the evaluation criteria and facilitate the transfer of knowledge by giving architecture a scientific quality, these rules are not expected to limit the creativity of educators and designer candidates. For this reason, it is essential to actively use educational models and tools that increase productivity while facilitating the expression and transfer of knowledge (Gökmen & Süer, 2003).

Yürekli and Yürekli (1995) emphasize that there is no longer a master-apprentice relationship in today's conditions, and information is exchanged between actors with different experiences. Studio culture defines the process of learning by designing. The fact that the discipline of architecture does not have strict and rigid rules is important for the development of creativity. For this reason, it is impossible for studio courses to follow certain rules and for the flow of information to be unidirectional from the educator to the student. In this process, there needs to be a continuous flow and acquisition of information between students, workshop instructors, and other actors involved in the process, whose cognitive competencies, cultural levels, and awareness differ. In this way, we can talk about the existence of a productive studio and the achievement of its purpose.

However, this situation brings along some problems. The lack of a single solution to the design problem, the inability to adequately express implicit information, and the disconnects in communication make the process difficult for students still in the learning stage. Hence, rather than adapting architectural education to a formal education system, more work should be done on effectively using expression languages that transform thoughts into concrete.

4.1. Design, Knowledge Acquisition, and Transfer Processes in Architectural Design Education

The design process becomes complex and imprecise due to the explicit and implicit nature of the information that constitutes data for the design, the layered structure of architectural knowledge, and the fact that it continues to be fed from different disciplines and cultures. In addition, another issue that affects the design process and design is the individual experiences of the subject who realizes the design. However, the problems designers set out to solve may not be well defined. These problems are challenging to grasp, abstract, not well-defined, and perceived. Therefore, it is not easy to systematize the design process.

Maps, diagrams, sketches, technical drawings, and models, which are made during and after the observation process, are representation tools that accompany the design process in the traditional sense and help to concretize the design idea. These representation tools are used to represent the information formed in the mind at one or more different stages of design. With the development of technology, computers have been added to these representation tools. These representation tools can create visuals for the creation of the final product, and at the same time, they can turn into a machine that develops creativity by acting productively.

On the other hand, the status of traditional technical expressions using pen and paper as an intuitive, productive tool should be questioned. While the mind can act productively by focusing on the pen in design processes using these techniques, such a process cannot be observed in computers. Although the number of academic studies on creativity is increasing daily, and they are found to be successful, it seems complicated to adapt this functioning to computer software for the moment due to the lack of a complete analysis of the functioning of mental processes that seem complex and uncertain. The fact that these processes can vary from person to person does not allow for the construction of a system (Sevaldson, 1999).

Nevertheless, there are some conventional paths that these processes follow as a system. The effort to solve the design problem primarily means defining the functions and programs for the needs and seeking solutions in a cause-and-effect relationship. Thus, a problem is first identified in the analysis phase, and function diagrams and stain studies are made. Then, the design is developed in the synthesis phase, and alternative plans are made. Finally, a decision is made in the evaluation phase, and the most appropriate solution for the design problem is developed and presented (Arcan and Evci, 1992).

The design problem that needs to be solved primarily requires knowledge. Therefore, whether the source of information is cognitive, behavioral, or experiential processes has often been a subject of debate. Likewise, the approach to problem-solving may involve one or both cognitive and behavioral models. Behavioral approaches began in opposition to cognitive approaches. According to Rowe (1991), this is basically a rejection of the distinctions made between the concept of mind and the concept of body and cognitive studies. Behaviorists believe that human behavior, including problem-solving, can adequately explain this process because it generates concrete data. Concrete expressions mean physical behavior patterns that are observable, measurable, and repeatable (Rowe, 1991). At the end of the 1950s and 1960s, several attempts were made to define the logical structure of the creative problem-solving process in design studies. As a result of these attempts, the design was recognized as a series of stages determined by active forms of action such as analysis, synthesis, evaluation, etc. (Rowe, 1991)

Although today's design approaches largely follow the traditional design processes mentioned above, the experiences, behavioral approaches, preferred sources of information, and expression/representation techniques used by professional architects or students as architect candidates in the design process help the processes progress and conclude variably.

To summarize, the subject of the study is based on the transfer of thought, especially in the form of representation and expression in architecture. A case study on the use and tendencies of diagrams, which constitute a new and contemporary medium for the transmission, transfer, and expression of ideas by students in architectural education, was needed. The reason for this is the potential of a complex situation based on purely theoretical foundations to be a tool that can be used in practice and become widespread. The extent to which students are able to use, understand, perceive, and internalize diagrams in the representation of architectural thinking made it necessary to resort to statistical tools.

5. FIELD STUDY ON THE USE OF DIAGRAMS IN ARCHITECTURAL DESIGN COURSES -EVALUATION

The idea of architecture becomes concrete to the extent that it can express itself. Architects who perform the profession effectively need to use representation/expression tools. Although the architect's education process defines a never-ending period, the architectural educational institutions where individuals take their first steps are the formations where the transfer of theoretical knowledge is intensively made. Although these transfers are experiential, they are mainly realized through visual languages. Changing expression languages within the framework of today's possibilities also changes students' tendencies. It is thought that diagrams, which are increasingly used today, should become more widespread in architectural education. Determining the possible reasons for using diagrams as an expression tool so that architectural students can convey their thoughts, their tendencies towards this tool, and the readability of information through this tool will help to reveal whether this tool is functional. For this purpose, it was tried to determine through which channels students' tendencies towards using diagrams are realized and how they benefit from diagrams.

Research Model: This questionnaire study aimed to reach conclusions about the students' tendency to use diagrams, the extent to which they benefit from diagrams, and whether the diagram is useful. Architecture students' preferences for using diagrams were analyzed numerically and examined in light of theoretical knowledge.

Population and Sample: Architectural expression tools start to be used in the first semester of architectural education. The use of various expression tools in educational institutions is seen especially in senior students. The reason for these uses is the increasing knowledge, and the desire to explain different aspects of the design with different tools with more than one expression tool learned.

Architectural education is 4-year; students must take architectural project courses for eight semesters. It is known that diagrams are an expression tool that students experience in architectural project courses. In this respect, it is thought that the students participating in the survey have gained knowledge and skills about diagrams.

Scope of the Field Study: Since the content of the architectural project courses was suitable for the study, no additional preliminary study was conducted with the students for the survey.

5.1. Data Collection Tools

The data were collected using a face-to-face questionnaire method. The questionnaire form used in data collection consisted of a preliminary information letter addressed to the respondent and two sections. In the first one, questions about the gender, age, semester of education, place of birth, and universities of the participants were included. In the second one, there were questions about 'sources of information before architectural design (8 questions)', 'preferred representation/ expression techniques in the architectural design process (16 questions)', 'questions on

traditional representation/expression techniques (9 questions)', 'Diagram as a Representation / Expression Tool (24 questions)', and Success in Reflecting Knowledge of Diagram Design as a Representation/Expression Tool (12 questions)'.

The questions were grouped according to the information they would provide. The questions in group A were prepared as questions about the channels through which students obtained the data they would use in the project and which of these channels were more effective. The questions in group B were prepared for which expression techniques preferred in the design process they found more compelling. The questions in group C are about traditional expression techniques, and their reasons for preference and general opinions about these techniques were to be measured. The questions in group D were designed to analyze the reasons for their preference for diagrams and their opinions on whether diagrams are an effective tool. With the visual questions in group E, it was tried to measure whether or not the students' readings of the diagram for the given information were positive.

The researchers created the questions related to the measurement tools by reviewing the relevant literature. Questions were selected from the pool of questions in line with expert opinions. The measurement tools were scored on a five-point Likert scale from one to five: 1= = strongly disagree, 2= = disagree, 3= = undecided, 4= = agree, 5= = strongly agree. The Cronbach's alpha reliability coefficients of the measurement tools are as follows: highly reliable for 'Sources of Information Before Architectural Design' with 0.611, highly reliable for 'Preferred Representation/Expression Techniques in the Architectural Design Process' with 0.761, highly reliable for 'Questions on Traditional Representation/Expression Techniques' with 0.684, highly reliable for 'Diagram as a Representation/Expression Tool' with 0.864, and highly reliable for 'Success in Reflecting Knowledge of Diagram Design as a Representation/Expression Tool' with 0.862 (Uzunsakal & Yıldız, 2018).

5.2.Data Analysis

SPSS 21.0 package statistical program was used to analyze the data collected in the study. In the analyses, it was first evaluated whether the data fit the normal distribution. After determining the conformity of the data to the normal distribution, unrelated sample t-tests and one-way ANOVA tests were applied. Furthermore, arithmetic mean, standard deviation, mean, kurtosis, and skewness values were analyzed. Pearson correlation analysis was performed to determine the relationship between the measurement tools.

5.3. Findings and Evaluation of the Field Study

In the first step of the study, the survey included architecture students from architecture schools in Kayseri. The survey questions were directed to students from four different classes from both schools. In the study, 105 students from Erciyes University and 138 students from Nuh Naci Yazgan University participated. In total, 243 students, including some senior students, participated in the study. SPSS 21 package program was used in the analysis of the questionnaire. As a result of the evaluation, the following results were obtained.

It was determined that 58.9% of the students participating in the study were female, and 41.1% were male. Moreover, it was observed that 51.6% of the participants were between the ages of 21 and 23, and 31.7% were in the 8th semester. When the institutions where the students received undergraduate education were examined, it was determined that 56.1% were studying at Erciyes University, and 56.9% lived in Kayseri province (Table 1).

When the mean standard deviation scores of the measurement tools were examined, it was observed that 'Sources of information before architectural design' was 3.935±0.536, 'Preferred representation/expression techniques in the architectural design process' was 3.456±0.537, 'Questions on traditional representation/ expression techniques' was 3.593±0.613, 'Diagram as a representation/expression tool' was 3.715±0.548, and 'Success in reflecting knowledge of diagram design as a representation/ expression tool' was 3.969-0.622. The Cronbach's

alpha reliability coefficients of the measurement tools were 0.611, 0.761, 0.684, 0.864, and 0.862, respectively (Table 2).

The correlation values of the measurement tools are given in Table 3. There was a moderate and positive correlation between the sources of information before architectural design and the preferred representation/expression techniques in the architectural design process ($r=0.478$; $p<0.01$). There was a moderate and

Table 1. Descriptive data of architecture students

		Number (n)	Percentage (%)
Gender	Female	145	58.9
	Male	101	41.1
Age	18-20	82	33.3
	21-23	127	51.6
	24-26	26	10.6
	27 and above	11	4.5
Education semester	1st semester	2	0.8
	2nd semester	65	26.4
	3rd semester	3	1.2
	4th semester	45	18.3
	5th semester	3	1.2
	6th semester	38	15.4
	7th semester	12	4.9
	8th semester	78	31.7
School	ERU	105	42.7
	NNYU	138	56.1
	AGU	3	1.2
Place of birth	Kayseri	140	56.9
	West	69	28.0
	East	37	15.0
	TOTAL	246	100.0

ERU: Erciyes University, NNYU: Nuh Naci Yazgan University; AGU: Abdullah Gül University

Table 2. Total mean scores of the measurement tools

	Min±Max	X ±SD	Cronbach's alpha (α)
Sources of information before architectural design	1.13-5.00	3.935±0.536	0.611
Preferred representation/expression techniques in the architectural design process	2.06-5.00	3.456±0.537	0.761
Questions on traditional representation/expression techniques	1.22-5.00	3.593±0.613	0.684
Diagram as a representation/expression tool	2.00-5.00	3.715±0.548	0.864
Success in reflecting knowledge of diagram design as a representation/expression tool	1.00-5.00	3.969-0.622	0.862

$\bar{X}$: mean; SD: Standard Deviation

Table 3. Mean, Standard Deviation, and Correlation values of Measurement Tools

	1	2	3	4	5
Sources of information before architectural design	-				
Preferred representation/expression techniques in the architectural design process	0.478**	-			
Questions on traditional Representation/Expression techniques	0.370**	0.446**	-		
Diagram as a representation/expression tool	0.351**	0.452**	0.485**	-	
Success in reflecting knowledge of diagram design as a representation/expression tool	0.360**	0.294**	0.341**	0.479**	-

Pearson rho (** $p < 0.01$, * $p < 0.05$), $\bar{X}$: mean; SD: Standard Deviation

positive relationship between the sources of information before architectural design and the questions on traditional representation/ expression techniques (r=0.370; p<0.01). Moreover, there was a moderate and positive relationship between the sources of information before architectural design and the diagram as a representation/expression tool (r=0.351; p<0.01). Furthermore, there was a moderate and positive relationship between the sources of information before architectural design and the success in reflecting knowledge of diagram design as a representation/expression tool (r=0.360; p<0.01). There was a moderate and positive relationship

Table 4. Distribution of the total mean scores of students' sources of information before architectural design according to their descriptive characteristics

		X̄±SD	Test	p
Gender	Female	4.026±0.467	**t=3.256***	**p=0.035****
	Male	3.804±0.059		
Age	18-20	3.788±0.651	**F=3.492****	**p=0.016****
	21-23	3.820±0.495		
	24-26	4.031±0.524		
	27 and above	4.034±0.506		
Education semester	1st	3.780±0.548	**F=3.061**	**p=0.004****
	2nd	3.888±0.475		
	3rd	3.894±0.419		
	4th	3.916±0.505		
	5th	4.017±0.579		
	6th	4.270±0.432		
	7th	4.500±0.000		
	8th	4.666±0.577		
School	ERU	3.907±0.508	F=0.480	p=0.620
	NNYU	3.962±0.562		
	AGU	3.750±0.250		
Place of birth	Kayseri	3.950±0.554	F=0.118	p=0.889
	West	3.916±0.522		
	East	3.935±0.536		

X̄: mean; SD: Standard Deviation; * t-test; ** one-way ANOVA; *** p<0.05; ERU: Erciyes University, NNYU: Nuh Naci Yazgan University; AGU: Abdullah Gül University, sem.: Semester

Table 5. Distribution of total mean scores of preferred representation/expression techniques in the architectural design process according to students' descriptive characteristics,

		X̄±SD	Test	p
Gender	Female	3.459±0.547	t=0.126	p=0.745
	Male	3.451±0.524		
Age	18-20	3.317±0.566	**F=3.241****	**p=0.023****
	21-23	3.439±0.386		
	24-26	3.533±0.545		
	27 +	3.642±0.537		
Education semester	1st	3.326±0.511	**F=3.318****	**p=0.002****
	2nd	3.370±0.413		
	3rd	3.403±0.569		
	4th	3.375±0.875		
	5th	3.535±0.525		
	6th	3.625±0.380		
	7th	4.375±0.000		
	8th	4.375±0.866		
School	ERU	3.276±0.439	F=0.000**	p=0.000***
	NNY	3.594±0.569		
	AGU	3.375±0.286		
Place of birth	Kayseri	3.487±0.574	F=2.138	p=0.120
	West	3.481±0.522		
	East	3.288±0.378		

X̄: mean; SD: Standard Deviation, * t-test, ** one-way ANOVA, *** p<0.05

between the preferred representation/expression techniques in the architectural design process and the questions on traditional representation/ expression techniques (r=0.446; p<0.01). A moderate and positive relationship existed between the preferred representation/expression techniques in the architectural design process and the diagram as a representation/expression tool (r=0.452; p<0.01). Besides, there was a low level and positive relationship between the preferred representation/expression techniques in the architectural design process and the success in reflecting knowledge of diagram design as a representation/expression tool (r=0.294; p<0.01). A moderate and positive relationship existed between the questions on traditional representation/expression techniques and the diagram as a representation/expression tool (r=0.485; p<0.01). Moreover, there was a moderate and positive relationship between the questions on traditional representation/ expression techniques and the success in reflecting knowledge of diagram design as a representation/expression tool (r=0.341; p<0.01). There was a moderate and positive relationship (r=0.479; p<0.01) between the diagram as a representation/expression tool and the s success in reflecting knowledge of diagram design as a representation/expression tool (Cohen, 1988).

The distribution of the total mean scores of the students according to their descriptive characteristics is given in Table 4. It was determined that the difference between the participants' gender, age, and semester of education and the total mean scores of the sources of information before architectural design was significant (p<0.05). The post-hoc analysis determined that the total mean scores of women's sources of information before architectural design were higher than those of men. At the same time, it was determined that as the age and semester of education increase, the total mean scores of the sources of information before architectural design increase. The difference between school and place of birth and the total mean scores of sources of information before architectural design was not statistically significant (p>0.05).

The distribution of the total mean scores of the representation/expression techniques preferred in the architectural design process according to the descriptive characteristics of the students is given in Table 5. It was determined that the difference between the participant's age, semester of education and school, and the total mean scores of representation/expression techniques preferred in the architectural design process was significant (p<0.05). According to the post-hoc analysis, it was determined that as the age and semester of education increase, the total mean scores of representation/expression techniques preferred in the architectural design process increase. In addition, it was determined that the total mean scores of NNYU students were higher than AGU students, and the total mean scores of ERU students were higher than AGU students. These differences were determined to be statistically significant (p<0.05). There was no statistically significant difference between ERU and AGU students' total mean scores of representation/expression techniques preferred in the architectural design process (p>0.05). The difference between gender, place of birth, and the total mean scores of representation/expression techniques preferred in the architectural design process was not statistically significant (p>0.05).

Table 6. Distribution of the mean total scores of questions on traditional representation/ expression techniques according to students' descriptive characteristics

		X̄±SD	Test	p
Gender	Female	3.676±0.588	t=2.577	p=0.814
	Male	3.474±0.631		
Age	18-20	3.604±0.615	F=2.075	p=0.104
	21-23	3.610±0.607		
	24-26	3.359±0.631		
	27 +	3.868±0.513		
Education semester	1st	3.777±0.000	F=1.659	p=0.120
	2nd	3.500±0.641		
	3rd	4.555±0.769		
	4th	3.637±0.524		
	5th	3.703±0.570		
	6th	3.611±0.653		
	7th	3.824±0.557		
	8th	3.555±0.607		
School	ERU	3.537±0.558	F=0.768	p=0.465
	NNY	3.636±0.642		
	AGU	3.592±1.134		
Place of birth	Kayseri	3.642±0.625	F=1.891	p=0.140
	West	3.589±0.599		
	East	3.417±0.572		

X̄: mean; SD: Standard Deviation, * t-test, ** one-way ANOVA, *** p<0.05

The distribution of the mean total scores of the questions on traditional representation/ expression techniques according to the descriptive characteristics of the students is given in Table 6. It was determined that the difference between the mean total scores of the questions on traditional representation/ expression techniques and gender, age, semester of education, school, and place of birth was not statistically significant (p>0.05).

Table 7. Distribution of mean total scores of students' use of diagrams as a representation/ expression tool according to their descriptive characteristics

		X̄±SD	Test	p
Gender	Female	3.771±0.531	t=1.953	p=0.998
	Male	3.633±0.564		
Age	18-20	3.614±0.563	F=1.687	p=0.170
	21-23	3.744±0.556		
	24-26	3.823±0.525		
	27 +	3.872±0.257		
Education semester	1st sem.	3.486±0.494	**F=5.791****	**p=0.000*****
	2nd sem.	3.663±0.594		
	3rd sem.	3.713±0.530		
	4th sem.	3.798±0.489		
	5th sem.	3.966±0.802		
	6th sem.	4.125±0.349		
	7th sem.	4.633±0.635		
	8th sem.	4.700±0.000		
School	ERU	3.653±0.415	F=1.608	p=0.202
	NNYU	3.767±0.629		
	AGU	3.466±0.493		
Place of birth	Kayseri	3.740±0.577	F=0.438	p=0.646
	West	3.697±0.520		
	East	3.651±0.491		

X̄: mean; SD: Standard Deviation, * t-test, ** one-way ANOVA, *** p<0.05

The distribution of the mean total scores of diagrams as a representation/expression tool according to the descriptive characteristics of the students is given in Table 7. It was determined that the difference between the participants' semester of education and the mean total score of diagrams as a representation/expression tool was significant (p<0.05). The post-hoc analysis determined that as the semester of education increases, the mean total score of diagrams as a representation/expression tool increases. The difference between the mean total scores of diagrams as a representation/expression tool and gender, age, school, and place of birth was not statistically significant (p>0.05).

Table 8. Distribution of total mean scores of students' success in reflecting knowledge of diagram design as a representation/expression tool according to their descriptive characteristics

		X̄±SD	Test	p
Gender	Female	4.079±0.597	t=3.390	p=0.584
	Male	3.811±0.627		
Age	18-20	3.870±0.599	F=1.449	p=0.229
	21-23	4.002±0.649		
	24-26	4.137±0.536		
	27 +	3.939 ±0.625		
Education semester	1st	3.763±0.649	**F=53.205****	**p=0.003*****
	2nd	3.770±0.554		
	3rd	4.027±0.867		
	4th	4.096±0.641		
	5th	4.097±0.602		
	6th	4.166±0.000		
	7th	4.187±0.542		
	8th	4.638±0.625		
School	ERU	3.977±0.587	F=0.219	p=0.803
	NNYU	3.959±0.651		
	AGU	4.194±0.673		
Place of birth	Kayseri	3.991±0.574	F=2.027	p=0.134
	West	3.425±0.592		
	East	3.783±0.812		

X̄: mean; SD: Standard Deviation, * t-test, ** one-way ANOVA, *** p<0.05

The distribution of the total mean scores of the students ' success in reflecting knowledge of diagram design as a representation/expression tool according to their descriptive characteristics is given in Table 8. It was determined that the difference between the semester of education and the total mean scores of the participants' success in reflecting knowledge of diagram design as a representation/expression tool was statistically significant (p<0.05). According to the post-hoc analysis, it was determined that as the semester of education increases, the total mean scores of successes in reflecting knowledge of diagram design as a representation/expression tool increase. It was determined that the difference between gender, age, school, and place of birth and the total mean success scores in reflecting knowledge of diagram design as a representation/expression tool was not statistically significant (p>0.05).

Distribution of the mean values of the answers given to the survey questions on a 5-point Likert scale according to the descriptive characteristics of the students (1: Strongly disagree, 2: Disagree, 3: Undecided, 4: Agree, 5: Strongly agree)

Although the survey questions are not included in the article, the mean values of the answers

given statistically show the tendency in the answers given to the survey question groups according to the descriptive characteristics of the students. The general tendency of the students, which is close to 5, shows that the tendency and knowledge are at a high level.

Sources of Information Before Architectural Design

The questions belonging to this group tried to evaluate how the students participating in the survey evaluate the sources they consult for information before starting architectural design. The aim was to determine the extent to which they were influenced by virtual environments, along with a curiosity about whether the information they would use in design was gained directly or indirectly. Accordingly, it can be interpreted that students attach great importance to the information they obtain from the physical environment that they directly experience and infer.

Preferred Representation/ Expression Techniques in the Architectural Design Process

Questions belonging to this group were asked about the representation tools that volunteer students may prefer in the architectural design

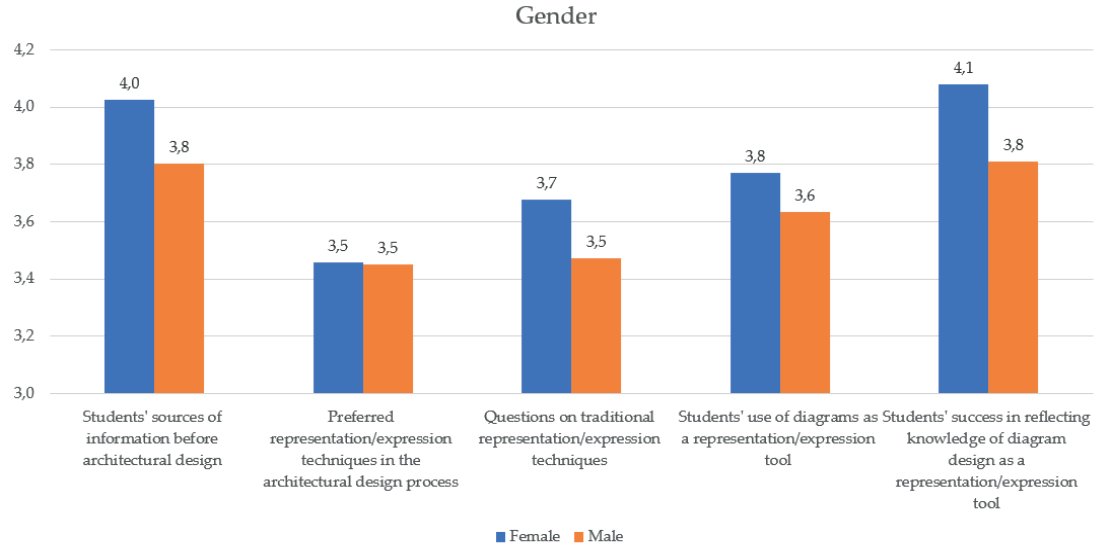


Figure 2. Gender

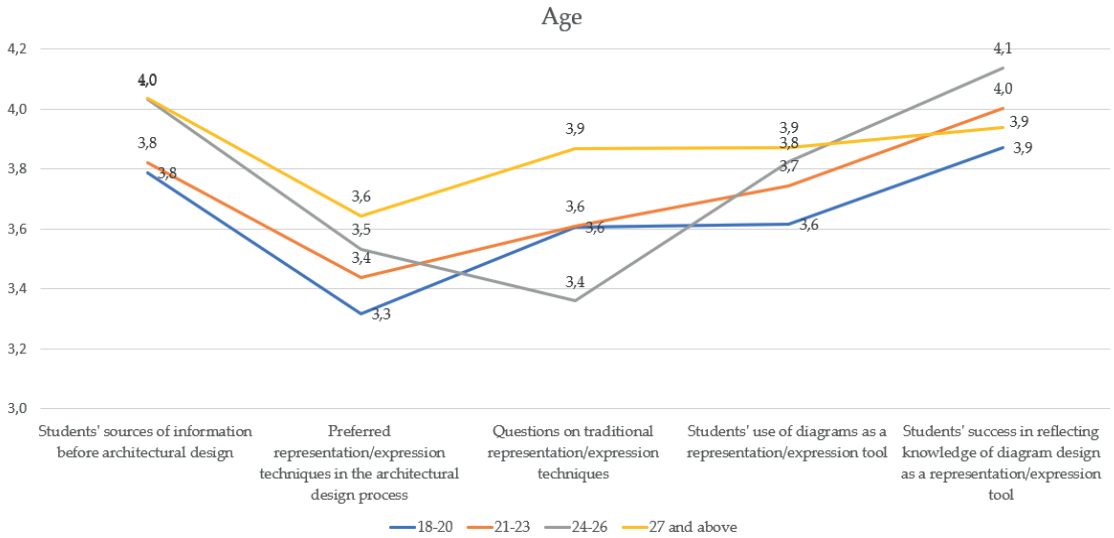


Figure 3. Age

process. Their tendency to use and choose traditional representation/expression media (2D drawings and models on the paper plane) and digital representation/expression media (digital plane and 3D modeling programs, animations, digital diagrams, AR, VR) were examined. The results showed that as the knowledge-skill level of the students increases, they tend to use diagrams.

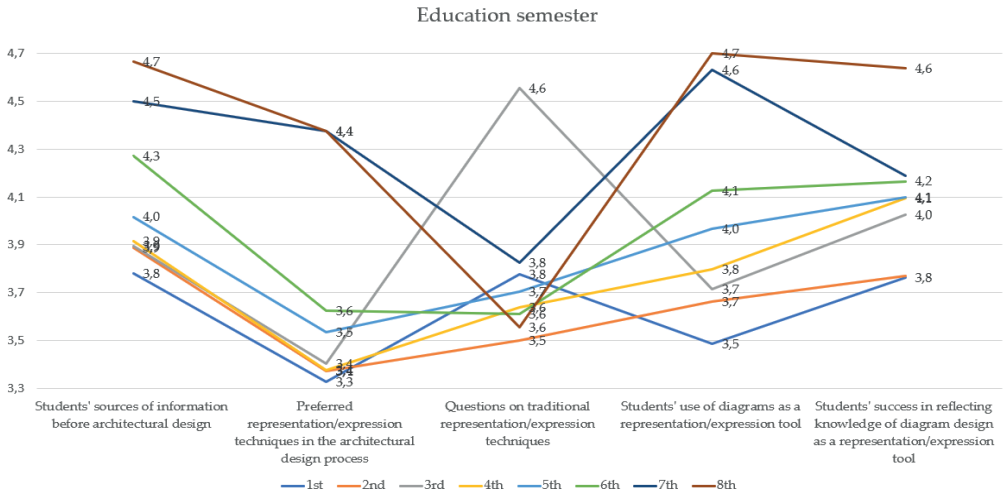


Figure 4. Student grade level

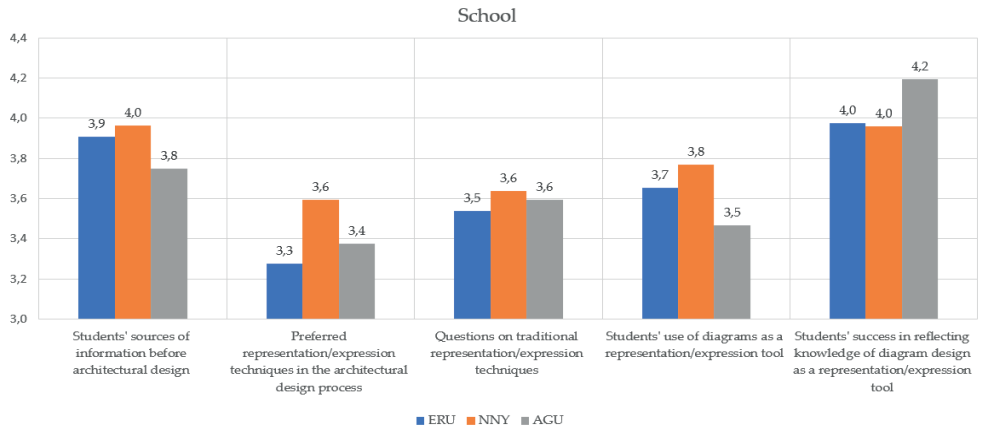


Figure 5. School

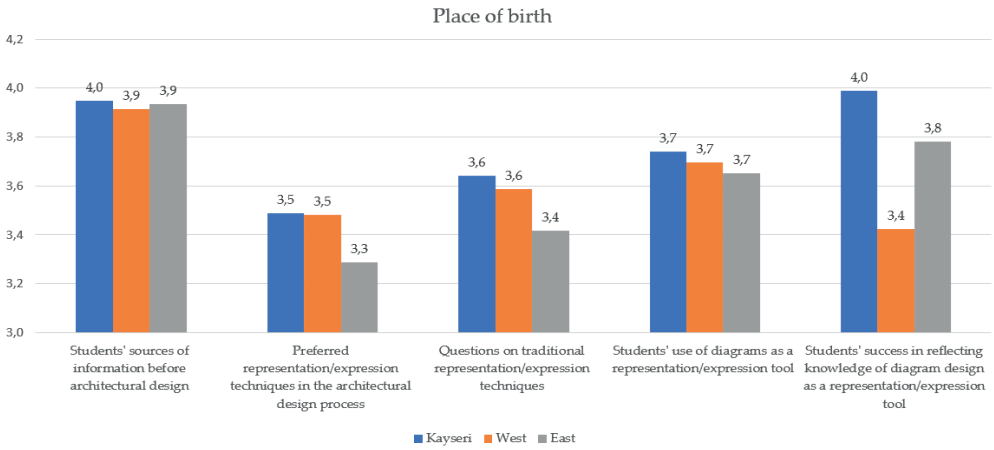


Figure 6. Place of birth

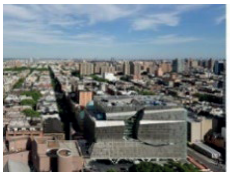
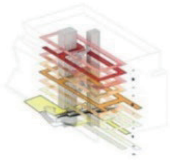
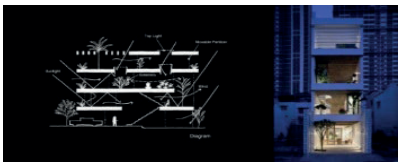
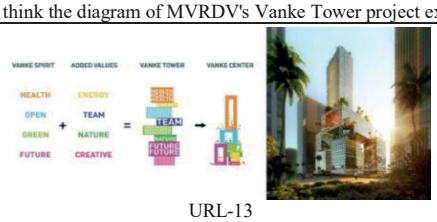
Questions on Traditional Representation/ Expression Techniques

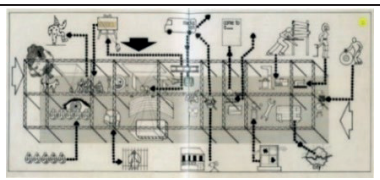
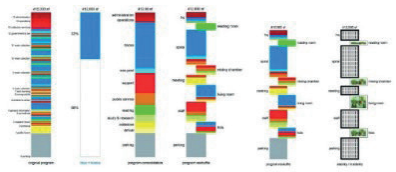
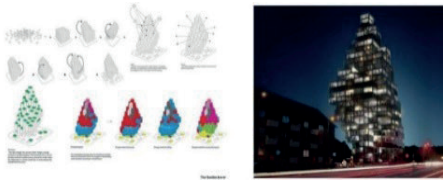
This section tried to learn how the volunteers who participated in the survey used traditional expression tools and their perspectives on these media tools in the design process. It is understood that as the participants' education semester increases, they approach expression tools differently from traditional ones. As their education of semesters increases, their ability to use other representation tools or interpret what is produced increases depending on their knowledge and skills.

Diagram as a Representation/Expression Tool

Questions were asked to understand the students' habits of using diagrams, how they obtained information in this field, and their perspectives on using this new medium. The status of the diagram as a tool that can be used

Table 9. Questions and answers on the success in reflecting knowledge of diagram design as a representation/ expression tool according to the students' descriptive characteristics

Success In Reflecting Knowledge Of Diagram Design As A Representation/Expression Tool		**Scale (5-point Likert)**	**n(%)**
1	I think these diagrams of the Cooper Union for the Advancement of Science and Art project by Morphosis sufficiently explain the circulation of the building.		
	  a. URL-8 b. URL-9	**Strongly disagree**	**4(1.6)**
		Disagree	**15(6.2)**
		Undecided	**49(20.2)**
		Agree	**90(37.0)**
		Strongly agree	**85(35.0)**
2	I think this diagram of the Anh House project by Sanuki+Nishizawa adequately explains the spatial organization of the building.		
	 a. URL-10 b. URL-11	**Strongly disagree**	**7(2.9)**
		Disagree	**15(6.2)**
		Undecided	**49(20.2)**
		Agree	**90(37.0)**
		Strongly agree	**82(33.7)**
3	I think that SO-IL's Pole Dance activity diagrams sufficiently explain the project concept.		
	 URL-12	**Strongly agree**	**18(7.4)**
		Disagree	**31(12.8)**
		Undecided	**68(28.0)**
		Agree	**72(29.6)**
		Strongly disagree	**54(22.2)**
4	I think the diagram of MVRDV's Vanke Tower project explains the program sufficiently.		
	 URL-13	**Strongly disagree**	**6(2.5)**
		Disagree	**23(9.5)**
		Undecided	**36(14.8)**
		Agree	**82(33.7)**
		Strongly agree	**96(39.5)**
5	The diagrams of BIG's VIA 57 West project successfully explain the development decisions of the building's form.		
	 URL-14	**Strongly disagree**	**4(1.6)**
		Disagree	**5(2.1)**
		Undecided	**37(15.2)**
		Agree	**75(30.9)**
		Strongly agree	**122(50.2)**
6	The diagrams of the Fun Palace project by Cedric Price are legible and provide information about the activities.		

	 URL-15	**Strongly disagree**	**5(2.1)**
		Disagree	**14(5.8)**
		Undecided	**52(21.4)**
		Agree	**94(38.7)**
		Strongly agree	**78(32.1)**
7	OMA's Seattle library is handy in explaining library information with a conceptual diagram. (Note: This and the following 2 questions belong to the same structure.)		
	 a. URL-16 b. URL-17	**Strongly disagree**	**6(2.5)**
		Disagree	**19(7.8)**
		Undecided	**68(28.0)**
		Agree	**80(32.9)**
		Strongly agree	**70(28.8)**
8	OMA's Seattle library programs the structure by compressing information from this diagram, which is useful for solving complex relationships.		
	 URL-18	**Strongly disagree**	**4(1.6)**
		Disagree	**18(7.4)**
		Undecided	**54(22.2)**
		Agree	**87(35.8)**
		Strongly agree	**80(32.9)**
9	The program diagrams of the OMA's Seattle library are similar to the final version of the structure.		
	 a.URL-19 b.URL-20 c.URL-21	**Strongly disagree**	**2(0.8)**
		Disagree	**9(3.7)**
		Undecided	**28(11.5)**
		Agree	**97(39.9)**
		Strongly agree	**107(44.0)**
10	The diagrams of MVRDV's mixed-use Sky Village project successfully explain form formation from part to whole.		
	 URL-22	**Strongly disagree**	**5(2.1)**
		Disagree	**9(3.7)**
		Undecided	**46(18.9)**
		Agree	**93(38.3)**
		Strongly agree	**90(37.0)**
11	This series of diagrams of the Serp & Molot Factory by MVRDV does an excellent job of illustrating the evolution of site decisions.		
	 URL-23	**Strongly disagree**	**1(0.4)**
		Disagree	**11(4,5)**
		Undecided	**40(16,5)**
		Agree	**95(39,1)**
		Strongly agree	**96(39,5)**
12	I think it is positive that the relational diagrams used in shaping the island in BIG's Oceanix City project also determine the project's final form.		
	 URL-24	**Strongly disagree**	**6(2.5)**
		Disagree	**14(5.8)**
		Undecided	**52(21.4)**
		Agree	**78(32.1)**
		Strongly agree	**93(38.3)**

in all design phases and the students' habits of participating in the survey to use this potential was questioned. The answers to the questions in this group are given in detail below.

Success in Reflecting Knowledge of Diagram Design as a Representation/Expression Tool

The understanding and interpretation skills of the volunteer students participating in the survey were questioned through examples. In this part of the questionnaire, architecture students were asked about the success of various diagrams given/transferred with their visuals in expressing the design idea, part or whole of the design. The answers given to this part reflect the conclusion that the students ' ability to understand and interpret the diagrams is high and that the information about the purpose of the diagrams is understandable by them).

From the answers given to this part of the questionnaire (table 9), it is understood that the architectural diagrams produced by world-renowned architectural offices, accessible and circulated on the Internet, can be understood by the students and are open to interpretation. It is seen that the rate of comprehension of the diagrams visibly increases in the upper grades. It is understood that the diagrams given in the examples have a high comprehension rate by the participating students and that the diagrams effectively convey the idea they represent, even among architecture students.

6. DISCUSSION & CONCLUSION

The production of architectural knowledge and objects, which are affected by the dynamics of the age, is realized with different justifications and possibilities in every period. The explicit and implicit structures of architectural knowledge make it difficult to transfer the knowledge of the discipline and make it open to interpretation. The fact that architecture's accumulation is multilayered with the information it receives from interdisciplinary intersections and the boundaries of knowledge have become ambiguous, making producing, transferring, and explaining knowledge even more difficult. Along with these changes, it also changes the perception of the subject who produces and uses knowledge.

Diagrams have historically been involved in many stages of the design phase. Starting from the analysis phase, they have become a productive model today. Although their effectiveness in education generally stays in the concept idea or form formation stages, the frequency of use is mainly in the analysis stage. The effective use of diagrams facilitates communication between students and educators, as they emphasize the critical qualities of the dialogue. Diagrams are also an interdisciplinary tool that should be given importance as an expression technique that should be used more by students and architects.

Considering that knowledge is obtained from a mental process or can be defined with the help of consciousness, it is necessary to look at how knowledge is produced to comprehend what and how architectural knowledge is. The view of the production of knowledge also changes the view of changing conceptions of space, the production and transmission of the architectural object. For this reason, within the scope of the study, a study was carried out on how the production and transfer of architectural knowledge should be produced-transferred environments, tools under the changing architectural environment, and the perception styles of the subjects who produce it.

Although architectural education occurs within an institutionalized educational space, studio/workshop courses, where students reflect on their work and personal preferences, are defined as an environment where experiences are transferred. The fact that students receive education under the direct guidance and rules of the studio instructor makes it possible to bring the educational space closer to the formal boundary. However, the fact that the educator's or instructor's approach to teaching knowledge to the student is to teach knowledge directly or to teach how to access knowledge enables the studio/workshop environment to be defined as an informal process. Students participating in informal environments gain alternative thinking skills and become productive subjects. Therefore, the educational environment needs to operate within informal boundaries to support the development of alternative thinking skills.

Since every concept or phenomenon with abstract and concrete content used in the design process can be expressed through diagrams, it becomes an effective tool for architects and architect candidates. Diagrams facilitate the transfer and understanding of multilayered architectural knowledge and complex design thinking between the two generations as the most appropriate means of expression between digital natives who have the skills to use graphic language as their mother tongue and digital immigrants who are considered more prone to use textual language. On the other hand, it can be said that the increasing interest in diagrams in the contemporary architectural environment through various dominant media tools affects the students' preference for diagrams in their designs.

For the reasons mentioned above, it was necessary to focus on architectural education as a field that is shaped or should be shaped by the changing environmental conditions within the study's boundaries. Referring to these subjects who are the demanders of education as digital natives and those who are the givers of education as digital immigrants can be considered as opening a new door. The architectural education process feeds from different environments and needs different resources. As mentioned, a large part of the architectural knowledge structure is tacit. It needs a dialogue-based and experiential model that requires a master-apprentice relationship to be transferred, but it also needs online or digital environments today. Since the students in the educational environment have become digital natives, changing the priority of reference sources and how they perceive them. Their use of computer technologies and internet resources has moved the space of knowledge production to a different dimension and created information stack spaces. Due to this situation, information processes are carried out in institutionalized and formal and informal educational environments. While trying to cope with these multimedia conditions, architecture students can neither receive education nor produce knowledge in an idealized way. The transfer of knowledge between individuals is always imperfect. However, considering that most educators in the educational environment are digital immigrants and their students are digital natives, new arrangements need to be made for the perceptions of the new generation to make education more effective.

This study attempted to examine the tendency of students, who are considered digital natives and whose numbers are increasing in architectural education, to use diagrams to represent/express their design thoughts. The reason for this examination is that diagrams are considered to be an appropriate communication tool and language for the generation considered to be digital natives, and to what extent do students adopt this language? Thus, today's architects use graphics-based data visualization techniques to collect data that can be used in the design and evaluate and manage this data with statistics. By organizing, compressing, and abstracting information through simple graphics, ideograms, maps, infographics, diagrams, etc., they explain the production and formation process of new information and the end product they produce in this way. Architects who shape the flow of architecture use diagrams for this purpose both in their practices, discourses, and competition projects and are published through various platforms. Architect candidates, on the other hand, learn architecture in all it is changing aspects through the methods and experiences of those practicing architecture. Therefore, the expression tool or language used in the current flow transforms the tool and language of the students, and the languages that the students are used to affect the flow similarly.

The results and recommendations obtained from the examination and analysis of the use of diagrams in design processes in architectural education are as follows:

- Architectural knowledge is constantly expanding and changing its boundaries dynamically and movingly due to its multilayered knowledge and openness to information input from interdisciplinary fields. As a result, it chooses diagrams as a tool to solve the problem of placing the resulting knowledge within the discipline, establishing a relationship, and managing it. However, diagrams as an

interdisciplinary tool enable the transmission and transformation of knowledge between different disciplines.

• Diagrams can visualize data by reducing, abstracting, deforming, and establishing relationships to analyze, define, produce, and explain their relationality or functioning. In this way, diagrams enable different information types to be made available and represented at different stages of the design process.

• It was observed that diagrams included in different stages of design processes also support producing the idea they represent. Hence, each diagram used in representation processes has a productive aspect.

• Today, the process-oriented production of architecture instead of the final product requires making design processes visible. Abstract and concrete concepts, explicit and implicit knowledge of architecture, are expressed through diagrams, establishing relationships with each other and producing new knowledge. At this point, every architectural element conceptualized by the diagram or the phenomena that architecture relies on can be used functionally by students through diagrams, and design thinking can be easily explained.

• The fact that architecture students incorporate diagrams into their design processes shows that they are open to developing a process-oriented design style. However, the low use of the generative diagram, which has the highest productivity in representation processes, shows that students use diagrams to explain, define, and present the design idea in the formation or completion process rather than producing the design directly with diagrammatic design approaches.

• It was observed that specific diagrams preferred by the students in each design process come to the forefront due to their overlapping actions with representation. For instance, analytical diagrams are most prominent in the analysis process, procedural diagrams are most prominent in the synthesis process, and descriptive diagrams are most prominent in the evaluation process. The prominence of operational diagrams rather than generative diagrams, especially in the synthesis phase, reveals that students use diagrams to strengthen comprehension and expression.

• Although diagrams can provide information on the properties of the final product, they can also be used in representation processes. Relational and operational diagrams in these processes contribute positively to developing conceptual thinking skills by defining the relationships between abstract concepts and phenomena. Therefore, diagrams should be included more in architectural education.

• Making tacit knowledge explicit to be used as data in architectural design through externalization facilitates the transfer, processing, and evaluation of the data; it becomes possible to transfer the information blurred in mind to digital environments through diagrams. This situation eliminates the necessity of face-to-face interaction for the transfer of tacit knowledge.

• In architectural education, the student should not be a passive learner but actively reflexively participate in the learning process. In this process, the studio environment should be organized to support alternative thinking skills and use diagrammatic generative tools and models.

• It was concluded that diagrams are a tool that can be used not only for design courses but also for transferring information to students in other theoretical courses due to their compatibility with digital language and its ease of perception by translating all kinds of information that can form data for design into visual code with a simple expression. Through this use, the educational environment can improve the quality of education by integrating with online/digital environments, which are the primary reference channels for students.

• To use the productive aspect of diagrams more effectively, it is clear that information about the theoretical underpinnings needed for the tool should be given in the early stages of education. Furthermore, it is thought that in architectural education courses where computer-aided

design and architectural expression techniques are taught, theoretical underpinnings should be established for the techniques and the use of the techniques.

As can be seen, diagrams can be used at all stages of the design process. Traditional and digital tools can be used to prepare the ground for initial decisions through analysis and resolution at an early design stage or to concretize and verify the initial design idea. However, it can be said that the features of the diagram not only make it easy to explain and understand the thought by simplifying the expression and contribute to conceptual thinking skills. In this respect, students should perceive diagrams as a tool that allows more than a presentation technique. Therefore, raising issues on the potential of the diagram in the educational environment and ensuring that students comprehend all aspects of diagrams in the changing architectural environment will facilitate the architect's education and adaptation to the discipline.

Ethical Aspects of the Research

Before starting the study, ethical permission (249) was obtained from the Erciyes University Social and Human Sciences Ethics Committee. Moreover, informed consent was obtained from the volunteers included in the study, and ethical principles were followed at every stage of the study.

REFERENCES

ALLEN, S. (2009). *Practice: Architecture Technique + Representation*, Routledge, 2nd Edition New York (pp.93).

ANTHONY, V. (2000). The diagrams of utopia, Daidalos-architecture, art, culture, *Diagrammania*, 74(1), 6-13s.

ARCAN, E.F., & EVCI, F. (1992). *Mimari tasarıma yaklaşım.* İki K Yayınevi, İstanbul (pp.208).

BUN, Z. (2009). Making design concepts in the nineties. Theoretical models of UN Studio. *Periodica Polytechnica Architecture*, 40(2), 55-63.

CEYLAN, E. (2010). Modern bir Mimari Temsil ve Performans Aracı ya da Mimarlıkta Diyagram. MSGSÜ Fen Bilimleri Enstitüsü, (Tez no: 276701), Doktora Tezi, İstanbul, 541s.

COHEN, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.) Hillsdale, NJ: Lawrence Erlbaum Associates, (pp109-139).

CORBELLINI, G. (2006). Diagrams. Instructions for use. *Lotus International*, 127, 88-95.

EISENMAN, P. (2005). *Diagram Diaries*, Universe Publishing, NY, ABD (pp.240).

GARCIA, M, (2010). *AD Reader - The Diagrams of Architecture*, AD Reader,John Wiley & Sons, London (pp.320).

GÖKMEN, H., & SÜER, D. (2003). Mimarlık eğitiminde tasarım stüdyolarına farklı yaklaşımlar. Ege Mimarlık, 47: 4-7. Erişim adresi: https://www.egemimarlik.org/cevirim-ici-okuma/47/779.

JACOBUS, F. R. (2014). Diagrams and abstractions: machines and desires, 634-640. *102nd ACSA Annual Meeting Proceedings Globalizing Architecture/ Flows and Disruptions* April 10-12. 2014, Miami Beach, FL., Florida International University, (pp.896).

JORMAKKA, K. (20129. *Adım Adım: Tasarım Yöntemleri*, (Çevirmeni: Z. Yazıcıoğlu Halu), YEM Kitabevi, İstanbul, 84s.

KÜRTÜNCÜ, B. (2011). Diyagram: Mimarlıkta Bir Düşünme, Tasarlama ve Temsil Aracı, İTÜ Fen Bilimleri Enstitüsü, (Tez no: 323755)Doktora Tezi, İstanbul, 147s.

PAI, H. (2002). *The Portfolio And The Diagram: Architecture, Discourse, And Modernity In America*, MA: The MIT Press, Cambridge, 383s.

PRENSKY, M. (2001(a)). Digital Natives, Digital Immigrants Part 1. From On the Horizon, 9(5). URL: http://www.marcprensky.com/writing/Prensky%20-%20Digital%20Natives,%20Digital%20Immigrants%20-%20Part1.pdf (Erişim Tarihi: 15.06.2019)

PRENSKY, M. (2001(b)). Digital Natives, Digital Immigrants Part 2: Do they really think differently? From On the Horizon, 9(6). URL : http://www.marcprensky.com/writing/Prensky%20-%20Digital%20Natives,%20Digital%20Immigrants%20-%20Part2.pdf (Erişim Tarihi: 15.06.2019)

ROWE, P.G. (1991). *Design Thinking*. The MIT Press, Massachusetts, (pp.229).

SEVALDSON, B. (1999). Research on digital design strategies. In Proceedings of useful and critical: The position of research in design, conference, (pp.13).

TEYSSOT, G. 2012. *The diagram as abstract machine*.V!RUS, (pp. 7)

URL-1. Oxford Dictionary. https://www.oxfordlearnersdictionaries.com/definition/english/diagram?q=diagram (Erişim Tarihi: 28.01.2023).

URL-2.TDK. http://sozluk.gov.tr/. (Erişim Tarihi: 28.01.2023).

URL-3. Cambridge Dictionary. https://dictionary.cambridge.org/dictionary/english/diagrammatic (Erişim Tarihi: 25.05.2019)

URL-4.(https://www.dailymail.co.uk/sciencetech/article-2478931/Is-worlds-oldest-warning-sign-9-000-year-old-painting-volcano-tells-people-nearby-danger.html) (Erişim Tarihi 03.06.2019)

URL-5.https://www.dailymail.co.uk/sciencetech/article-2478931/Is-worlds-oldest-warning-sign-9-000-year-old-painting-volcano-tells-people-nearby-danger.html(Erişim Tarihi 03.06.2019)

URL-6.https://content.openclass.com/eps/pepearson-reader/api/item/33c1ac75-46ce-4867-ae30-5281538f14a6/1/file/RubesteinCHG3-071415MB/OPS/s9ml/chapter01/filep70004 968340000000000000000502.xhtml (Erişim Tarihi 03.06.2019)

URL-7.https://www.unstudio.com. (Erişim Tarihi 03.06.2019)

URL-8. https://www.archdaily.com/40471/the-cooper-union-for-the-advancement-of-science-and-art-morphosis-architects/5011e78528ba0d5f4c000332-the-cooper-union-for-the-advancement-of-science-and-art-morphosis-architects-photo (Erişim Tarihi:15.03.2023)

URL-9.https://www.archdaily.com/40471/the-cooper-union-for-the-advancement-of-science-and-art-morphosis-architects/5011e79228ba0d5f4c000337-the-cooper-union-for-the-advancement-of-science-and-art-morphosis-architects-axon. (Erişim Tarihi: 15.02. 2023)

URL-10.https://www.archdaily.com/453719/anh-house-s-na-nil-sanuki-nishizawa-architects/529d232be8e44e553d00002a-anh-house-s-na-nil-sanuki-nishizawa-architects-diagram. (Erişim Tarihi:15.02. 2023)

URL-11.https://arqa.com/en/_arqanews-archivo-en/anh-house-vietnam.html. (Erişim Tarihi: 15.02. 2023)

URL-12. http://so-il.org/projects/pole-dance. (Erişim Tarihi: 16.02.2023)

URL-13. https://www.mvrdv.com/projects/370/vanke-3d-city. (Erişim Tarihi: 17.01.2023)

URL-14.https://www.archdaily.com/794950/via-57-west-big/57d16167e58eceafe5000175-vil-57-west-big-diagram. (Erişim Tarihi:02.02.2023)

URL-15.https://www.arkitektuel.com/fun-palace-cedric-price/cedric-price-paskplanas/. (Erişim Tarihi:02.02.2023)

URL-16.https://www.archdaily.com/11651/seattle-central-library-oma-lmn/572187c5e58ece53e100000d-seattle-central-library-oma-lmn-books. (Erişim Tarihi: 05.02.2023)

URL-17.https://www.arkitektuel.com/tag/kutuphane-mimarisi/.(Erişim Tarihi: 05.02.2023)

URL-18.https://www.archdaily.com/11651/seattle-central-library-oma-lmn/57219542e58ece408a000002-seattle-central-library-oma-lmn-seattle-program-diagram. (Erişim Tarihi:05.02.2023)

URL-19.https://www.doublestonesteel.com/blog/architecture/an-examination-of-the-design-theory-behind-seattle-central-library-by-oma/.(Erişim Tarihi: 15.02. 2023)

URL-20. https://worldarchitecture.org/article-links/pmhnv/the-perfect-drawing-8-sensational-sections-that-raise-the-bar-for-architectural-representation.html. (Erişim Tarihi:05.02. 2023)

URL-21.https://www.arkitektuel.com/tag/kutuphane-mimarisi/.(Erişim Tarihi:15.02. 2023)

URL-22.https://www.mvrdv.com/projects/70/rodovre-sky-village?photo=1274. (Erişim Tarihi: 08.02. 2023)

URL-23.https://bustler.net/news/3518/mvrdv-led-consortium-to-refurbish-historic-serp-molot-factory-site-in-moscow. (Erişim Tarihi:15.03.2023)

URL-24.https://big.dk/projects/oceanix-city-6399. (Erişim Tarihi:15.03.2023)

UZUNSAKAL, E., & YILDIZ, D. (2018). Alan araştırmalarında güvenilirlik testlerinin karşilaştirilmasi ve tarimsal veriler üzerine bir uygulama. *Uygulamalı Sosyal Bilimler Dergisi*, 2(1), 14-28.

VITRUVIUS, P. (2005). Vitruvius: Mimarlık Üzerine On Kitap. (çev: S. Güven). *Şevki Vanlı Mimarlık Vakfı Yayınları*, Ankara, 240s.

YÜREKLI, F., & YÜREKLI, H. (1995). Öğrenci ortaktır. *YAPI Dergisi*, (S 168), 65