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Learning by Doing: Construction Students' Learning in a Design-Build Studio

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Abstract

This paper briefly describes two construction studios in which freshmen students learn construction equipment and methods through various educational modules. These modules incorporate designing and building aspects of a construction program. The studio-based learning model in construction education, unlike architecture, interior design, or art, is new; however, this educational model is increasingly absorbing construction educators' attention. Construction studios provide an opportunity for intensive interactions between instructors and students through incremental perform, feedback, and revise stages. Studios are an ideal place to implement active learning approaches using a project-based educational structure. Studios A and B are the first two studios in the Building Construction Science Program at Mississippi State University, offered in the curriculum's first year. In these two studios, students learn and practice the basic subjects of the construction processes such as drawing construction plans, site survey and logistics, designing and building concrete units, developing shop drawings for a modular house and its fabrication, including steel and wood framing, roofing systems, envelope systems, wall systems, openings, and interiors. The holistic construction education approach used in these two studios provides students with an excellent opportunity to explore a wide range of activities and foster their construction knowledge by learning the theoretical content in class and practicing it afterward. A quantitative survey was used to explore the perception of students about studios. The results indicated the design-build process used in these two studios for building modular houses has a affected students' perceptions in construction. In addition, the "learning by doing" approach, practiced in studios, had a positive impact on students' engagement and helped students to comprehend the construction materials and methods more efficiently.

Keywords: Construction; Design-Build; Education; Studio; Project-based learning

Background

Learning By Doing

Learning by doing has recently emerged as an effective method in the educational realm in various areas. The core theme of the concept is that people learn more when they actually "do" the activity. The history of this concept extends back to a century ago when John Dewey popularized learning by doing concepts. This process is often accompanied by learner engagement in which learners (i.e., students) find some degrees of relevance between their practical curriculum and their experiences. Some factors make this learning method to be more effective. This experimental learning method engages students more and puts them in situations where they have to think, employ their previous knowledge, use all available resources, and generate actions. This cycle may repeat many times, and through these iterations, students can see the consequences of their actions and refine them if needed. Doing by learning is considered as an active learning approach that creates content knowledge with a longer retainment. Based on Dale's cone of learning, doing real things has a long-lasting effect and increases learning quality (Lee & Reeves, 2017). Dale depicted the progression of learning experiences from the concrete to the abstract (Figure 1).

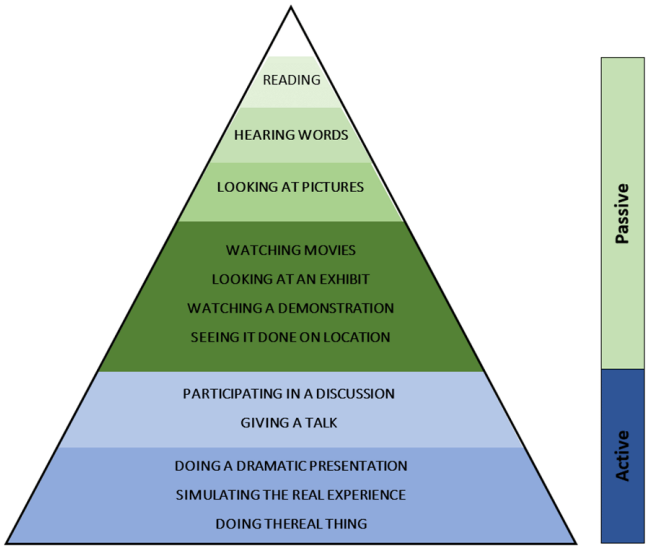

Figure 1: Edgar Dale's Cone of Learning

Learning by doing also provides a more personal education which is a richer learning experience (Ho, 2021). This experience can lead to a personal connection that encourages exploration and curiosity from learners. The concept of learning includes various design models that strive to embed learning within real-world contexts, including studio work, internship and Co-Op, project-based learning, and laboratory. The variety of tools and methods employed in learning by doing realm shows its independence from any particular medium.

Learning by doing has been used in many higher education programs. Bagarukayo et al. (2012) developed a model for the introduction of an Information and Communication Technologies education program and used the learning by doing concept as a method for the effective integration of content knowledge in the educational process following Bloom's Taxonomy. OECD (2016) explored the power of digital technologies and skills for innovating education and discussed educational gaming as an example of technology-supported pedagogical models that can promote learning by doing, which will benefit professionals such as architects and engineers who think and work simultaneously. Goggins (2012) explored the impact of community-based projects in enhancing student learning and engagement through various ways, including university-community partnerships, city-university partnerships, and partnerships with other official agencies in which real learning problems and contexts for students are provided. He found these learning by doing examples can increase the students' sense of ownership of their own learning. Welskop (2013) discussed action learning as an effective and efficient process-oriented quality educational method in which and provided eight recommendations to change from traditional to experiential methods in action learning and stated students with the ability of expression are more likely to take action. Glasby (2015) discussed future trends in teaching and learning in higher education and strategies universities can utilize to respond to change and stated that massive open online courses might be used to enable universities to provide a higher quality education through learning by doing. The learning by doing concept is particularly practiced in construction programs. Hinson (2007) reviewed the application of learning by doing notion in the design-build programs to incorporate research-driven" design-build in addition to hands-on learning and community service. It was shown that multilayered projects in architecture programs allow students and instructors to interact in a learning-by-doing cycle of present-practice-evaluate-revise. Zhu (2007) reported participation as Learning-by-Doing in a Habitat for Humanity project and discussed participation in the construction process noticeably increased the attachment to the house, learning satisfaction, and the frequency of maintenance. Sáez et al. (2016) reported a practical workshop for studying gypsum as a material and its traditional use, both for mortar and plaster, and showed students learned the content better through their first-hand experience while they remained satisfied and interested throughout the course. Roussou (2004) investigated interactivity as a critical component of virtual reality environments and its effects on learning and showed VR could provide a context for the learning by doing method. Fonseca (2021) analyzed the interaction between learning by doing concepts and implementing changes during the building process of a project and showed through learning by doing, consequent improvement in quality, productivity, and worker safety are facilitated.

Building Construction Science Program

While studios are the default structure of programs in the design-based programs such as architecture, interior design, and landscape design programs, studio-based curricula are an anomaly in construction education; there are only a few construction programs in the U.S. with a studio- or project-based curriculum. Despite this fact, construction programs provide an ideal environment in which the studio pedagogical model can be employed. The complex and multifaceted nature of construction and its flows, products, and processes make project-based learning an effective method that enables construction educators to teach collaboration, design, create, and produce high-quality outputs. Studios are shown to foster key characteristics of successful education such as creativity, collaboration, hands-on experiences, communication, and critical thinking.

The Building Construction Science (BCS) program is a four-year degree structured to prepare knowledgeable and creative professionals for various careers in construction-related areas. This program has employed an interdisciplinary curriculum that builds upon expertise existing within the College of Architecture, Art, And Design, the College of Engineering, and the College of Business along with the construction industry, to provide a knowledge base for students. The core component of the BCS program is project-based learning, by which students will empower their theoretical knowledge through a series of projects designed for major courses. The project-based learning approach allows instructors

to effectively interact with students individually or in groups and navigate their learning paths toward determined course objectives. The studio-based delivery method employed by BCS is unique in construction education. BCS and a few other construction schools in the U.S. are promoting this model to boost the traditionally lecture-based construction education.

The BCS 124-credit hour curriculum includes a general education foundation of mathematics, science, business, and construction-specific topics, including construction materials and methods, emerging technologies in construction, structures, estimating, scheduling, safety, project management, and construction law. The core component of the BCS program is a chain of eight construction studios that are offered sequentially. Each studio provides six semester credit hours and meets a total of 12 contact hours per week. Construction topics are provided in each of the eight semesters of the program through different modes such as lectures, group presentations, individual and group projects, and collaborative work. In addition to time spent in studios, students, on average, spend about twelve hours outside the class time for their studio activities and projects. Since instructors and students spend a great deal of time on studio activities, BCS provides a great potential for covering both construction-based subjects as well as other relevant multidisciplinary topics through collaboration with other programs such as architecture. In each studio, a series of interrelated subjects with an appropriate level of detail is provided, which extends to the next semesters and thus creates a cohesive and holistic range of topics. Eight BCS studios cover a variety of construction topics in iterative cycles. Main topics and processes for these studios are specified in the BCS curriculum as follows:

BCS Studio A: *Introduction to construction materials and methods, construction drawing and modeling, building systems, project life cycles and management, and professional thinking and action*

BCS Studio B: *Development of building assemblies and construction sequencing, drawings and computer applications, project management skills, and professional thinking and action.*

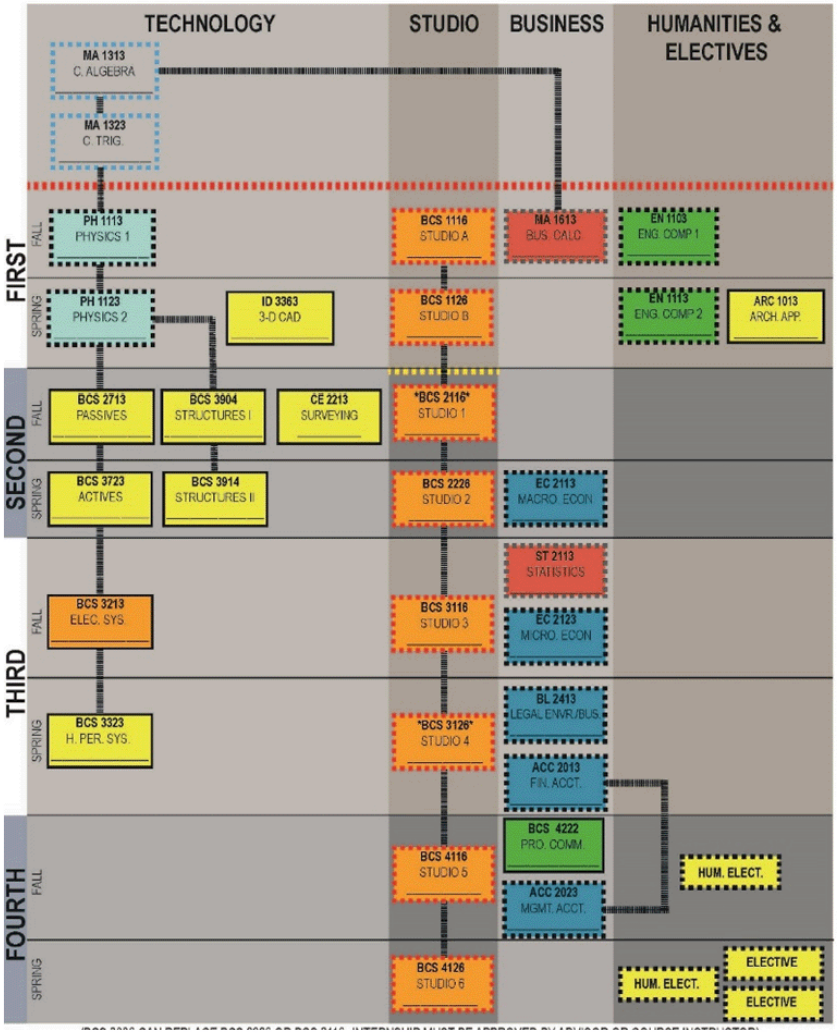

Figure 2: BCS Curriculum

BCS Studio 1: *In-depth examination of building construction materials and methods, systems, construction drawing and details, and construction finishes*

BCS Studio 2: *In-depth study of building assemblies and systems, fabrication, construction methods and sequences, computer modeling and analysis, and design and construction integration*

BCS Studio 3: *In-depth study health and safety, project management, construction management, plant and equipment management, logistics and operations management, and building pathology*

BCS Studio 4: 6 hours. *In-depth evaluation of the principles and applications of construction productivity, estimating and bidding procedures, cost alternatives, scheduling, sequencing, budgeting and project cashflow management*

BCS Studio 5: *In-depth evaluation of the legal and contractual environment for construction activities/projects. Emphasis on specifications; dispute resolution; construction contracts and procurement systems; and project delivery modeling*

BCS Studio 6: *In-depth study of project controls, risk management, strategic management, construction accounting, facilities, and maintenance management, and international construction and contracting.*

While all eight studios utilize various aspects of the design-build approach in their course agendas, Studios A and B, as the first-year studios, put an emphasis on advocating the design-build approach in construction education. The agenda for these two courses include the following sections:

The Construction Profession: The goal of this assignment is to reinforce students' understanding of the different types of opportunities available in the construction management profession. In this module, students perform written and oral communications, develop research skills, understand the influence of culture on construction, a variety of construction materials and methods, and the evolution of construction.

Scale Drawings: In this assignment, students field measure one of the four existing modular buildings in the BCS department, and through that, they understand how to field measure and record information, and they practice drawing conventions and how to create scale drawings.

Site Survey: In this module, first students hand sketch, field measure, and photograph all aspects of the existing site. They also need to document a portion of the adjacent properties that directly affect their site. These field measurements, hand sketches, and photos are then used to create a site plan. They are required to measure all aspects and details, including width, length, height, and other properties.

Concrete Modules: The purpose of this module is to study the nature of concrete from hands-on experience. Students make several samples of different mix designs to test the strength, efficiency, workability, and formwork. Students also learn to work with their group to achieve an efficient quality result.

Foundation Systems: In this module, students learn how to research different types of foundations, and then they build a model of a complete foundation system. Foundation systems include spread footing, monolithic slab on grade, raised slab, belled caisson, socketed caisson, friction resistance pile, h section end-bearing pile.

Foundation Fabrications: This module aims to study the nature of concrete, foundation systems, construction drawings, and quantity takeoff. Students also learn to work with their groups to achieve an efficient quality result.

Structural Frame Fabrication: The purpose of this module is to study the properties of steel and wood structural frames, framing assembly techniques, job management, and quality control through the study and fabrication of a small modular building. This module includes shop drawings and fabrication steps through which safety reports, quality assurance, performance evaluations, and workflow evaluations are provided by students.

Figure 3: Sample Students Work in Studios A and B

Scope of Work: The purpose of this module is to learn how to investigate existing conditions and the needs of the client to put together a clear scope of work that includes a schedule of events.

Roof Systems: The purpose of this module is to study envelope systems and the design process. To understand efficient design, proper use of material, and proper construction methods, students explore roof systems, design a roof system, create shop drawings, fabricate the wall system onto the modular building, and document the entire process.

Wall Systems: The purpose of this module is to understand the envelope systems/wall systems, the materials and construction methods used to assemble these systems, the design process and the construction process, and how to manage a multidisciplinary team. To understand efficient design, proper use of material, proper construction methods, and proper team management, students investigate the wall system, design a wall system, create shop drawings, fabricate the wall system onto the modular building, and document the wall system entire process.

Methodology

Students' perceptions are among the factors that impact the performance of students. The main objective of this study was to explore BCS students' perceptions toward their hands-on experience in Studios A and B, in which they followed a design-build approach to build a module house.

A survey was designed to gather quantitative data to provide a basis for further course modification. A quantitative research method was utilized to capture students' feedback and comments about their experience and, in general, their studios. For this purpose, students who had at least one year of previous studio experience in the studio were eligible to participate in the survey. The survey covered studios' different aspects, including studio potential learning outcomes, various layouts and features of studios, and the possible setting for studios in construction. The data were gathered, cleaned, and modeled for descriptive and inferential analyses. A total of seventy-four undergraduate construction students, including 30 sophomore, 25 junior, and 19 senior students, participated in the study.

Results

A major section of the survey covered different possible outcomes of studios. These outcomes were derived from the literature and were highlighted as in different BCS studios. Students were asked to rate the importance of a group of BCS outcomes, including professional socialization, encountering in-depth problems, adapting procedures to real cases, creativity, application of knowledge, analysis of problems, evaluation of ability, hands-on experiences, communications, group discussions, group work/teamwork, practical work, increase self-confidence, and learning in different ways. A five-level Likert scale was used to quantify students' ratings (1: Very Low, 5: Very High). A weighted average was calculated for each outcome. The first seven highest scores were selected. Figure 4 shows the percentage of each agreement level for these outcomes. Group work, hands-on experiences, and group discussions were perceived as the most important outcomes by students.

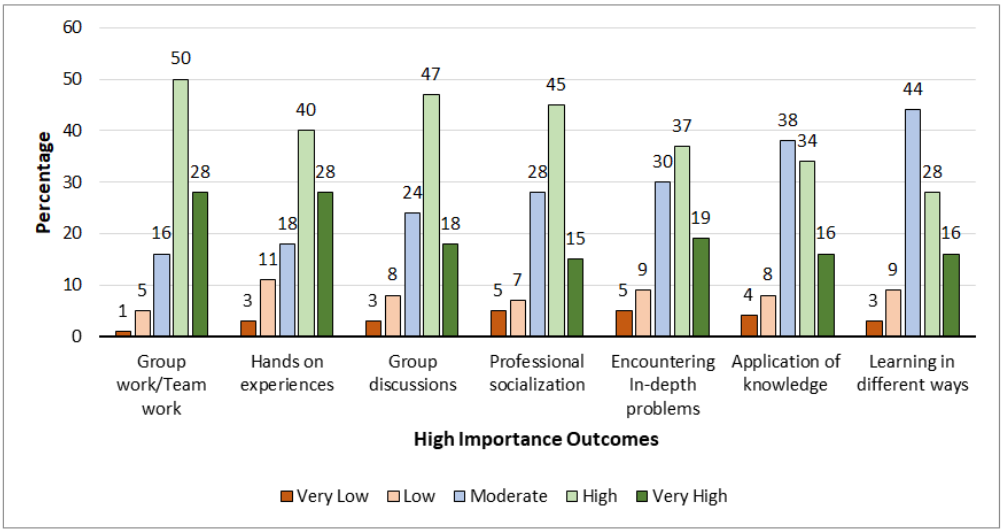

Figure 4: Percentage of importance level for studio outcomes

In another section, students were asked to rate the importance of various aspects of studios. Like the previous section, a five-level Likert scale was used to quantify students' ratings (1: Very Low, 5: Very High). The list of studio features included different items that were generally observed or used by students throughout their classes, including proper time to work on assignments or projects, having more time to be in the department and interact with people, greater access to instructors, the broad range of topics covered, doing various activities right after lectures were presented in studios, having guest speakers from industry, group discussions, and group work/teamwork. A weighted average of each item (out of 5) was calculated and shown in Figure 5.

As shown in Figure 5, group work and having proper time to work on assignments during class time were perceived as the main features of studios, which is consistent with students' perceptions toward different outcomes of the studio model.

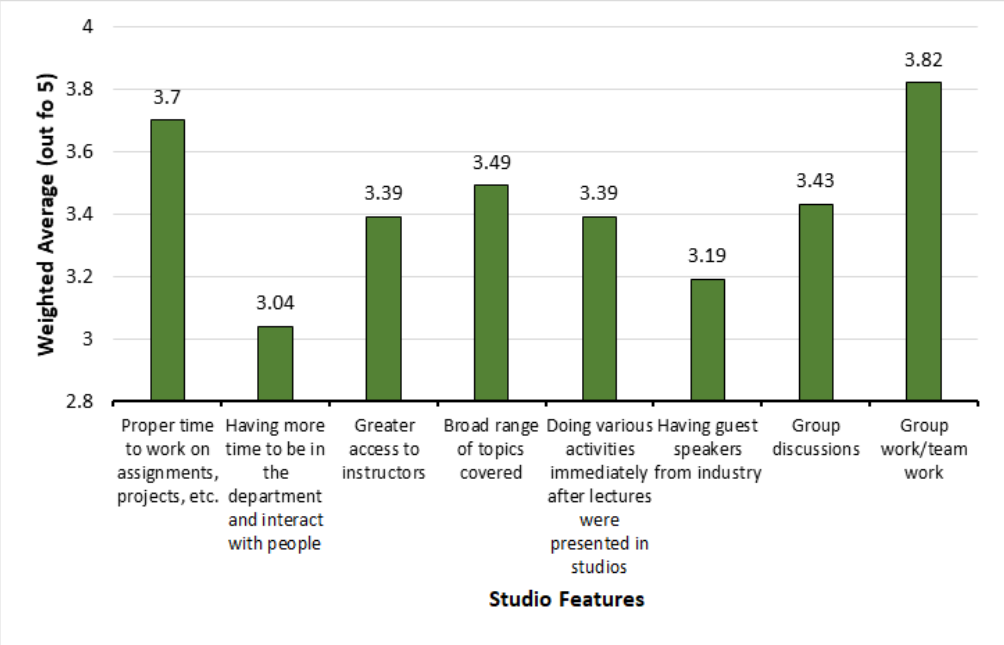

Figure 5: Weighted average of studio features

Conclusion

Although the studio-based curriculum is new in construction education, it is an emerging teaching method. Construction programs offer various hands-on topics which are completely suitable to be provided in a studio format. The studio-based delivery method enables educators to design their course contents in a way to incorporate a present-practice-evaluate-revise approach. In this approach, instructors present the course topics through different methods, including lectures, recorded sessions, flipped classrooms, student research, or so forth. These tools provide the required information for students to begin with their projects, designed based on the presented content. In the next part of the studio, construction students work on their design or creation projects in which the flexibility of the studio and ample time allow them to interact with their instructors or peers and develop their work. In the next section, students' work is evaluated by their peers in groups or instructors. As a result, required comments and feedback are provided to them, which help them revise their work for the next iteration or final submission. BCS Studios A and B are perfect examples for this cycle in which students learn the basics of design through the plan design and development process for a modular house and then build their designed products. The design-build approach used in the context of the studio-based model equips construction students with the required technical knowledge. Students' content knowledge, then, is reinforced by their practical work through hands-on experiences. In addition, this iterative learning process extends to a more in-depth cycle in their next studios. While analysis of student performance observations and perceptions exhibits the efficacy of the studio-based model in construction programs, especially for design-build approaches, generalization of the data provided in this paper is not warranted. Studio-based models are new in the construction realm, and more construction programs or classes should be explored to develop an effective studio-based model for construction education. In addition, gender, course subject, educational home unit, instructors' previous experiences, and facilities are among factors that can change the outcomes of any construction educational setting. Further examination of the studio's cognitive, behavioral, and physical features will reveal insight toward developing a standard studio-based model for construction programs.

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