

## **Board 2: WIP: Mind-mapping to Improve Architecture Students' Skills in Navigating Hands-on and Lecture-based Pedagogies**

### **Ignacio Guerra P.**

Ignacio is a part-time professor of Construction in the College of Architecture and Interior Design CADI at Universidad San Francisco de Quito USFQ. Ignacio is an architect from UCE and gained his MBA with emphasis in sustainability from the UCV. Ignacio's interests are in the areas of sustainable architecture and construction, new pedagogies for architecture studies and development. Ignacio is passionate to bring his experience in the construction industry into the classroom.

### **Juan Sebastian Andrade, Universidad San Francisco de Quito**

Juan Sebastián Andrade is an undergraduate student in the College of Architecture and Interior Design CADI at Universidad San Francisco de Quito USFQ.

### **Nicole Janine Villacís, Nicole Villacís**

Nicole is an undergraduate student in the College of Architecture and Interior design CADI at University San Francisco de Quito USFQ.

# WIP: Mind mapping to improve architecture students' skills in navigating hand-on and lecture-based pedagogies

Ignacio Guerra P.<sup>1\*</sup>, Juan Sebastián Andrade<sup>2</sup>, Nicole Villacís<sup>2</sup>

<sup>1</sup> Professor, Universidad San Francisco de Quito USFQ, Colegio de Arquitectura y Diseño de Interiores CADI, Departamento de Arquitectura, Casilla Postal 17-1200-841, Quito 170901, Ecuador.

<sup>2</sup> Undergraduate student, Universidad San Francisco de Quito USFQ, Colegio de Arquitectura y Diseño de Interiores CADI, Departamento de Arquitectura, Casilla Postal 17-1200-841, Quito 170901, Ecuador.

\* Correspondence: Ignacio Guerra P., [iguerrap@asig.com.ec](mailto:iguerrap@asig.com.ec), [iguerrap7@gmail.com](mailto:iguerrap7@gmail.com)

## Abstract

Worldwide architecture students learn under two main pedagogies such as studio hands-on practice and traditional lecture classes. Navigating under two unsynced pedagogies is difficult and can create disconnection between subjects under different pedagogies. To address this issue, educators are trying different approaches to bridge the skills required for both. This article explores the role of using Mind Mapping in lecture-based courses to connect with the knowledge of hands-on courses. During Fall 22, researchers used mind mapping in 4 courses of construction III (62 junior students) and 1 course of Constructions I (18 sophomore students). This study analyses the outcome of students' performance in terms of the knowledge highlighted in their mind maps and the application in their exams. Finally, instructors conducted a survey to inquire students about their perception about the role mind mapping plays in their learning and course performance. The authors reflect on the design of the intervention and explore the avenues academia could take to form new pedagogical approaches to connect skills from both pedagogies in architecture education. Implications for research and practice are provided.

## Introduction

Mind maps are a visual pedagogic tool that can be implemented for students who have a preference towards this type of learning method. It is relevant to emphasize that architecture students need to have visual learning methods to a certain extent because it is an artistic career in which visuals are highly relevant. "...Architecture students are generally visually orientated and have rather creative minds, capacities that seem less compatible with the more-strict rules and systematic approach of doing research" [1], [2]. Considering that architects are visually oriented, there is a preference towards the use of create visual study tools rather than traditional reading-writing methods.

It is important to consider that through the application of different teaching methods the knowledge can be further approached. In architecture, it is necessary to make relations between theoretical aspects and concepts with much more practical and technical applications. Thus, the requirement of having a broad comprehension of topics and the relations between them is fundamental. Through mind maps, graphic relations can be made between the several topics covered on a course. Visual tools can help "clarify the relationship

between material objects and concepts to understand” [3]. The critical challenges faced by an ArPM (Architect Project Manager) are ‘poor planning,’ ‘unfamiliar technology,’ ‘unfamiliarity with green buildings and materials,’ ‘inappropriate scheduling,’ and ‘poor workmanship’” [4]. Consequently, it is possible to question undergraduate architecture courses and whether they are properly preparing students for their professional performance.

Similarly, it is required for architecture students to develop academic skills. Academic skills have an interdisciplinary characteristic. Nevertheless, architecture students need them due to the nature of their career which cannot be completely classified as an art or science subject. Even though design is at the center of their focus, it is linked to plastic and technical aspects, which conform architecture. Hence, diverse study techniques must be adopted by the students to attend each of their academic needs. Some of the abilities expected to be developed through a traditional undergraduate education are reading, writing, discipline, and disposition towards studying [5]. All these skills are relevant and should be worked to prepare students to do architectural research. Second year of architecture students in Netherlands were questioned about their perspectives about research and their disposition towards taking academic courses related to the matter. The results reflected that even though most had a slightly positive opinion, mostly because they thought it was somewhat useful, they highly disliked them and got stressed about them [1], [6], [7]. Thus, academic skills should be developed, and traditional methods are not favorably taken by students.

As a result, researching about different teaching methods in the architecture field will lead to better prepared students in both academic and professional aspects. Hence, the use of mind maps and their benefits directly applied on architecture students on a course of their discipline is questioned. Also, the benefits mind maps have on the development of skills for traditional courses and how these could be related to skills acquired by other courses such as studio is core focus.

## **Background**

Nowadays, institutes and learning divisions have always been focused on the innovation and improvement of learning systems that are employed to transmit knowledge towards students. The usage of graphical study tools has grown in popularity to enhance teaching and learning by strengthening students' cognitive abilities [8], [9]. The ability to turn theoretical concepts into concrete and simple words through a didactic organization that is entertaining for students is a fundamental part of its success and constant use. First popularized by psychologist Tony Buzan in the early 20th century, mind maps are a method of note-taking and summarizing ideas in a particular order to maximize the different functionalities of the brain, developing better learning abilities [10]. In other words, in relation to young students, mind mapping is a method to expand ideas from a central theme. Also, it is understood how mind maps are diagrams that represent concepts related to a specific topic, stimulating visual learning capacity.

Likewise, it is interesting to emphasize that the tool allows a complete intellectual, cognitive, emotional, and even motor development, totally opposed to the old method of the rational school, typical of the nineteenth century, which placed a strong emphasis on reading and memorizing [11], [12].

There are several investigations about the importance of mind maps and their rapid integration as a tool that enhances mental activity. It is important to mention that, as defined by Eder Aco in his study, that mind maps are mainly used as representations of complex ideas [13], given that they are versatile in its visual application to several academic fields where graphic elements such as images, symbols and diagrams enhance the relationship of the concept explained. The ability to be able to summarize, diagram, explain and conceptualize theoretical ideas in a tangible and simple way allows its easy adaptation of application to branches of study such as architecture. In more detail, although mind maps are mainly for the development of children, the application of these in the learning of young university students means the possibility of a change in how processes are organized, which rules out the notion of depending on reviews before taking a test [11]. The university student, even having reached a certain mental maturity, can adapt to a new teaching tool that complements his development as a professional.

Despite bringing several benefits, the importance of mind mapping lies in the fact that it achieves a complete "holistic" learning process, where factors such as thinking, feeling, and acting are stimulated [11]. In this way, the activity is valuable for the student as it is a personal tool, i.e., it adapts to the needs and interests of everyone. Likewise, mind maps are creative ways for students to participate in a distinctive teaching approach that can assist establish a new environment for processing information [10], strengthening the relationship between the learner and the content. Finally, mind maps are concise and, therefore, will provide a technical summary of a student's strengths and weaknesses; being a useful tool for teachers who are interested in the progress and development of their students.

In architecture, there are two types of classes throughout the major, hands-on studios and traditional lecture-based courses. Both require different skills to navigate through them as they are different, the first one is totally based on the ability to express an idea with practical and manual skills whereas the traditional lecture-based courses are directed to the use of cognitive skills related to a different kind of mind focus. Mind mapping tries to connect hands-on skills in lecture-based classes as it encourages students to display their knowledge and course contents in a personal didactic way. Mind maps have advantages related to the skills or learning necessary for students, especially architecture students considering that they are the focus of the study. Therefore, it is necessary to consider which such academic skills are required by a college student, and which are necessary especially for an architecture student. As a first point, when considering a college student receiving more traditional classes, regardless of their major, academic proficiency is sought.

The skills of college students are directly related to their academic performance. "Academic preparedness is conceptualized as an overarching term comprising reading and writing skills, basic disciplinary skills and academic working skills, all of them preconditions for further academic development" [5]. These skills are through which students acquire their knowledge and develop their ideas, such as reading and writing [5]. Thus, they represent a primary form of learning in all disciplines. In fact, it is considered that the work of creating texts and skills of synthesis, conceptualization, among others, are necessary for a mastery and familiarity of the content studied. "Questioning, summarizing, clarifying and predicting are all phases of the learning process that students need to pursue despite challenges, exemplifying what it means to master academic work" [5], [14]. Similarly, the skills of

discipline and willingness to work academically are also vital in college students. "[Academic working skills] implies working in an engaged, focused and persistent way, following academic goals, despite obstacles and distractions" [15].

The skill that is essential to the discipline studied, architecture, is design, which is the focus of their learning process. "In practice, the architect provides a range of services ranging from design, contract administration, and renovation to project management. Design, however, remains the core competence of the architect" [16]. For which, there are classes where abilities required to design get developed. These abilities can be cognitive, problem-solving strategies or tools related to architecture. Cross [17] identified several core features of design abilities, such as: production of novel, application of imagination, use of graphs for problem-solving, adoption of solution focused strategies and the ability to create graphics and spatial models [16].

Of such skills related to design there are a few which are incredibly relevant such as: use of graphics as visual aids to communicate and solve ideas. Moreover, the use of graphs by architecture students goes beyond technical directions. Being able to work on visual aids includes the use of diagrams, composition of sheets and other aspects necessary to properly address a project.

Cognitive skills in architecture students ~~have been compared to other group,~~ science students. The evidence indicates architecture students tend to create several different solutions after analyzing certain situation. "Architects already showed greater ability in the production of solutions and less ability in the recognition of the problem structure" [18]. This is attributed, according to Lawson [19], to their academic learning process which also reflects the development of more refined planning skills than the other group they were compared to.

## **Research Objective**

The objective of this research was to pilot-test the influence the role that mind maps can have in the learning process of architecture students, who are constantly faced with the mix of conceptual and practical learning. The purpose of this study was (i) to support architecture students learning, and (ii) to help connecting practical concepts with theoretical knowledge, which happens often in architecture curriculum. This article presents the responses of the first pilot of assessment validation.

## **Methodology**

The first part of this exploratory study, which is reported in this article, uses a qualitative approach [20]–[22] to measure the cognitive performance in architecture students. The data was collected during the Fall 2022 semester with students from architecture courses Constructions-1 (n=16 students) and Constructions-2 (n=14, n=17, n=17, n=17 students) to a total sample size of n=81 students. All students provided responses. The survey contained

both closed- and open-ended questions. The survey aimed for students to self-report their perception regarding the benefits of delivering a mind-map before an examination, and the perception if the mind-map had an impact on the examination. The unit of analysis for the case study [22] consisted of the days leading up to the examination when students worked on the mind-map and to the moment when the examination itself ended. The surveys were administered using Qualtrics software and cleaned up in the Excel software. The answers were coded for evidence of how the mind mapping influenced learning process, learning outcome, and practical skills characteristics in architecture students. Students' answers were coded for content analysis—using a-priori and emerging codes—following Saldana's [23] and Yin's guidelines [24]. The codes were grouped by overarching themes. The sets of questions were divided into the two research questions- The first research question inquired about how do mind mapping helps architecture students learning. The second research question inquired about how do mind mapping connect studio practical-based skills with architecture lecture-based learning.

All courses reported in this study had the same instructor who designed the exams. The exam that was implemented for the courses had the same set of questions in terms of difficulty, pedagogy, solving approaches, and themes. The exams consisted of five descriptive answers and three concept application questions. The examination was individually, and not open book. The time limit to complete the examination was 120 minutes.

## **Results**

The first question of this study was "How do mind maps help in the formation of architecture students?" The answers can be briefly condensed in four specific premises in relation to mind maps: they are a study and learning tool, a creative way to put knowledge into practice, a tool with visual elements that facilitate the understanding of the course, and finally, mind maps are a method to develop architecture skills.

<b>How do mind maps help in the formation of architecture students?</b>	
Study and learning tool	Summarize and synthesize the contents seen throughout the year.
	Extract useful information and main ideas.
	Optimize time by studying while doing the activity.
	Easy access to review for the exam.
Creative way to put knowledge into practice	Encourage the practice of personal reflection by internalizing the contents.
	Organize the information to your preference in your own words.
	Create an effective relationship between reading and understanding the course.
Visual elements that facilitate the understanding of the course	Allows information to be captured and memorized.
	Allows to analyze contents in greater detail without much difficulty.
	Create relationships between content through visual proximity.
	Achieve a clearer information hierarchy
Method to develop architecture skills	Improves graphic expression.
	Allows the practice of sketch drawing.
	Encourages more precision when drawing.

Firstly, **mind maps are great study and learning tools** since the student can use them to summarize and synthesize all the content seen in class, while being able to optimize study time. As a result, one student expressed his appreciation for the tool since "at the time I developed the mind maps, I was studying at the same time". Likewise, another student described mind maps as "efficient" as a study method. On the other hand, mind maps demonstrate the ability to extract useful information and main ideas that facilitate study. As indicated by one of the students, "personally it helps me a lot to identify the main ideas about a topic, and at the same time in what I am looking for it helps me to study". Another important aspect to consider about the performance of mind maps is that its format allows them to be easy to review and memorize before an exam, as one student stated, "I think it is a very positive methodology because it is a great way to review the subject before the exam", being an easily accessible and manageable tool created by oneself.

Mind maps also **support architecture students in representing technical and practical knowledge in a creative way**, from a completely personal perspective. One student recognized the importance of the tool as it encourages the practice of personal reflection, as he states that "it is a creative way to put knowledge into practice". Similarly, mind mapping allows information to be organized and incorporated in one's own words, for example one student mentioned that "[mind mapping helped him understand better] because I could understand in my own words what was taught". Therefore, mind maps allow us to summarize

all the knowledge in a creative way, building a relationship between the reading and the general understanding of the course. Regarding the main premise, a student explained that "to make the mind map I have to read and understand the whole text to get a main idea", specifying the relationship that the activity created.

Likewise, mind maps are also **visual tools that facilitate the training of architecture students**. One student described the role of visual diagrams when studying for the exam, in which the activity "helps to memorize the subject better" as well as allowing him to pick up new information. Graphic tools also allow for a more detailed analysis of knowledge, for example, one student expressed that he felt that "[mind maps] motivate the student to analyze the contents with more attention to detail". Another aspect to consider is that visual diagramming allows organizing ideas based on hierarchy and proximity since, as one student explains, "I had them next to each other and I could understand myself better", demonstrating that mind maps allow understanding the information in a clearer way.

Finally, mind maps help greatly in the shaping of architecture students since they even encourage the **development of skills applied throughout their major**. The practice of drawing and sketching improves graphic expression, as one student explained how valuable the activity had been for him because it "helped him to learn to draw better and to show a better graphic expression". Another student emphasized how the mind mapping activity allowed him to work on that skill, since by summarizing the concepts learned he was able to "practice sketch-type drawing", an activity that is super useful in architecture assignments. Also, mind mapping is a tool that provides greater precision when drawing, as one student stated that working with mind maps helps "to being able to explain a concept clearly and briefly".

The second question of this study was "How do mind maps connect studio practical skills with traditional classes skills?". The responses can be summarized as them explaining mind maps aim for an analytic approach of topics, improve communication of ideas, develop studying habits, and directly relate to the ability to synthesize.



How do mind maps connect studio practical skills with traditional classes skills?	
Aim for an analytic approach of topics.	Obtention of main ideas and synthesis skills.
	More interest towards details about the topics learnt.
	Practice of abstraction skills.
Improve communication of ideas.	Development of clear ideas with simple explanations.
	Creation of diagrams, texts and diverse formats to explain ideas.
Development of studying habits.	Repetition of topics thanks to relations between topics.
	Improvement at organizing ideas and time.
	Visual studying technique to fasten comprehension.
Summarizing skills.	Contents allow to integrate this methodology and apply in class.
	The student is motivated to be conscious about content and express in their own words.
	They are files of knowledge seen along the development of the course.

Mind mapping leads towards **an analytic approach towards of the contents** on the course. A student mentions “they were a complete analysis in retrospective”. For which several skills such as the synthesis of ideas, interest towards details and abstraction process. Towards synthesis, it is evident the need to obtain main ideas and summarize content despite the extension leads to the hierarchy of ideas. A student said: “it helped to obtain the most relevant ideas and organize our own”. Additionally, the interest towards detail provides insight. An answer, although referring to architectural skills says they improved their drawings because they were more detailed. They explained: the drawing of an architect must be very precise and clear, such as constructive details and in general everything that is related to building”. This aspect reflects over the acquired skilled developed due to the use of mind maps. Finally, as part of the analytic process there is abstraction. A student said the skills they developed because of using mind maps were: “summarize information and abstract it”.

Another benefit provided by mind maps that is useful in traditional classes is **the improvement of the communication of ideas**. A student explained it: “helps us be precise, straightforward and clear”. Which is further evidenced because they explain complex ideas through brief messages and the creation of diverse text types. An answer said mind maps: “helped explain a concept short and plain”. Considering mind maps work with images and diagrams, the diagramming skills that have as a focus to be intelligible and communicative are developed. Thus, students learn to do this because: “the most complex aspect was to diagram the paper in order for the information to be understood”. All mentioned above, make students focus on working on their communicative skills.

Mind mapping before examinations help to **develop positive studying habits**. Students constantly mentioned how having similar classes regarding the same topics “helped them make the mind maps for final exams”. Moreover, the use of mind maps requires organization

from students. About the time they take, a student said: “it is a disadvantage how long it takes to do”. But in general, a student thought they were very useful to “organize ideas. And overall positive for any professional area”. Finally, they were a visual study technique which made the acquisition of knowledge faster and benefited visual learners. Students said, “if you are a more visual person this study method is the best” and they thought “it is so much easier to understand things with an explication and graph to represent it”.

Lastly, there is an emphasis on **summarizing skills because of mind mapping**. Some of the students thought the contents of the chosen course were the ones that allowed to apply this methodology. A student answered they could find relations along the topics because “they were connected and related between them”, furthermore, they “could notice the relation along the concepts through the course” without attributing it to mind maps. However, students believe mind maps made them more conscious about the subject as they were required to express their knowledge in their own words. An answer indicated that: while rewriting the topics learnt in class i was able to explain myself with more ease”. Finally, through this briefness of mind maps students have used them to review previous classes. They thought that “reviewing every topic led to noticing the most relevant ideas through the course”; and considering there were several topics seen: “mind maps help remember”.

## **Discussion**

From the results obtained, we could see that the students completely agree that the mind maps are important tools that helped them in the training by representing an opportunity to ease the synthesis and understanding process of the contents learned. The preference for mind maps is based on the students' improved performance, especially since they were able to personally connect with the subjects taught by making their own diagrams. As intended and studied, mind maps fulfilled their function as creative ways for students to engage in a distinctive method of learning [10]. Clearly, the students felt that the mind maps added considerably to their education as architecture students, given that in addition to being able to prepare for an exam, they were putting into practice the skills they typically use as architects. The conclusions can be supported by the statement of one of the students who considered that the mind maps “[contributed] as a whole, since it meant a recapitulation of all the topics seen in class”. We were able to identify certain trends in the students' responses that suggest attachment to mind maps as study tools. Undoubtedly, students consider that working with graphics contributed as a dynamic means to study because they were able to internalize the contents using diagrams and images that improved overall understanding.

Similarly, we were able to conclude that students agreed that mind maps also helped them connect the practical skills they use in architecture classes with the ones used in traditional subjects. The study of the students' use of mind maps implied a considerable improvement in their analytical approach to the topics of study. The development of specific skills such as questioning, summarizing, clarifying, and predicting that shape the student type profile [5] are worked alongside mind maps, consolidating a constant study habit in benefit of the students. Likewise, through common skills of summarizing and synthesizing content, students feel more confident in analyzing ideas since mind maps are used as representations of complex ideas [12]. The general opinion showed how the use of mind maps helped

considerably in all subjects connecting different skills as evidenced by the opinion of one of them: "Yes totally since we have to organize by topics and for us as architects it helps us to see things and to take into account the organization and development for a project".

Therefore, when students make their own mind maps, the communication of this represented knowledge improves considerably. So, we were able to identify how the use of mind maps as a study method makes students feel more confident, by connecting skills in a direct way.

## **Conclusions and Future Work**

Through the research it has been shown mind maps and their use inside of classes have been tools that benefited architecture students to develop skills related to their careers. Such benefits were: being a study and learning method, being a way to practice their knowledge, working on the development of visual elements to facilitate comprehension, and practicing drawing. There were also positive results concerning the relation between practical studio skills and traditional classes with more academic skills. The characteristics of mind maps which connect both aspects were focus on analytical approach of topics, improvement in communication skills, development of study skills and ability to synthesize content. Overall, it is possible to indicate mind maps provide several advantages in the development of skills useful for the professional and academic life of an architecture student. As a pedagogic tool, they contribute as a visual method that was enjoyed by most of the students on the study. They considered mind maps to be an ideal method to comprehend and study content. In this study, in which the construction classes were used to apply the method it is necessary to make relations between theoretical and material aspects. For future studies, the current research could be elevated by improving the student perception survey to expand the analysis of contents of mind maps, as well as by taking into consideration quantitative data that would allow us to deepen into the impact of mind mapping in students' grades. On the other hand, the research could also be improved if its repeated with construction students to further analyze the impact of mind maps as a part of the education of the building industry. Similarly, the use in art classes could provide more insight on the tool for students with a different set of skills. Moreover, considering students said they felt they had a better performance at class: improved retention, confidence on their knowledge, discipline, and others. However, it would be relevant to consider the faculty perspective making a comparison between classes that use mind maps and classes that do not.

## **References**

- [1] S. J. T. Jansen, H. Boumeester, and R. M. Rooij, "Architecture students and research courses: are they aligned? Students' attitude towards research courses," *Learn. Environ. Res.*, vol. 25, no. 2, pp. 549–563, 2022.
- [2] B. Obeidat and L. M. Obeidat, "Attitudes of Jordanian architecture students toward scientific research: A single-institution survey-based study," *Cogent Eng.*, vol. 10, no. 1, p. 2163571, 2023.
- [3] G. Shabiralyani, K. S. Hasan, N. Hamad, and N. Iqbal, "Impact of Visual Aids in Enhancing the Learning Process Case Research: District Dera Ghazi Khan.," *J. Educ. Pract.*, vol. 6, no. 19, pp. 226–233, 2015.

- [4] M. Yadollahi, M. Mirghasemi, R. Mohamad Zin, and B. Singh, "Architect critical challenges as a project manager in construction projects: a case study," *Adv. Civ. Eng.*, vol. 2014, 2014.
- [5] S. Wollscheid, B. Lødding, and P. O. Aamodt, "Prepared for higher education? Staff and student perceptions of academic literacy dimensions across disciplines," *Qual. High. Educ.*, vol. 27, no. 1, pp. 20–39, 2021.
- [6] C. Ubidia, M. Guerra, and H. Murzi, "Understanding Student's Perceptions of Cultural Dimensions in construction majors: Deconstructing barriers between architecture and civil engineering students," in *2022 ASEE Annual Conference & Exposition*, 2022.
- [7] N. Granja, V. Guerra, and M. A. Guerra, "Give me a coffee break! Pilot study on improving exam performance and reducing student stress," in *2022 ASEE Annual Conference & Exposition*, 2022.
- [8] Y. Liu, G. Zhao, G. Ma, and Y. Bo, "The effect of mind mapping on teaching and learning: A meta-analysis," *Stand. J. Educ. Essay*, vol. 2, no. 1, pp. 17–31, 2014.
- [9] H. Velásquez, M. Guerra, and M. Jimenez, "Exploring Interdisciplinary Contributions to More Sustainable Solutions in the Built Environment and Infrastructure Development Students," in *2022 ASEE Annual Conference & Exposition*, 2022.
- [10] K. Wilson, E. C. Solas, and N. Guthrie-Dixon, "A Preliminary study on the use of Mind Mapping as a Visual-Learning Strategy, in General Education Science classes for Arabic speakers in the United Arab Emirates.," *J. Scholarsh. Teach. Learn.*, vol. 16, no. 1, pp. 31–52, 2016.
- [11] A. Ontoria, J. P. R. Gómez, and Á. De Luque, *Aprender con mapas mentales: una estrategia para pensar y estudiar*, vol. 164, pp. 28-142. Narcea Ediciones, 2017.
- [12] C. Ubidia, M. Guerra, V. Guerra, and C. Gallardo, "Work in Progress: Collaborative Environments in Architecture and Civil Engineering Education—Case Study," in *2022 ASEE Annual Conference & Exposition*, 2022.
- [13] E. A. A. Corrales, "Los mapas mentales en el proceso de enseñanza aprendizaje," *Yachay-Rev. Científico Cult.*, vol. 8, no. 1, pp. 559–565, 2019.
- [14] M. A. Guerra and C. Gopaul, "IEEE Region 9 Initiatives: Supporting Engineering Education During COVID-19 Times," *IEEE Potentials*, vol. 40, no. 2, pp. 19–24, Mar. 2021, doi: 10.1109/MPOT.2020.3043738.
- [15] C. A. Farrington *et al.*, *Teaching Adolescents to Become Learners: The Role of Noncognitive Factors in Shaping School Performance—A Critical Literature Review*. ERIC, 2012.
- [16] A. A. Oluwatayo, I. Ezema, and A. Opoko, "Development of Design Expertise by Architecture Students.," *J. Learn. Des.*, vol. 10, no. 2, pp. 35–56, 2017.
- [17] N. Cross and N. Roozenburg, "Modelling the design process in engineering and in architecture," *J. Eng. Des.*, vol. 3, no. 4, pp. 325–337, 1992.
- [18] B. R. Lawson, "Cognitive strategies in architectural design," in *Developments in design methodology*, N. Nigel, Ed. London: John Wiley & Sons, 1984, pp. 209–220.
- [19] B. Lawson, *How Designers Think*. MA: Architectural Press, 2006.
- [20] J. W. Creswell, *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications, 2013. [Online]. Available: <https://books.google.com/books?hl=en&lr=&id=EbogAQAAQBAJ&oi=fnd&pg=PP1&dq=creswell+mixed+methods&ots=cbaKsVQtFb&sig=Z8omA9pn0S1XPf7-jZaAjBN1H50>

- [21] H. U. Chih-Pei and Y.-Y. Chang, "John W. Creswell, research design: Qualitative, quantitative, and mixed methods approaches," *J. Soc. Adm. Sci.*, vol. 4, no. 2, pp. 205–207, 2017.
- [22] R. K. Yin, *Case study research: Design and methods*. Sage publications, 2013.  
Accessed: Apr. 23, 2017. [Online]. Available:  
<https://books.google.com/books?hl=en&lr=&id=OgyqBAAAQBAJ&oi=fnd&pg=PT243&dq=use+study+research+yin&ots=FaN1gdj45i&sig=EMc6lWrXmburXS1-mI3XSvyxfiY>
- [23] J. Saldana, *The Coding Manual for Qualitative Researchers*. SAGE, 2015.
- [24] R. K. Yin, *Case Study Research: Design and Methods, 3rd Edition*, 3rd ed. SAGE Publications, Inc, 2002.