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Collaboration as a Multifaceted Skill Set in Construction Education

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Abstract
Collaboration is a key element in many programs, especially those with common themes with other disciplines. The collaboration concept in recent years has been a focal point in educational models for multidisciplinary programs. A similar situation also exists in the professional environment. The construction industry is a broad industry with numerous interactions with trades, developers, engineers, and designers. Likewise, construction programs incorporate subject modules in their curricula that are shared with other relevant programs such as civil engineering, architecture, and business. The intertwined nature of several topics in construction makes collaboration an effective approach for content delivery. The collaboration takes place in various forms and different capacities. This paper addresses the collaboration efforts in two major courses between the Building Construction Science and Architecture programs at Mississippi State University. A quantitative method was used to explore both majors' students' perceptions toward the different aspects of teamwork and collaboration. The result indicated that different components of the collaboration system, such as teammates, instructors, content, and tools, were perceived at different levels by students. The findings of this study not only provide insight on nuances of collaboration but also help construction educators and administrators to better design and develop collaborative environments and control factors that impact the efficiency of such educational realms.

Keywords
Collaboration, Construction, Education, Architecture.

1. Introduction

In recent decades, the role of collaboration in the construction industry and education has become increasingly more important. In construction education in particular, due to the necessity of today's industry work environment, having the ability to work with other disciplines is critical. Research suggests simulating real-world experience for construction students can significantly help students develop their skills while in school prior to entering the job market. In Mississippi State University College of Architecture, Art, and Design, two of eight studio courses in Building Construction Science (BCS) and Architecture (ARC) curriculum are collaborative studios. In these studios, BCS and ARC students work alongside each other to complete the group projects defined in the studio. As part of this effort, students develop their communication skills to prepare for industry standards and eventually deliver projects to the client. An important aspect of this collaborative effort is for students in both disciplines to understand the challenges faced in the other discipline as well as learn effective communication and collaboration tools and technics. Students also research various project delivery methods to analyze the benefits and disadvantages of each method and finally choose one to utilize for their project. In the first collaborative studio, which happens during the second year of the curriculum, BCS and ARC students collaboratively work on a design/build project to design, develop, and construct real-life products and deliver to clients. The teams consist of 10-12 students divided into subgroups of designers, general contractors, and fabricators. During this process, the BCS students are fully immersed in the iterative process of design and ARC students begin to realize the challenges of constructing a real-life full-scale project. In the second collaborative studio, which happens during the third year of the curriculum, BCS and ARC students collaboratively work on designing and further developing a commercial size building to propose a comprehensive solution to a design issue. ARC students focus on the aspect of schematic design and design

development and presentation while BCS students focus on using technology -- as members of a multidisciplinary team -- on aspects of estimating, scheduling, site planning, logistics, and so forth.

2. Background

Collaboration, as defined in a seminal study by Wood & Gray (1991), takes place when a group of autonomous stakeholders of a problem domain is involved in an interactive process, using shared rules, norms, and structures, to act or decide on issues related to that domain. Thomson et al. (2009) further elaborated this notion stating that collaboration requires negotiations among the parties involved to jointly create rules and structures for mutually beneficial relationships. Collaboration is not defined in the same way across different disciplines (Thomson et al., 2009; Bedwell et al., 2012). Within the construction industry, collaboration has been widely discussed lately. BIM-based Construction Networks (BbCNs) is a new term coined which entails the teams, comprised of members from several specialist organizations, to undertake BIM-related tasks on BIM-enabled projects (Oraee et al., 2017). Within this context, fostering collaboration is a top priority for construction project managers. On the other hand, research in the past decades identified gaps in educational paradigms, which lead to inconsistency with the constantly evolving needs of the industry, particularly with respect to collaboration and building information modeling (BIM). A recent study on improving collaboration in construction employed action research (A.R.) approach to investigate the role of participants in a construction project (Connaughton & Weller, 2013). The results highlighted the importance of effective collaboration within the framework of action research. In a cross-national study, multiple universities across Turkey, the United States, Israel, and Brazil developed a course, "International Collaborative Construction Management," to investigate the efficacy of collaborative paradigms in construction education (Soibelman et al., 2011). The course was developed over three years and required students to collaboratively develop construction schedules, cost estimates, risk assessment plans, and so forth. The study argued that the traditional skills and education style of engineers and construction managers did not prepare them to successfully address globalization issues (Soibelman et al., 2011). Therefore, there was a need to devise more innovative approaches to construction education to keep up with the present needs of the industry. Research from the early 2000s also indicated that due to globalization, academic institution, industry professionals, and corporations highly benefited from the advantages of collaboration and development of students who were trained in multicultural teams with international content (Steele & Murray, 2000; Bradner & Mark, 2002). It is also worthwhile to note that industry internationalization has been accompanied by revolutionary changes in engineering practices, management, and the structure of collaborative groups (Doerry, 2003). Therefore, adequate training and preparation for students in construction fields is essential. Findings from later studies also indicate the necessity of collaboration skills to succeed in today's rapidly evolving, complex, and multidisciplinary construction workforce (Ozbek & Clevenger, 2017). Also, the construction industry increasingly seeks employees with demonstrated collaboration and teamwork skills (Valdes-Vasquez & Clevenger, 2015). Therefore, the development and implementation of collaboration skills and paradigms in construction education have become increasingly important.

The international demand and emphasis on sustainable approaches and the necessity to improve efficiency and address present needs require new educational approaches to Architecture, Engineering, and Construction (AEC). A comprehensive study in 2011 examined the current AEC educational environment to provide a baseline solution to cope with the complexity of this challenge (Becerik-Gerber et al., 2011). The study looked at 101 U.S. AEC programs concentrating on emerging topics of Building Information Modeling (BIM) and sustainability and investigated how educational innovations of distance learning, multidisciplinary collaboration, industry collaborations, were incorporated to develop core competencies in those two subject areas (Becerik-Gerber et al., 2011). This research highlighted the disparities in reviewed educational programs and suggested realignment to develop the future workforce that will lead the AEC industry transformations. A recent study on collaboration and coordination modules for BIM education at the Illinois Institute of Technology indicated the significance of BIM education and the necessity of collaboration in a shared knowledge network (Bozoglu, 2016). The study discussed that the challenges reside in the classic gap between academic vision on disciplinary principles and the industry needs for specific application competency. On the other hand, the heart of BIM is an effective collaboration (Du et al., 2020). Several studies looked at the ways that collaboration in BIM-related courses impacted student learning through peer pressure. Zhao (2021) examined the existence of peer pressure in BIM collaboration and explored its effect on student learning outcomes. In this study, the researcher designed four pedagogical scenarios to simulate different degrees of peer pressure and found a positive relationship between the level of peer pressure and the student learning outcome (Zhao, 2021). Other studies explored innovative ways to implement collaboration in virtual worlds in construction education. In a study by Ku & Mahabaleshwarkar (2011), the researchers proposed the concept of building interactive modeling to complement the

capabilities of BIM with social interaction to enhance collaboration information and knowledge sharing. This is even more critical since back in the late 2000s, almost fifty percent of the AEC industry was using BIM, and twenty percent of non-users were planning to adopt it within the next two years (Construction, 2009). The authors also discussed that through using virtual worlds, building interactive modeling will leverage participants' knowledge to better lead the management and collective decision-making. Given the nature of the construction industry with qualities like fragmentation and the need to communicate over a distance in large-scale projects, researchers looked at solutions in the education sector to prepare students for working in such a context. A study by Soetanto et al. (2012) reported on an industry-sponsored project that implemented an innovative learning approach that consisted of a distanced collaboration between students from different disciplines from two institutions in the U.K. and Canada. While the study utilized empirical work entailing interviews and surveys in different stages of the project, the findings revealed the impact of disciplinary training on the development of effective virtual collaboration (Soetanto et al., 2012). To further elaborate the underlying reasons for the enhanced efficiency, Soetanto et al. (2012) argued that there are attitudinal requirements that facilitated successful multidisciplinary working including willingness to accept other ideas, levels of trust, a preference to working in teams, the ease to establish relationships with others in the team, which are dependent on the culture at functional, organizational and national levels. These aspects could be more easily acquired through experiential learning provided by collaborative environments as opposed to the process of knowledge transfer in traditional lecture sessions (Soetanto et al., 2012). Additionally, it is noteworthy to mention that the changing operational environment and increasing competition in the higher education sector played an important role in promoting the introduction of new pedagogical approaches to teaching and learning, including Problem-based Learning (PBL), which is at the core of the collaborative industry and educational environments. PBL revolves around student activities; students learn more effectively from the activities they undertake and experience first-hand, rather than attending seminars and listening to traditional lectures in classrooms (Soetanto et al., 2012).

3. Methodology

The main purpose of this study was to investigate the effect of collaboration as a multifaceted skill between two groups of Building Construction Science (BCS) and Architecture (ARC) students. The participant population included 125 students (BCS: 91 and Arc: 34) who were engaged in two of eight studio courses in the BCS and ARC curriculum in Mississippi State University College of Architecture, Art, and Design in 2021. In these studios, BCS and ARC students worked alongside each other to complete the group projects defined in the studio. Upon the completion of data collection, all the data were combined into a data model, uncompleted responses were deleted, and standard imputations were applied, organized, and analyzed with statistical software SPSS. The questionnaire consisted of two sections. The first section was designed to collect the demographic profile of students. The second section focused on obtaining information regarding different features of collaborative studios in BCS and ARC programs. In all relevant questions, if the participant was a BCS student, the collaborator major was Architecture, and vice versa. The survey was distributed on paper to increase the rate of return. The obtained data were collected, cleaned, and modeled, and descriptive analyses were performed to explore the constructs related to the research questions.

4. Results

The first section of the survey was designed to obtain demographic information. The questions were based on five-point Likert scales ranging from very low (1) to very high (5). Table 1 provides demographic information of students. Participants were asked to what extent they considered their teamwork with their collaborator major students successful. Fifty-six of the students believed their teamwork with the collaborator was successful. The percentages of the consideration of both BCS and Arch groups are shown in Figure 1.

Table 1. Demographic Information

		BCS	Arc
Gender (%)	Male	91.2%	47%
	Female	8.8%	53%
Expected Final Grade (out of 100)		87.47	89.70
Hours spent per week		16.67	18.78

In the next section, participants were asked to specify the impact of several pre-defined factors on the success of the collaborative studio. Those factors included shared understanding of the perspectives, commitment to participate, mutual benefits, trusting relationships, effective communication, diversity, working at the same time in the same place, complementary skills, regular feedback by teammates, and regular feedback by professors. A five-level Likert scale (1: Very Low; 5: Very High) was used to rate the factors. The weighted average of each score (out of 5) is shown in Figure 2.

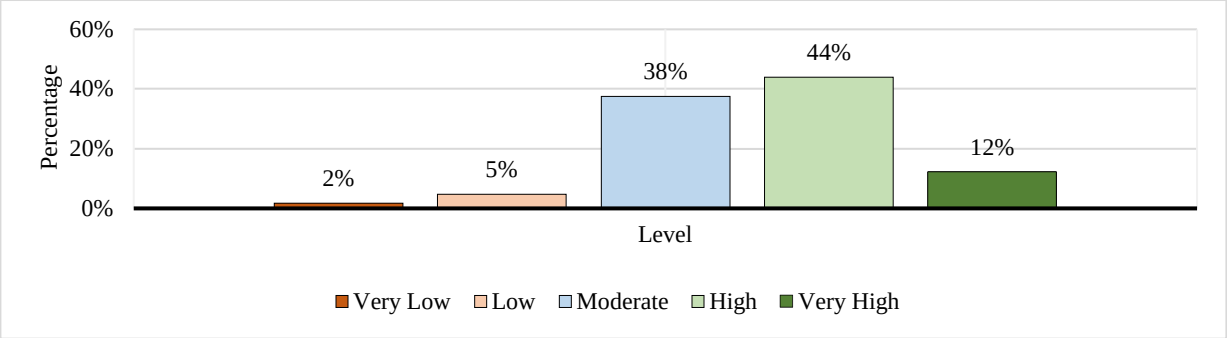

Figure 1. Percentage of success level of teamwork with collaborators

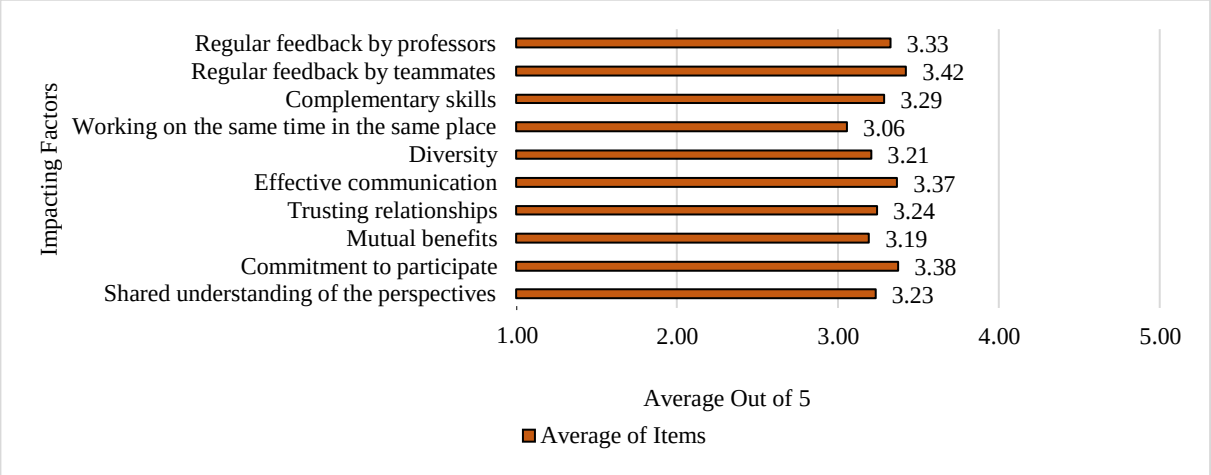

Figure 2. Weighted average score of factors impacting the success of the collaborative studio

The participants were also asked to what extent they learned from teammates in their own major or their collaborators in their collaborative studio. Figure 3 shows that in the "High" and "Very high" levels, the percentage of "learning from own major" was higher than that of "collaborator". The survey participants were also asked to what extent they learned from both majors' instructors in their collaborative studio. As shown in Figure 4, the majority of students expressed a high rate of learning from their own instructors in the collaborative studio rather than collaborator

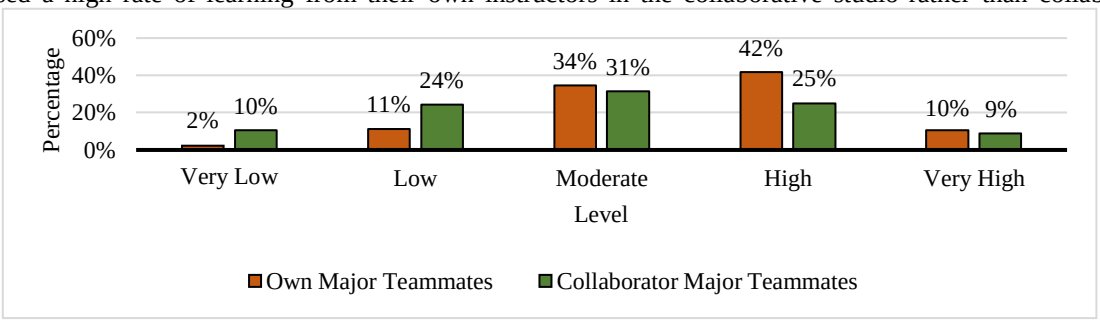

Figure 3. Percentage of learning levels from collaborators

professors. In another section, participants were required to specify their preference for asking questions or discussing issues with their own or collaborator instructors in the collaborative studio. Figure 5 shows that students preferred to ask their questions or discuss issues with their own major instructors instead of collaborator instructors.

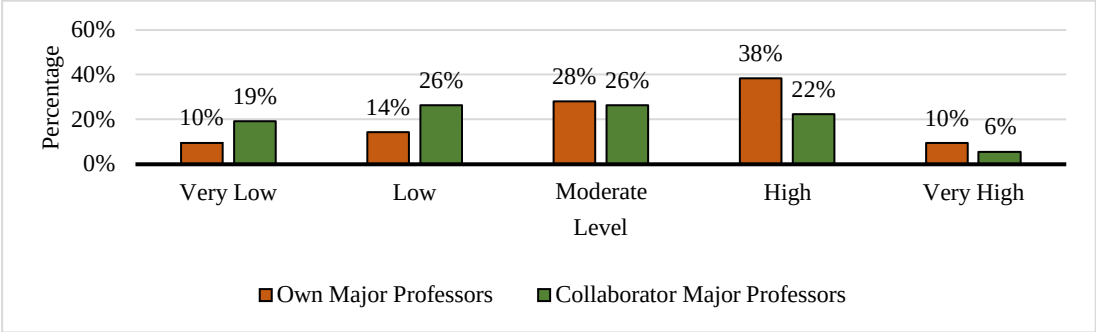

Figure 4. Percentage of learning levels from instructors

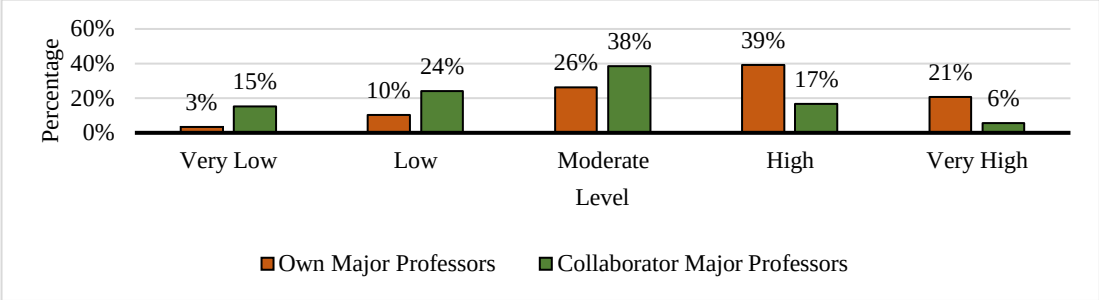

Figure 5. Percentage of discussion preference levels

Students were also asked about their evaluation for the quality of communication (timeliness, clarity, politeness, etc.) with their team members in the collaborative studio. Figure 6 shows that most of the students had better communication with their major teammates rather than the collaborator teammates. The results also showed that 6% of students evaluated the low quality of communication with their team members in the collaborative studio. The survey participants were also asked about the rate of the usefulness of collaborative studio and its content to all students, including their own major and collaborators. Based on the results, students shared a similar opinion based on the five-point Likert scale ranges. As shown in Figure 7, more than 54% (High and Very High) of both groups of BCS and ARC students believed the collaborative studio is equally useful for both majors' students.

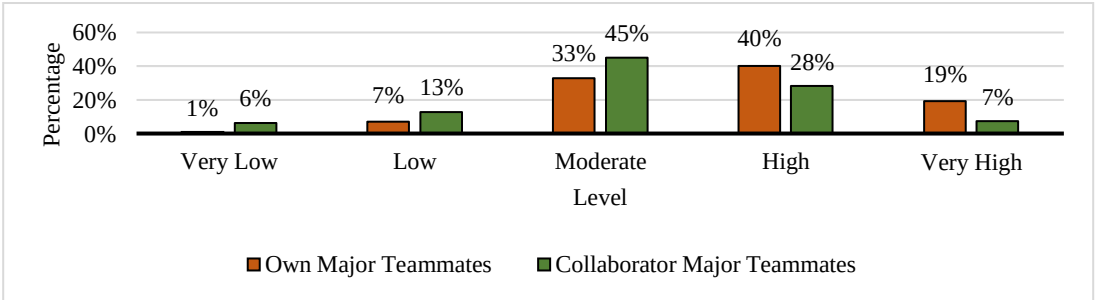

Figure 6. Percentage of communication quality levels

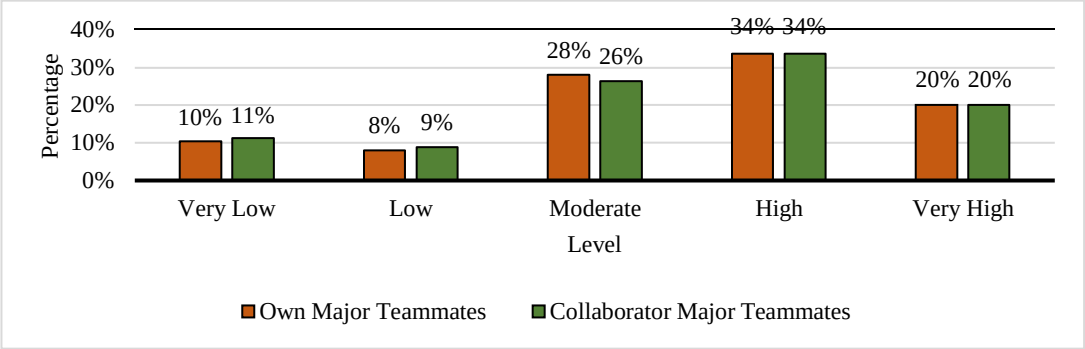

Figure 7. Percentage of perception about the collaborative studio

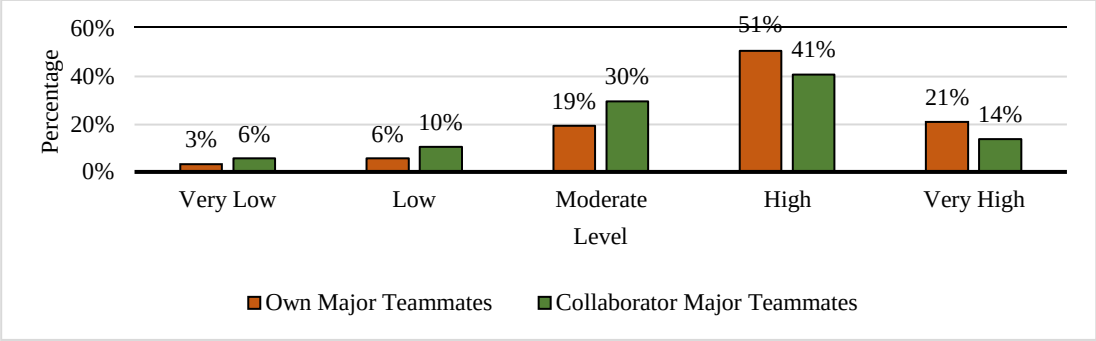

Figure 8. Percentage of student performance level impacting the success of the student's projects

The survey participants were also asked about the performance of the members in the collaborative studio that impacted the success of the student's projects, as shown in Figure 8. As the figure implies, both BCS and Architecture students believed that the performance of both majors' members in their collaborative studio highly impacted the success of their projects/assignments, although the percentage of their own major teammates was higher in the "high" and "very high" levels. The next question examined students' satisfaction with both groups' performances. As Figure 9 shows, the satisfaction with the performance of the own major teammates in the collaborative studio in "High" and "Very High" levels was higher than that of collaborator teammates. Finally, participants were asked about their willingness to take another collaborative studio with their current one versus another major. Figure 10 represents the extent to which students were willing to have another collaborative studio. Two groups of BCS and ARC students shared similar opinions on having another collaborative studio with their current one or another major from art or engineering.

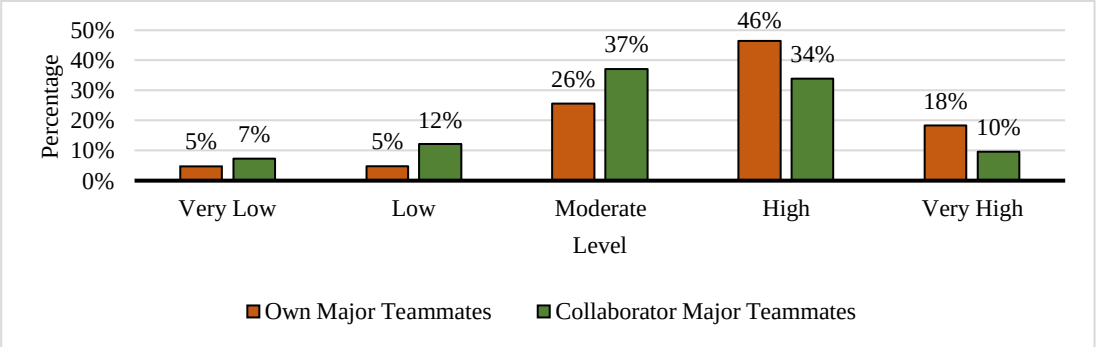

Figure 9. Percentage of overall satisfaction level

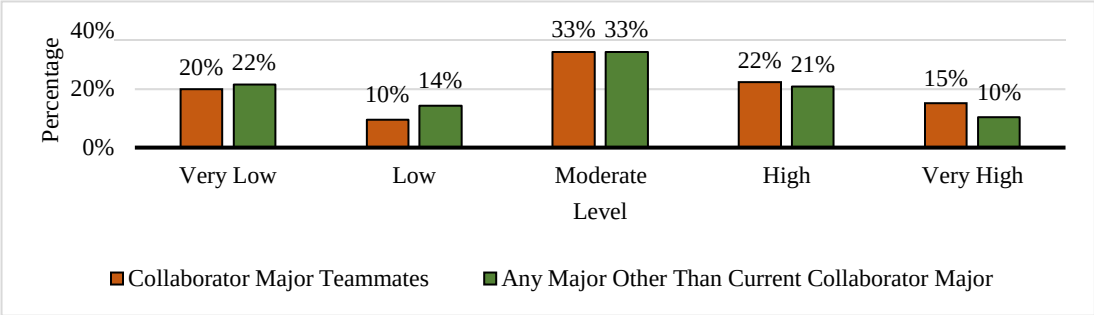

Figure 10. Percentage of willingness to take another collaborative studio

5. Discussion

To conduct this study, the literature review and discussion with the educators identified various factors to better understand the different features of collaborative studios in BCS and architecture programs. Then, the related questionnaire was responded to by 125 students. In this group, 73% were studying BCS, and 27% were architecture major students. As shown in Table 1, the average of females' studying hours per week was greater than male students' (Male=16.66 hours, Female=19.04 hours). Also, the expected final grade of architecture major students was higher than BCS (BCS=87.47, Architecture=89.70), and the average studying hours per week of architecture students was higher than BCS students (BCS=16.67, Architecture=18.78). The results showed that more than 56% of students considered a high rate of successful teamwork with their collaborator major students, and less than 7% believed the teamwork with their collaborator major students was not successful. In addition, the results showed that the learning rate, the quality of communication, the performance of the following members in the collaborative studio impacted the success of student's projects, and satisfaction with the performance of own major teammates in the collaborative studio was more than corresponding numbers in collaborator group. For example, 52% of students reported a high level of learning with their own major teammates. Additionally, 59% of students reported a high impact of quality of communication with their own major teammates. In contrast, just less than 8% expressed that the rate of quality of communication was low. A similar pattern was discovered for collaborator teammates. Additionally, students believed that the collaboration student was equally useful for both majors. Also, students stated that the course content is highly useful for both sides. Furthermore, the results indicated that students generally considered a high rate for both majors' performance on the success of projects. In other words, students, on average, did not distinguish between the impact of both majors' students' performance on the success of their projects. Another notable point from the results was the preference of students for interactions with their instructors. In this section, the difference between the percentages of "High" and "Very High" levels of "own major" was higher than those of "collaborator." This means students preferred to communicate with their own major instructors, even though other instructors were available to them.

6. Conclusion

This study was an attempt to look at two collaborative studio courses between ARC and BCS programs at Mississippi State University and explore aspects associated with collaboration as a multifaceted skill. The findings of this study, consistent with existing research, supported the efficacy of collaboration in overall success from the students' perspective in AEC educational programs. The findings also highlighted the importance of communication in overall success. Therefore, efforts should be implemented to enhance the communication between students of each discipline with the other as well as the collaborator professors. In future research, it may be helpful to conduct a more detailed interview with a select group in order to further explore the fine details and nuances in students' perception. In spite of the apparent anticipation that collaboration should always result in a higher rate of success, the findings of this study suggested that students' perceptions does not always agree with that. Possible reasons include the lack of efficiency in communication leading to unsuccessful collaboration, improper team dynamics, the project scope, presence of external entities or industry partners and so forth. Also, it is evident that the results may have changed if the population included students in other disciplines where collaboration framework was different. For future research, certain measures should be taken to investigate specific dimensions of projects defined in collaborative courses and

explore how different modules of a project might induce or discourage collaboration. Additionally, exploration may entail how and to what degree different kinds of assignments could be better completed in a collaborative effort or as an individual effort. Other factors to be considered in future is the size of the collaborative teams, the make-up of the team (number of students from each discipline), the time needed to complete the project and so forth.

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