

Architectural Engineering Students' Perception of Knowledge Acquisition in a Senior Project Course Delivered Synchronously Online Due to COVID-19*

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The COVID-19 pandemic, which began in spring 2020, led to the sudden termination of conventional learning systems. Since then, Synchronous Online Distance Learning (SODL) has been employed as an alternative teaching modality in engineering education. During this shift, educators were required to maintain successful Student Learning Outcomes (SLOs). Therefore, a substantial question was raised about how we could ensure that the knowledge presented through SODL approaches is of sufficient quality? This study aims to develop a tool to evaluate the students' knowledge acquisition while utilizing SODL approaches in engineering education in order to define the ability of this approach to maintain educational continuity, when forced to transition to SODL. A Design-Based Research (DBR) methodology was adopted to link the qualitative research variables in this study; the variable of dimensional analysis is one substantial approach to identifying the aspects of SLOs in a SODL Architectural Engineering (AE) senior project while the collaborative component of this study has been integrated as in-depth structured interviews. Following our analysis, findings indicate that SODL does not necessarily compromise students' skills in acquiring knowledge; furthermore, it advances the AE senior projects curricular paradigm positively.

Keywords: architectural engineering; student experience; synchronous; senior project; knowledge acquisition; online distance learning (ODL); student learning outcomes (SLOs); Design-Based Research (DBR)

1. Introduction

Recently, conventional means of teaching have been challenged by the sudden advent of the Coronavirus pandemic that started during the Spring semester of the academic year 2019/2020. The whole world faced the sudden closure of schools and universities. Teachers around the world have had to start teaching virtual courses, communicating with their students on social networking platforms [1, 2]. The academic sector was left with new epistemological challenges that intensify existing difficulties associated with ODL applications including (a) lack of online student discipline, (b) lack of tolerance and faculty acceptance of ODL, and (c) high costs associated with the development and delivery of online system [3]. In the face of this unprecedented health crisis, countries around the world have had to come up with an educational continuity plan that could be implemented as quickly as possible [4]. In the event of the temporary removal of pupils or the closure of schools, pedagogical continuity plans have sought to maintain the pedagogical connection between teachers and pupils, so as to preserve the knowledge already acquired by pupils while assisting in the acquisition of new knowledge [5]. This full shifting to the ODL

approach as a teaching method may affect the knowledge acquired by students. In other words, it may affect the Student Learning Outcomes (SLO) that are associated with a given course.

Therefore, the identifying of the students' preferred way of e-learning guides educators during the current and future crises in course designing. Although the COVID-19 health crisis has highlighted the usefulness of digital technology in higher education, a main key question arises; How can we evaluate knowledge and skills learned at a distance and their relevance? In other words, how can we ensure that the knowledge presented through a distance learning course is of sufficient quality? However, the results presented in this article are not intended to highlight the virtues of ODL, but rather to open up a debate and reflect more widely on the sustainability of this transformation of education in universities, especially in AE education.

This article seeks to provide a fully comprehensive answer to this key question through taking a case study. In particular, it presents a qualitative assessment of the tools that have been put in place, in the context of the current global health crisis, with the aim of ensuring quality and continuity in higher education pedagogy.

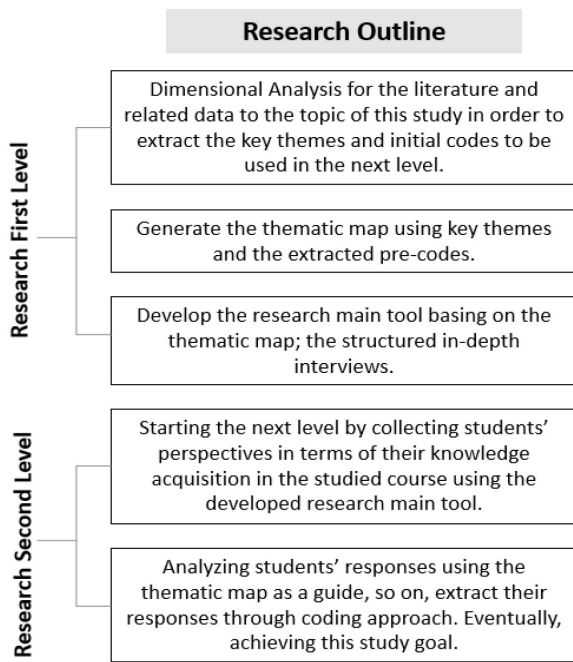


Fig. 1. Research Outline.

To this end, this paper develops a measuring knowledge acquisition instrument to discuss the students' perspective on SODL implemented for the AE senior design projects at the University of Texas at Arlington (UTA) in the USA. This paper demonstrates the knowledge acquisition aspects in the AE senior design project courses which reflect the expected SLO that fosters students' skill development. Students are the best representatives for evaluating the process through which the targeted knowledge is obtained; thus, techniques in the SODL courses should foster the appropriate approaches and learning environment enabling students to develop and enhance their skills.

Thus, this paper adopted the dimensional analysis for the literature and related data to the topic of this study, therefore, as the first level of the qualitative methodology in this study, this step is needed to extract the key themes and the needed codes in order to develop the thematic map to be used in the next level of the study. The next level in this study is to obtain students' perspectives in terms of their knowledge acquisition in the studied course based on the previously developed thematic map as a tool to generate the main tool of this study; the in-depth structured interview. Fig. 1 shows the outline framework for this study.

2. Dimensional Analysis for Literature and Related Data

2.1 Online Distance Learning (ODL)

Distance Education is defined as a learning environ-

ment in which students and teachers are geographically separated by distance [6–9]. It incorporates different forms of learning, such as online, e-learning, virtual learning, etc. [10]. ODL is a process by which students and teachers use internet technologies to communicate and interact with each other during the learning process [11]. Almost 80% of the course should be delivered using internet technologies in order to classify it as an online course [12]. ODL is an improved version of distant learning [13, 10].

One of the ODL approaches is Synchronous Online Distance Learning (SODL), which serves as an access to real-time interaction with the instructor and class peers that mimics a traditional classroom setting [14]. The use of synchronous conference technologies can provide opportunities for social interaction in the virtual classroom space [15]. Previous studies pointed to the positive responses of students about using SODL approaches in their courses [15–20]. Furthermore, ODL has proven popular among students for various reasons, such as convenience and equal opportunity [21].

ODL does not necessarily compromise levels of students' achievements during the course of their learning process. In fact, the use of technology has not only created new opportunities within the conventional classroom but has also served to expand learning experiences [22–28]. Based on previous studies, Allen maintains that online classes do not essentially reduce the level of student achievements when compared with conventional in-class classes [27]; it may even improve the level of student achievement. After all, ODL has been established as an effective mechanism in the higher education system [23, 25, 26, 29]. As it improves students' access to education, encourages student's involvement because of the acceptance of advanced technologies by a wider community of the younger generation [3, 30, 31], and, most importantly, because it allows better attainment of SLOs [22, 27, 32–38]. It is pointed out that many applications of online classes could prove more effective than in-class systems. ODL methods have been tested in many disciplines categorized as applied science, such as medical-related disciplines and geology and soil sciences; both of which require training in laboratories and real-life fields [39–42]. They tend to compare in-class conventional learning methods with distance learning. They found that distance learning could be satisfactorily incorporated into these kinds of studies while achieving better SLOs.

2.2 Accreditation Board for Engineering and Technology (ABET)

In this study, the AE courses in UTA-Arlington are derived firstly to meet the Accreditation Board for

Engineering and Technology (ABET). The ABET is nonprofit, non-governmental agency that accredits programs in applied and natural science, computing, engineering, and engineering technology. They accredit college and university programs in the disciplines of these programs at the associate, bachelor's, and master's degree levels. These standards are developed by technical professionals from ABET's member societies; the criteria focus on what students experience and learn. ABET accreditation provides assurance that a college or university program meets the quality standards of the profession for which that program prepares graduates. Therefore, according to the ABET guidelines, it is expected that the undergraduate students will attain the following SLOs by the time of graduation [43]. In other words, these SLOs should be maintained even if the course was provided in the form of SODL:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. An ability to communicate effectively with a range of audiences.
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments.
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6. An ability to develop and conduct appropriate experimentation, analyze, and interpret data, and use engineering judgment to draw conclusions.
7. An ability to acquire and apply new knowledge as needed.

2.3 Architectural Engineering (AE) Learning

In order to identify the aspects of SLOs in AE courses, the goal of establishing such a university discipline should be well-demonstrated. AE is a profession that focuses on the close interaction between architecture and engineering [44]. The basic premise of AE learning is to graduate architectural engineers who can correctly design engineering solutions, can work in multi-disciplinary teams, and can design effective solutions to meet social needs [45, 46]. The appearance and develop-

ment of AE in the construction field have been stimulated by the need to optimize construction project development and improve the sometimes-inefficient collaboration between the architect and structural engineer. The AE senior project represents a graduation requirement for undergraduate engineering majors and for ABET accreditation of the AE program. The purpose of this course is to provide a realistic experience by integrating basic material learned during the engineering undergraduate program to address real-life design problems including advanced engineering design aspects in some of the chosen focus areas; structural, mechanical, electrical, and construction/construction management. Authors believe that improving collaboration between the architecture and engineering professions leads to more efficient structures. It is indicated that this collaboration can be improved by professionals who have training and experience in both professions [44].

2.3.1 AE Senior Project Course in UTA

The curriculum of AE in UTA provides a strong foundation in science, mathematics, and engineering science; technical competence in the structural engineering area of civil engineering; and an understanding of the importance of ethics, safety, professionalism, and socioeconomic concerns [47]. The AE senior project course in UTA is named AREN 4383 and loads 3 credit hours. Senior Project is typically a course taken on campus. But naturally, due to the COVID-19, AE students at UTA were challenged with taking this course online. During this course, students should apply their skills and principles towards one single project with the consideration of ABET requirements. AE Senior project courses are different from one University to another. ABET-accredited AE programs are required to address four areas: structural, mechanical, electrical, and construction/construction management. Few universities focus only on one topic (mechanical for example), others focus on multiple topics. This paper sheds light on interdisciplinary projects with an emphasis on the structural aspect. Students learn how architects designed the studied building, not how to design a similar building. The students typically design other systems including structural, mechanical, electrical, plumbing (MEP), and electrical lighting. The students cannot design the structural systems of the studied building without the ability to analyze and read the architectural design in the first stage. With this understanding, students will be able to define the loads and their paths. This enables them to design the structural elements. Also, with an understanding of the volumes of the architectural spaces, the students can run the MEP design.

Thus, AE students in this study had an opportunity to analyze an architectural design of (5) projects; two groups in Fall 2020 (7 students designing the Crescent Bay Hotel at Laguna Beach, California, and 5 students designing the UTA Lecture Hall Complex). Three projects were presented in Spring 2021 (5 students working on the New Structural Engineering Research Laboratory, 5 on the Standalone Three-story Building extension to an existing hospital, and 4 on the three-story educational center). At these selected projects, they have to design the complete structural system, along with a preliminary design of the MEP system. Each student had the opportunity to pick which project they preferred to work on. Then, groups were formulated based on the chosen project. All AE students in UTA are required to complete one-semester AE senior project courses in sequence.

Autodesk Revit 2020 was pivotal in systems design. It provided students with 3D views of everything they design. It is worth noting that the professional Engineers in the AE field were consultants for the students and donated their time and efforts to help in the AE senior project courses. The course leader worked as a director for one group while the other two groups had directors from the field (professional engineers). The course leader was responsible for overseeing the other two groups and their discussions periodically. Additionally, there is an architectural engineering Ph.D. candidate who worked as a teaching assistant for this course.

2.4 Knowledge Acquisition's Aspects in AE Senior Project Course at UTA

In the process of developing the undergraduate AE program subject matter, authors collected courses essential for the training of the particular skills and

knowledge presented in the ABET of the AE professional. The AE senior project in UTA forms the last bridge for students between undergraduate education and the engineering profession in their respective disciplines; the purpose of the capstone design course, required of all seniors, is to provide a realistic experience by integrating basic material learned during the engineering undergraduate program to address real-life design problem from schematic phase into the construction design levels. Thus, the undergraduate AE program complies with the ABET regulations on the program curriculum design. Presented briefly, competencies include the following knowledge and skills that are determined as a predicted SLOs by the course leader. These SLOs are categorized into five main groups which reflect the predicted students' competencies extracted from the competence model, see [44]. Authors believe that the integration between these five groups by acquiring knowledge aspects from AE courses led to an acceptable level of the predicted SLOs (Fig. 2).

2.5 Learning Process within SODL Environments

To apply the learning process mechanisms within SODL environments, these mechanisms should be identified first. There are three common views of what constitutes teaching and learning processes: teaching as transmission, teaching as transaction and teaching as transformation [48, 49]. 'Transmission' perceives teaching as an act of transmitting knowledge from the instructor to students. It is an objectivist and instructional pedagogy in which instructors practice the unidirectional method of knowledge transmission, relying on a fixed curriculum developed solely by the instructor.

Transaction learning theory perceives learning as

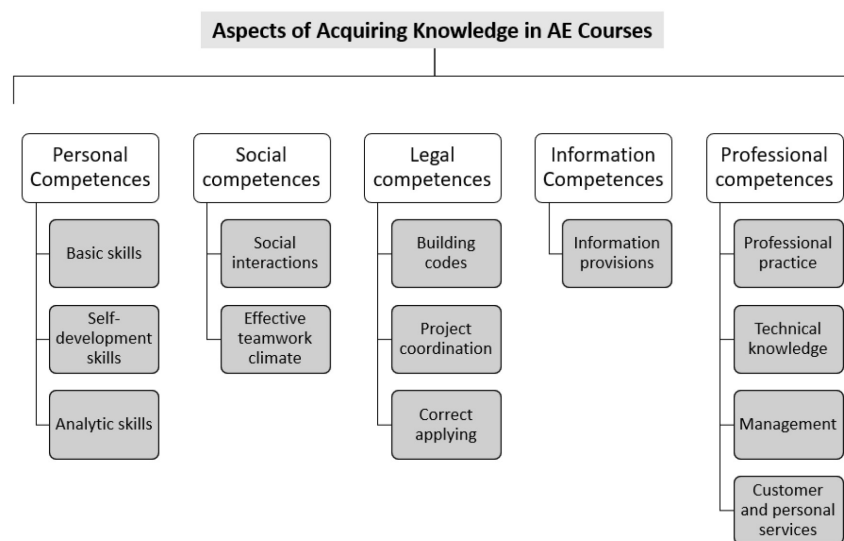


Fig. 2. Knowledge Acquisition's Aspects in AE Courses based on (Parasonis & Jodko, 2013).

a means of constructing knowledge and moving away from the passively received methods that characterize transmission teaching and learning. In distance education, transaction learning occurs through a physically separated environment, but learning should remain active and dynamic [6, 50]. In other words, transaction theory should operate within an interactive learning environment that allows students to comprehend established knowledge but also construct new knowledge [51–55].

Transformation creates conditions that transform the learner on different dimensions, such as intellectual, artistic, moral, cognitive, emotional, social, intuitive, and many others [52]. It is a holistic educational philosophy [49]. Despite their benefits, transformative (and transaction) learning methodologies could be problematic in ODL environments. Thus, considerations should be given to (1) creating a safe environment; (2) encouraging students to think about their experiences, beliefs, and biases; (3) using teaching strategies that promote student engagement and participation; (4) introducing real-world problems that address societal inequalities, and (5) assisting students to implement action-oriented solutions [56, 57].

One of the most highlighted theories discussed in distance education is Moore's theory of transactional distance, which provides a framework for current research into students' perceptions of SODL [58]. According to the theory of transactional distance, the sense of distance the learner forms during the learning process goes beyond geography and is concerned with students' interaction and participation in the learning experience. Transactional distance theory consists of three main elements: dialogue, structure, and autonomy. He suggests that instructors need to pay attention to the three elements in order to reduce the "distance" a student experience [58, 59].

2.6 SODL Environment for the AE Senior Project Course in UTA

Accordingly, this section details the AE senior project course in UTA that was provided in the form of SODL through the defined mechanisms previously.

• Dialogue

Dialogue is a very important component of the learning process, but it is a challenge in SODL. In online contexts, educators should strive to improve interaction through effective and flexible communication methods [58, 60, 61]. In this study, the dialogue was demonstrated in the interactions between students and course instructors using the Microsoft Teams Application. Microsoft Teams is a digital hub for cloud applications that brings

channels, conversations, meetings, files, and apps into Microsoft 365. Teams are made up of channels and the channels are used to divide Teams into different topics, or in this case, university units. Many files can be downloaded through this application and users can facilitate PowerPoint presentations in group workshops [62]. Also, Canvas students App was used throughout the studied course. Canvas Student allows students to access their courses and groups using a mobile device. Students can submit assignments, participate in discussions, and view grades and course materials [63].

• Structure

All instructors adopt the structure and organization of the course in their classrooms, both in traditional learning and in SODL. The 'structure' in the transactional distance theory represents the rigidity or flexibility of the course organization. Moore asserts that the more rigorous the organization and delivery of the course, the higher the level of knowledge acquisition the student achieves [58]. The acquired knowledge through SODL for AE senior project courses is approached through the transaction, transformative, and transmission learning mechanisms; with consideration of different measures involved in educational phases (Fig. 3) [64].

By conceiving teaching as a design process in itself, we may be able to inform the way that students acquire knowledge in architectural engineering courses [65]. The students' acquired knowledge in AE courses is shown by their newly formed and improved skills during the course [66]. The stages in AE courses are the clear result of conceiving the teaching as a design process. In other words, these stages represent the structure of the AE courses that guide students to the most necessary knowledge that forms the SLOs. Based on the syllabus that was derived from the requirements of the ABET, the main stages of the AE senior project course structure are shown in (Fig. 4).

First stage is the analysis, in which site, program, building type, context, and other investigations are carried out [65]. We think that this stage depends on the knowledge gained in the first three years of AE education and the knowledge presented by course leaders. Thus, it depends on the ability to memorize the facts, ideas, or methods. The synthesis and organizing processes are also widely used. Also, it lets the students have the full ability to make judgments about the value of the information that they gained. At some point, the design process shifts in focus from the analytical part to the conceptual design part. During this stage, references are made "back" to analysis work, but no new analysis

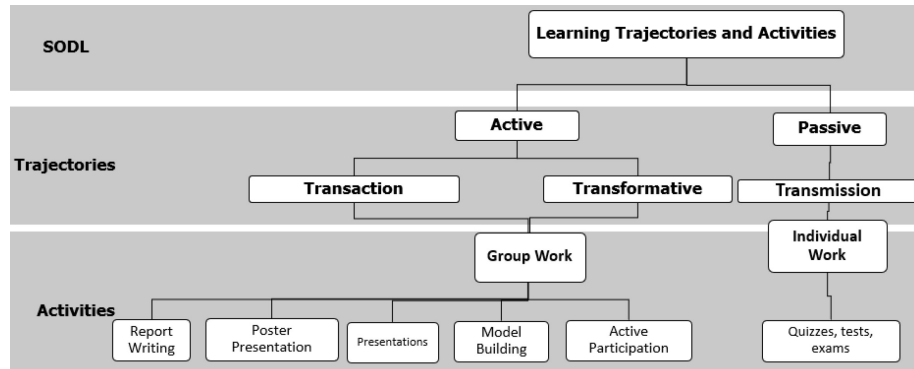


Fig. 3. AE Senior Project Course's Learning Mechanisms, (Rababeh, Muhsen, Al Rabady, Al-Bqour, & Rababeh, 2021).

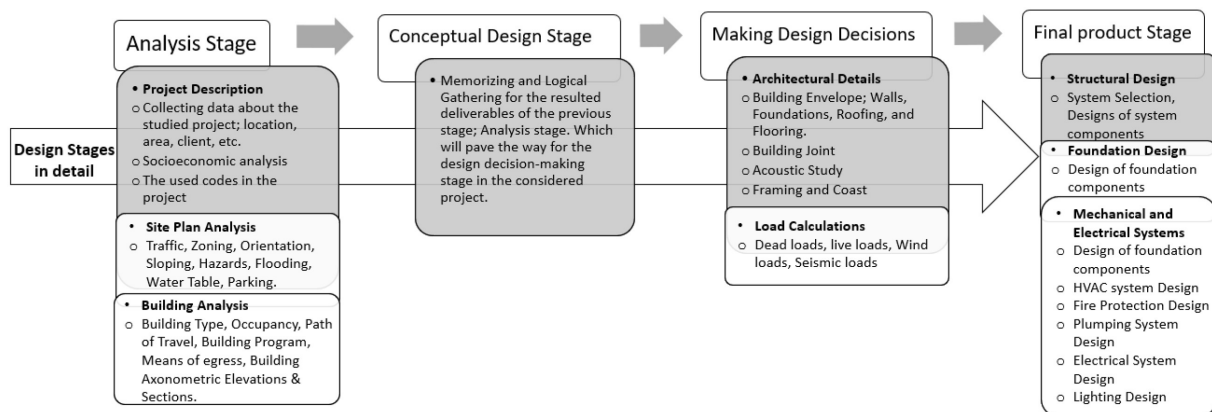


Fig. 4. AE Senior Project's Design Stages.

assignments are made [65]. The conceptual design stage can be translated through the Activity Theory for Graphic Design (ATGD) which is offered as a particularly useful model for understanding the way practitioners use available tools to achieve objectives in activities ranging from the routine to the creative [67, 68]. This stage turns the parts of the first stage into a creative design through mental activity skills of memorizing and logically gathering. The next stage of the design process is represented by the making design decisions stage [64]. We think that this stage mainly depends on mental activity skills which help students make the correct judgments. The final stage of the designing process in AE courses is representing the final design product. This stage ties up the previous stages as the concluded solution of the design problem presented at the beginning of the AE course. We think that the necessary mental activity skill here is the ability to apply developed theories, concepts, and design methods through practical application.

• **Autonomy**

Autonomy is a fundamental component of distance transaction theory. SODL offers students the possibility of more self-directed learning opportunities

and flexible structures for participation, which can increase levels of emotional independence [69]. It is suggested that this is a critical feature of students' participation in their learning. In this study, autonomy is demonstrated through the ability of every student in each group to show a full understanding of the project that they handled [58].

2.7 Theoretical Framework – Keys of Thematic Map

The developing theoretical framework in this study is the pure result of the held dimensional analysis of related literature. This thematic map is based on extracting the key themes and pre-codes. The pre-codes were formulated in order to facilitate the answering process of respondents as well as to narrow the scope of the answer in line with the objectives of the current study, in order to save time and effort for both researchers and respondents. Thus, considering the elements of Moore's theory with the knowledge acquired through SODL for AE senior project courses that are defined by the adopted learning mechanisms in this study. Also, with adopting the course stages in AE at UTA that are based on the SODL of the AE's syllabus which derived from the requirements of the ABET, the

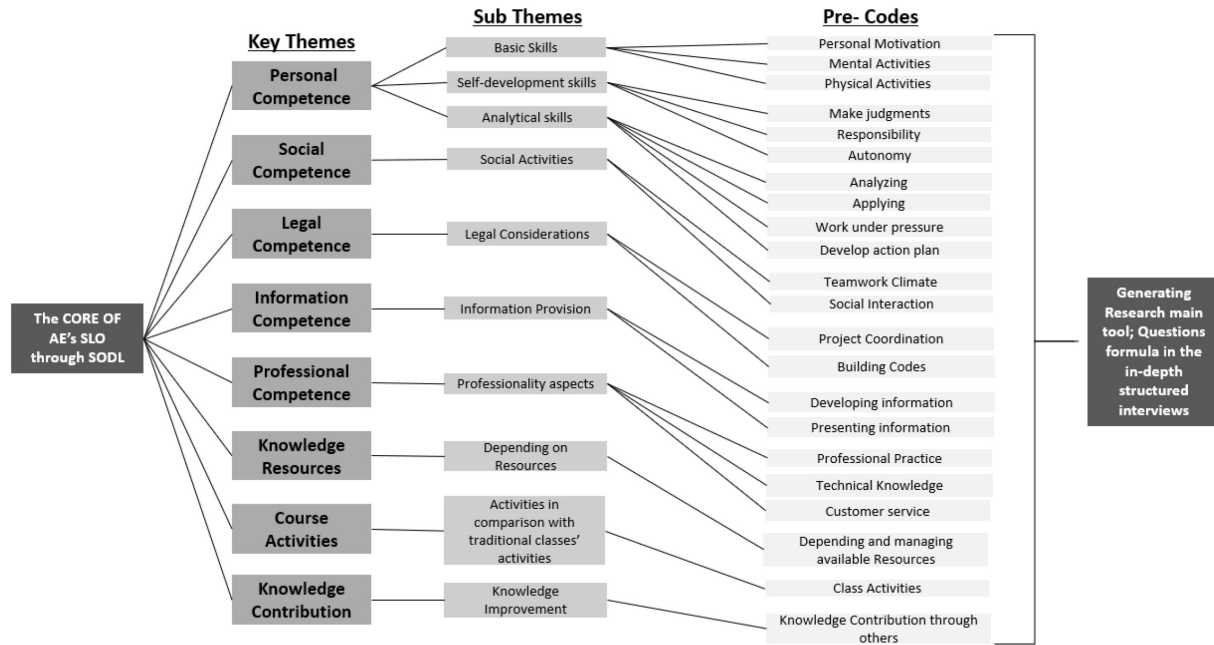


Fig. 5. The Theoretical Framework; thematic map.

thematic map is presented. This map is used as a model which is essentially presented by the term “the core of AE’s SLOs through SODL” in which the aspects of SLOs that emanate from it are required. Eventually, to identify the students’ perspective in terms of the studied course through the SODL approach. This model forms the base of the main research tool (Fig. 5); the in-depth structured interviews with participating students in this study.

3. Methods

This study combines elements of course design with aspects of qualitative research, thus, it considers using design-based research (DBR) as a methodology. DBR is a type of research methodology used by researchers in the learning sciences, which is a sub-field of education. It holds promise for realizing effective solutions that – by design – traverse the research-to-practice divide [70]. Therefore, to obtain a full description and comprehensive understanding of the students’ knowledge acquisition, qualitative research structured in-depth interviews reflected the result of holding DBR as a methodology. This collaborative approach helped in identifying the students’ perspective about their knowledge acquisition in AE senior project.

3.1 Database Search

A literature review was undertaken using the Cochrane collaboration method [71], by combing through Knowledge bank, Science Direct, Elsevier, SAGE, JSTOR, EBSCO, IEEE, ERIC, Gale, Aca-

demis Search, and Web of Science. A previously described qualitative approach [72]; which reflects the first level in this study, was used for data extraction as an objective approach that includes extracting key themes utilized in developing the thematic map. Afterwards, the used questions of the in-depth structured interviews were formed (Table 1).

3.2 Participants

The developed interviews were used twice: once at the end of the Fall semester with 2020 to 12 students, and once at the end of the Spring semester in 2021 with 14 students. Each interview took 30–45 minutes with each student in the mentioned course terms (Fall 2020 and Spring 2021) in suitable times for students and interviewers as well, within a two weeks period at the end of each of the mentioned semesters.

3.3 Data Collection

Structured in-depth interviews were done utilizing the Zoom application. Zoom is a cloud-based video communications app that allows you to set up virtual video and audio conferencing, webinars, live chats, screen-sharing, and other collaborative capabilities [73]. Also, the goals of this interview were demonstrated for the students before they enrolled in the zoom meetings. Data were collected through open-ended questions during the zoom meeting sessions. Each interview was divided into eight main sections, which reflect the main aspects of “the core of AE’s SLOs through SODL.” Then,

Table 1. The adopted in-depth structured interviews

Key Themes	Sub Themes	Question Formula Based on the extracted pre-codes
1. Personal Competence	Basic Skills	Express your experience throughout this course in terms of motivation, mental and physical activities.
	Self-development Skills	Express your experience throughout this course in terms of self-development skills such as making judgments, responsibility, and Autonomy.
	Analytic Skills	Express your experience throughout this course in terms of your analytic skills, such as analyzing, applying, working under pressure, and developing an action plan.
2. Social Competence	Social Skills	What is your expression about the social experience in terms of teamwork climate and social interaction during this course?
3. Legal Competence	Legal Considerations	Based on your experience in this course, what is your expression about the coursework legal considerations in terms of project coordination and keeping up with building codes in the country?
4. Information Competence	Information Provision	How can you describe your experience in terms of information developing and presenting throughout this coursework?
5. Professional Competence	Professionalism Aspects	Express your impression of your gaining professionalism in different aspects throughout this course work, e.g.: professional practice, technical knowledge, and customer service?
6. Knowledge Sources	Depending on sources	Describe your experience throughout this coursework in terms of depending on and managing available knowledge sources.
7. Course Activities	Activities in comparison with traditional classes	Describe your experience throughout this course in terms of class activities in comparison with your previous conventional courses.
8. Knowledge Contribution	Knowledge Improvement	Express the contribution of knowledge that you gained or enhanced through your instructors and classmates.

each section consisted of one question, except section one illustrated through three questions, see (Table 1).

3.4 Thematic Data Analysis

Respondents' responses were recorded as videos. Collected data were analyzed thematically based on the analysis of the eight main themes. The authors thoroughly familiarize themselves with transcripts of each held Zoom meeting. Thematic analysis is a qualitative method for identifying, analyzing, and reporting patterns (themes) through minimal organization and rich description and interpretation of data related to various aspects of the research topic [74, 75]. The thematic analysis was an inductive process and consisted of five phases that were completed manually (Table 2).

4. Results and Discussion

Although 26 participants were included in the study, data saturation was achieved with 23 participants who were met for the purpose of this study, therefore, data from 23 participants were analyzed. The key findings are basically listed under the extracted key themes in the first level in this study. Therefore, the students' perspectives about their acquired knowledge are categorized under these extracted eight key themes. The views and the notes were read several times in order to achieve a sense of the content.

4.1 Personal Competence

The sub-themes in this category were summarized in: Basic skills, self-development skills, and analytic

Table 2. Phases of the adopted thematic analysis

Phase	Description of the Process
1. The authors familiarizing with the data	Transcribing data (if necessary), reading and rereading the data, and noting down initial ideas.
2. Generating codes and matching with previously generated pre-codes	Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code and pre-code.
3. Searching for themes and matching with previously generated themes	Collating codes into potential themes, gathering all data relevant to each potential theme.
4. Reviewing themes	Checking the themes work in relation to the generated themes and extracted pre-coded (Level 1) and the entire data set (Level 2).
5. Producing the report	The final opportunity for analysis. Selection of vivid, compelling extract examples, final analysis of selected extracts, relating back the analysis to the research question and literature, producing a scholarly report of the analysis.

skills. For the basic skills as a sub-theme in the personal competence key theme, it seemed that the students agreed that there is a positive effect of adopting SODL approaches in AE senior courses. Specifically in terms of having real motivation in accomplishing the course requirements, also using their mental abilities in achieving course activities. While their responses indicated that students' physical activities were reported by students as affected negatively. Findings illustrated that most of the students had the feeling of having an inner motivation to accomplish course requirements perfectly as the phrases that indicate this situation were repeated notably.

"I think that I was driven by a great inner motivation to accomplish this course with high grades! Well, it is my final year in AE at UTA, and the COVID-19 cannot stop me from producing my best!" – Student X.

Results indicated that most of the students could fully judge their activities during the senior project coursework. As the phrases matched the per-code of "Make judgments" repeated notably, such as: what situation is the most suitable for their project. Also, along with the ability to make right judgments, results revealed that the feelings of responsibility and autonomy were highly presented. Most responses matched the pre-code of "responsibility"; such as: handling the project with full awareness.

"I think the feelings of independence in this course were driven mainly by our instructors who fostered us to show a full understanding of the studied project's aspect even if we are working in teams. The SODL approach in this course has helped a lot in this situation, as I needed to always be ready to show my full awareness about the project, I was involved in. Well, to avoid feelings of embarrassment throughout these recorded Microsoft team meetings!" – Student X.

"I felt that I can make the right judgment about the best structural form that suits my teams' project in our senior project course. Also, my instructors had confirmed my choice with some pieces of advice and suggestions" – Student X.

Moreover, for the analytic skills, students referred that they were able to get more complex interpretations and relationships that helped them in generating their analyzing reports while they were having AE senior project course through SODL. As well as for self-development skills, most of the students referred that they were trying to produce their own Charisma to be shown clearly in their meetings throughout the semester. Thus, to be known for instructors by their work even if they are not present physically.

Besides, the skills of working under pressure and developing an action plan were reported as being enhanced through the SODL approach in AE senior project course at UTA. Wide responses

within held interviews indicated that students' skills were improved in terms of working under tight deadlines, thus, they were able to generate real action plans for their projects and submissions each week. Especially that the online submissions were closed each week on time and there was nothing to do after the deadline. Thus, it seemed that adopting SODL approaches made the students more aware of time and had a full consideration of weekly requirements or even pre-final and final submissions.

While for physical activities, thematic analysis findings revealed that upset feelings were felt among students as they could not meet their team members physically whenever they want to, as well as for site visits. However, they indicated also that the online course approach saved their time and effort.

4.2 Social Competence

The sub-theme was summarized in social activity skills. Several pre-codes were adopted through formulation structured in-depth interviews: team-work climate and social interaction. It seemed that the students agreed that there is a positive effect of adopting SODL approaches in AE senior courses on the social activities' side. However, students' responses' thematic analysis results revealed that some students already miss the group meetings activity in person, also, course meetings with the related practitioners for their projects.

"COVID-19 was converting our conventional activities into online activities; I think it was worthy to try. We were already in touch with online activities through WhatsApp or Facebook groups before COVID-19, but in this term, it was a full experience that depended on online approaches to reach the goals of our social meetings. It was fully scheduled meetings and our group members were able to keep attending mostly each meeting without skipping any. Thus, I think using online approaches shortened the time and effort as well as coming up with acceptable accomplishments for each online group meeting" – Student X.

"I think there was a satisfying degree of easy interaction and communication with others. As we could as a group finish our work remotely through online and virtual meetings, thus we were able to meet our objectives. Well, I really think that I can work effectively with others remotely, it was somehow a hard process in the beginning as the beginning of everything in life." – Student X.

4.3 Legal Competence

The sub-theme was summarized in legal considerations. Several pre-codes were adopted through formulation structured in-depth interviews: building codes and project coordination. It seemed that the students had a full awareness of the legal consideration side, Basically, the studied course structure and syllabus mainly derived by ABET.

It seems that students were having the building codes as clear border lines for their working on senior project stages. Especially, working in compliance with laws, regulations, industry, government, and public contracts on project-related matters. Additionally, few responses indicated that some students had the ability of Applying engineering design to produce solutions that meet specified needs. Also, in terms of project coordination skills, students' responses referred to most of the students involved in this experience.

“I think the experience of accomplishing the AE senior project course through SODL approaches allowed me and my team members to develop project directives, timelines, resource studies, and strategies to meet relevant building regulations and permits, investigation of regulations. We did this remotely, and I think we tried to reach the perfect somehow in matching with regulations!” – Student X.

However, the authors revealed that there are some students who are struggling with keeping up with regulations and building codes in the country. Some phrases were notably repeated throughout the transcript data: Keeping up with regulations was the hardest part within the senior project.

4.4 Information Competence

The sub-theme was summarized in information provision. Several pre-codes were adopted through formulation structured in-depth interviews: developing information, presenting information. Also, some codes were extracted through analyzing the transcript of the held interviews with participants, these codes were matched with previously set pre-codes. These extracted codes were summarized in: making presentations, professional language, using annotation, digital applications, diagrams, video animation, simulation. It seemed clear that there is a general agreement among participant students about SODL effects on Information competence. Almost all responses indicated the positivity of utilizing SODL in developing and presenting information.

“I think that the highest importance of online tools is located in delivering and receiving information. It was really joyful and more understandable to get the idea from the instructors weekly through presentations, where our instructors used well-made presentations with professional language weekly, which shortened the way for us, especially our weekly meetings with instructors were recorded on Classnotes that allowed us to get each meeting we had in this course whenever we want!” – Student X.

“I think utilizing digital applications was the most joy able part. Where we enhance our skills in presenting our projects in online meetings, to equal the presenting projects in-person” – Student X.

4.5 Professional Competence

The sub-theme was summarized in professionalism aspects. Several pre-codes were adopted through formulation structured in-depth interviews: professional practice, technical knowledge, and customer service. Also, some repeated phrases were repeated throughout the transcript interviews data, which were matched with previously extracted pre-codes, the codes summarized in: engineering architect professional path, contemporary trends, professional ethics, customer needs, and customer satisfaction. Results of the thematic analysis for the held structured in-depth interviews reveals that students tied the professionalism aspects with their meetings with practitioners and specialist instructors where they get the newest trends in architectural engineering practices.

4.6 Knowledge Resources

The sub-theme was summarized depending on resources. Several pre-codes were adopted through formulation structured in-depth interviews: depending and managing resources. It seemed clear that there is a general agreement among participants that they were almost fully adopting the online approaches in accomplishing AE senior project requirements. Some phrases were notably repeated throughout the interview's transcript data, such as Internet websites, Lectures and instructors' meetings, online scientific papers, Codes, and Standards.

4.7 Course Activities

The sub-theme was summarized in Activities in comparison with traditional classes' activities. Main pre-code was adopted through formulation structured in-depth interviews: Class activities. Responses illustrated that students were experiencing the same activities in conventional classes but in the form of online activities. Students showed satisfaction about online class activities through different phrases repeated among the transcript data, such as the ability to ask questions without interruption, contributing to class discussions, the ability to prepare two or more drafts of assignments weekly, the ability to integrate ideas and information from various sources, working on the project with classmates outside of class, and received prompt feedback from instructors.

“I was able to have serious conversations with others and my team members students of a different way of thinking or behavior than my own” – Student X.

4.8 Knowledge Contribution

The sub-theme was summarized in Knowledge Improvement. And pre-coded as the knowledge

contribution through others. It seemed that the students agreed that there is a positive effect of adopting SODL approaches in AE senior courses on improving or enhancing students' knowledge. Some phrases detected through scanning transcript data, such as acquiring a broad general education, and acquiring job or work-related knowledge and skills later.

"This course allowed me to gain knowledge from the practitioners in the field, my specialist instructors, as well as my team members, especially in exchanging experiences" – Student X.

Noting that ABET related credits were involved in the adopted interview's questions, as these questions reflected the needed SLOs in this study which are driven basically by ABET.

5. Conclusion

The results of this study indicate the viability of student acceptance of the SODL instruction and demonstrate its effectiveness as an alternative teaching modality for the Senior Design Project course in the Architectural Engineering Program. Responses show that students have successfully applied knowledge and skills acquired in previous

courses and developed and enhanced new skills throughout the duration of the course. In addition, students were able to experience the typical scenarios that architectural engineers are subjected to in professional practice and industry through a single comprehensive project. Successful outcomes accomplished via SODL modalities include (1) advancement of problem-solving skills, (2) increased awareness and acquaintances with several types of building systems, and their integration with structure and architecture.

By returning to the main research question and goal that were raised earlier, it is cleared that we can evaluate the quality of the knowledge delivered by SODL approaches through students' perspectives as they are the best representatives for their knowledge acquisition. Furthermore, the DBR methodology allowed us to combine the elements of course design taken in this study with the extracted aspects of the qualitative research to develop the main research tool that links the theoretical and practical sides in the field of this study. Additionally, it is demonstrated that the SODL approaches in engineering education could maintain the quality and continuity of engineering education when needed.

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