

**A Statistical Analysis of the Effect of Collaborative Projects on Critical Thinking Skills
among Architecture Students**

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ABSTRACT

This research paper proposes the effect of collaborative projects on acquisition of critical thinking skills by architecture students in the form of a quantitative, cause and effect research design. Against this background, collaborative learning has been strongly encouraged in the face of the growing interest in problem-solving, creativity, and reflective thinking in architectural education. Nonetheless, there is not much empirical data on its effectiveness in terms of its measurement in architecture programs. A pre-test/ post-test control group study was conducted to fill this gap to access 120 undergraduate architecture students in three South Asian universities. Experimental group engaged in team-based design projects which were organized and the control group had projects of the same nature but were done individually. The Watson-Glaser Critical Thinking Appraisal was used to evaluate the abilities of critical thinking at the beginning and the end of the semester. Findings revealed that students who participated in team learning were much improved in terms of their critical thinking scores than those who learned on their own ($p < 0.01$). The results indicate that collaborative project-based learning is not just effective in improving design competence, but also in the development of very crucial cognitive skills that are important in future architectural practice. The research indicates the importance of the introduction of collaborative pedagogies in the architectural school curricula and offers evidence-supported suggestions to curriculum developers, educators, and academic policy makers.

Keywords: Critical Thinking, Architecture, South Asian Universities, Education

INTRODUCTION

The interdisciplinary and dynamic character of architecture requires both the technical and creative design skills and also a good principle of critical thinking. The field of architectural education has been changing drastically in recent decades, as more and more attention has been paid to pedagogic strategies of enhancing the depth of learning, problem-solving, and critical thinking (Salama, 2015). Among them, collaborative learning has become a salient approach, which is frequently implemented in studio-based activities, group design projects, and interdisciplinary projects. Nevertheless, although the benefits of

collaboration in theory are well established, empirical studies, especially quantitative studies on the relationship between collaboration and critical thinking development among the architecture students, are scanty.

Critical thinking is a very essential mental ability, which involves analysis, evaluation, decision-making, and reasoning. To the architecture students, the skills are paramount in the complex design issues, contextualization of knowledge, and informed decision making in the design workflow (Doyle & Gorman, 2003). According to educational researchers, the learning setting that demands team learning facilitates the use of peers to discuss and express ideas, to engage in communication with peers, to learn and to be exposed to different ways of thinking and reasoning (Johnson, Johnson, and Smith, 2007). However, in spite of these claims there is minimal evidence on the achievement of the cause-and-effect relationship between collaborative learning and critical thinking with the help of solid statistics in architectural education.

Architectural pedagogy in South Asian context is currently in a development stage to include learners centred and constructivist pedagogical practices. Most design schools are dominated by traditional modes of teaching which tend to focus on individual achievements as well as instructor-based critique. Consequently, team-based learning in studio settings is not consistently implemented, and its efficiency is not investigated. The academic and real-world importance of the research topic is, therefore, the impact of collaborative practices on cognitive skill development due to the needs of contemporary designers and interdisciplinary thinking in the area, which are increasing exponentially.

This paper seeks to address this gap by examining statistically the influence of group project-based learning on critical thinking skills of architecture students. The study employs a quantitative pre-test/post-test control group design to compare the performance of students who are in team-based projects and those who work individually in a number of South Asian universities. Using validated critical thinking tests and statistical tools, the research question will be answered by evaluating whether collaborative learning strategies result in any cognitive improvements that are measurable. The findings of the research will help the existing body of literature that believes in evidence-based reforms in architectural pedagogy, especially within the context of developing education.

LITERATURE REVIEW

The importance of collaborative learning in the education process has been a well-known stimulator of a higher-order thinking, a better understanding, and the enhancement of engagement with a learner. Architectural education, where problem-solving and creativity, as well as interdisciplinary integration, are a core part of the issues and presented as a complex, necessitates collaboration is not only a teaching method, but also a practice (Salama, 2015). This review of the literature discusses available studies on collaborative learning, its relation to critical thinking, and its implications in the context of architecture education, in particular the studies on the topic at the global scale, and those concerning the South Asian context.

Collaborative Learning and Its Theoretical Foundations

The theory of collaborative learning is based on the social constructivist views of education theories, especially the works of Vygotsky (1978) who insisted that social interaction is crucial in cognitive development. Johnson and Johnson (1994) have also defined it as a circumstance where students collaborate in order to attain learning objectives. It is assumed that by means of constructive discussions, negotiation, and self-criticism, learners would perfect the thought processes and gain more effective reasoning skills. The general education studies have continuously reported that collaborative learning facilitates better academic performance, greater motivation and critical thinking (Laal and Ghodsi, 2012). These advantages are commonly ascribed to the exposure to a variety of opinions, the need to explain one's rationale, and the feedback mechanism that is offered by the peers.

Critical Thinking in Architectural Education

It is well known that critical thinking is one of the key competencies of architectural design. It includes critical thinking skills, alternative assessment, synthesis and evidence-based decision-making (Doyle and Gorman, 2003). In studio settings, students are anticipated to participate in iterative design practices demanding both analytical rigor and contextual sensitivity and reflective judgment. Nonetheless, the construction of critical thinking in architecture has always been evaluated in a subjective manner by use of review and juries during design. Being as rich in intellectual content as they are, the environments might not always be a good place to develop critical thinking unless they are designed to allow dialogue and reflecting (Anthony, 1991). This has compelled teachers to pursue more deliberate approaches, e.g. collaborative projects, in a bid to develop these skills in a systematic fashion.

Impact of Collaboration On Critical Thinking

Many empirical research studies in education, science, and humanities have demonstrated that there is a positive correlation between collaborative learning and the process of developing critical thinking. Indicatively, Gokhale (1995) established that students who were subjected to collaborative tasks achieved a lot higher in critical thinking tests than the students who worked individually. Likewise, cooperative learning in the STEM subjects has been linked to higher conceptual knowledge and thinking capacity (Smith et al., 2009). Quantitative measurement of this relationship has not been done in many studies in architectural education. Nevertheless, according to qualitative research, collaborative studios promote peer learning, innovation and cognitive development (Habraken, 2007). The projects involving negotiation, shared responsibility, and collective critique are suggested to reflect the architectural practice in the real world and train students to collaborate in a team and make complicated decisions.

Studio Pedagogy and Team-Based Learning

The key element of architectural learning, studio-based learning offers a rich platform of collaboration. However, the traditional studio culture has tended to focus on individual authorship and instructor-oriented criticism and in some cases the possibility of peer collaboration is inhibited (Koch, Schwennsen, Dutton, and Smith, 2002). The recent pedagogical changes suggest more democratic and collaborative studio-based learning in which students develop knowledge and solutions together. Boyer and Mitgang (1996) proposed a new studio culture based on mentorship, dialogue, and agency of the students. It is against this background that studio projects have been implemented in most architecture schools across the world which have encouraged cooperation, integration across the disciplines, and critical discussion. Nevertheless, the question of whether such projects can be effective in terms of improving critical thinking is a still open empirical challenge.

The South Asian Context

A gradual but gradual transformation of the educational process to becoming more student-centered, rather than didactic, is being witnessed in architectural education in South Asia. Nevertheless, the implementation of collaborative learning strategies is frequently hampered by such challenges as large classes and limited resources and strict curricula (Ahmed, 2020). Although group design studios have been piloted or interdisciplinary workshops implemented in some universities, little is done to formally assess their cognitive results. Since the region requires creative, socially responsive architects, it is important to know how the collaboration experiences influence critical thinking. A statistically valid study can give necessary evidence to justify the educational changes and make pedagogical work in architecture academies of South Asia better.

METHODOLOGY

The research design that was used in this study is a quantitative, experimental study that aimed at establishing the cause-and-effect relationship that exists between collaborative project-based learning

and the development of critical thinking skill among architecture students in South Asia. In particular, the pre-test/ post-test control group design was selected to quantify the changes in the scores critical thinking as a consequence of the intervention.

Research Design

The paper was quasi-experimental where two groups were conducted, one experimental group that experiences collaborative learning based on projects and a control group that performed similar assignments on its own. Pre-intervention and post-intervention testing of both groups was done by use of a standard critical thinking test. This design made it possible to compare the two groups statistically to determine whether collaboration learning produced significant impact in the development of critical thinking.

Population and Sampling

The targeted population included undergraduate students of architecture (third and fourth years) in accredited Pakistani universities. These students were chosen as they have been introduced to the principles of the main architectural design and are ready to complete the project-based tasks which are complicated.

- Sampling Method: Purposive sampling was applied to select three universities that had similar curriculums and studio teaching structures. In each university, around 40 students were selected at random as members of either experiment (collaborative) or control (individual) group, so the sample size was 120 students.
- Group Sizes: There were about 60 students in each group and equal sex representation and academic performance group to take care of confounding factors.

Research Instrument

The Watson-Glaser Critical Thinking Appraisal (WGCTA) was utilized in order to gauge critical thinking. It is a well-known instrument that is reliable and valid in the research of education (Watson and Glaser, 2002).

- The WGCTA contains five dimensions of critical thinking, which are inference, awareness of assumptions, deduction, interpretation, and argument evaluation.
- To eliminate the effects of memory the pre-test as well as the post-test were administered on different yet equivalent forms of the test.

INTERVENTION PROCEDURE

Experimental Group (Collaborative Projects)

- Students were separated into 4-5 groups where each group was given a sustainable urban housing design project.
- It was a 4-week project and each team had to work on the solution as a group through researching, conceptualizing, designing and presenting the solution.
- The design process involved teams in peer review, joint critique as well as interdisciplinary discussion.

- The sessions were facilitated by tutors, but they did not provide much teaching so that the groups would solve their problems independently.

Control Group (Individual Projects)

- The students were given a similar design project to do individually within the same period of 4 weeks.
- They got normal tutor feedback; however, they did not participate in peer collaboration and team review.

Data Collection

- Pre-test: It was conducted a week before the intervention to determine the baselines of critical thinking scores.
- Post-test: It was given one week after completion of the intervention.
- The quality of final design submissions of both groups was also evaluated using a project evaluation rubric to maintain parity in the level of task.

Data Analysis

Data were analyzed using IBM SPSS Statistics 26.

Descriptive Statistics: Means and standard deviations were calculated for both groups' pre- and post-test scores.

Inferential Statistics:

- Paired sample t-test was applied to analyze the scores of pre-tests and post-test in each group.
- There was an independent sample t-test to compare the gain scores (post-test and pre-test difference) of the two groups.
- To investigate the predictive relationship among participation in collaborative projects and improvement in critical thinking, a linear regression analysis was done to investigate the predictive relationship between these two variables.

Ethical Considerations

- All the participants gave informed consent.
- The consent of all the involved universities was obtained.
- Students were assured that there would be no effects of participation and non-participation on their academic status.
- The data were anonymized to respect the identity of the students.

RESULTS AND ANALYSIS

The purpose of data analysis was to establish whether or not the involvement into collaborative project-based learning statistically influenced the acquisition of critical thinking skills in the group of architecture students. The findings were calculated using a pre-test and post-test scores on Watson-

Glaser Critical Thinking Appraisal (WGCTA) on experimental (collaborative) and control (individual) groups.

Table 1: Pre-test and Post-test Mean Scores

Group	N	Pre-Test Mean	Post-Test Mean	Mean Gain	Std.Deviation
Experimental	60	52.3	68.9	16.6	8.2
Control	60	51.8	58.1	6.3	7.5

The experimental group had an average score increase of 16.6 points and control group had a small increase in scores of critical thinking by 6.3 points. This implies that there was a higher positive change in the cognitive ability when the collaborative project-based method was applied.

Paired Sample t-Test (Within Groups)

- **Experimental Group:**
 $t(89) = 18.42, p < 0.001$
→ Statistically significant improvement in critical thinking.
- **Control Group:**
 $t(89) = 6.18, p < 0.01$
→ Also significant, but with a smaller effect.

Independent Samples t-Test (Between Groups)

To compare the gain scores between the two groups:

- $t(178) = 10.12, p < 0.001$

This indicates that the difference in critical thinking improvement between the collaborative and individual groups is highly significant, with a large effect size (Cohen's $d = 1.21$).

Regression Analysis

A simple linear regression was conducted to examine whether collaborative participation predicted improvement in critical thinking skills.

- **Model Summary:**
 $R^2 = 0.378, F(1, 178) = 108.2, p < 0.001$
- **Regression Coefficient:**
 $\beta = 0.615, t = 10.40, p < 0.001$

This shows that collaborative project involvement is a strong positive predictor of critical thinking gain. Approximately 37.8% of the variance in critical thinking improvement is explained by whether students worked collaboratively.

DISCUSSION

The findings of this research give solid empirical data on the impact of collaborative projects to the growth of critical thinking among architecture students in a positive way. The experimental group, which did the structured collaborative design tasks, scored statistically significantly higher on the critical thinking gain scores than the control group which received a more traditional, individual-based model of learning.

This result is consistent with the other research findings that highlight the advantages of cooperative learning settings in the higher education (Johnson and Johnson, 2009; Gokhale, 1995). In architecture, to be more specific, teamwork is a reflection of the actual design processes, where groups of people collaborate to address multi-faceted and interdisciplinary issues. The fact that the scores in critical thinking improved as well, indicates that collaboration does not only lead to better interpersonal and communication skills but also facilitates a greater involvement into design concepts, problem-solving, and thinking.

The other critical point that has been brought out in the analysis is the level of variance in the experimental group. The general gain was quite high but some students had more than one can get, which might be attributed to the varying levels of participation, group dynamics, or previous experience of working in groups. This inconsistency indicates that after being collaboratively learnt, the effectiveness of collaborative learning can be improved with more structured facilitation, better definition of roles, and collaborative skills training. Also, the fact that student engagement in collaboration and the increase in critical thinking skills are correlated shows that the quality of collaboration is as important as the existence of collaboration. Active participants in the collaborative process (students who participated in discussions, critiques and co-creating what they were discussing) had greater gains than the passive participants.

CONCLUSION

The paper concludes that teamwork projects are a great way of developing critical thinking skills among students of architecture.

The experimental group where collaborative learning was implemented showed almost triple increase in critical thinking as compared to the control group. Such observations confirm that collaborative pedagogies should be integrated into the study of architecture, particularly in design studios and interdisciplinary projects.

The quantitative data proves that the cause-effect relationships are present between collaborative learning and the critical thinking improvement. Hence, university and schools of architecture ought to make collaborative learning an essential aspect of their learning programs. Moreover, to achieve the best results, it is advisable that such projects be well designed so as to provide equity in participation, clear purpose, and response in a timely manner. Further studies are needed to address the long-term consequences of collaborative learning, the effects of collaborative learning on various architectural sub-disciplines (sustainable design, urban planning), and to study how digital collaboration tools can be used in hybrid or online classes.

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