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Innovation of an Effective Blended Learning Technology in Architectural Engineering and its Validation by Response Data Analysis

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ABSTRACT

With the availability of countless choices of tools and technologies through computers and the internet, blended learning technology is further enriched by non-conventional powerful modes of online synchronous and asynchronous interactions between learners and instructors. The questionnaire was developed by using the web-based Google Forms platform and shared with architects and students of architecture by using WhatsApp and Gmail as the primary source of distribution. In light of the Council of Architecture's Minimum Standards of Architectural Education Regulations 2020 Recommendations, All India Council for Technical Education's Report, and Bloom's Taxonomy, the research-based learning technology is found to be the most effective learning technology due to its active nature. Therefore, this fact was validated by obtaining the response regarding the attitude and understanding of all the stakeholders in architectural engineering viz. learners, teachers, and professionals towards research-based learning technology. All the respondents strongly supported the concept of introducing research-based learning technology in architecture education from the undergraduate degree level.

1. Introduction

Before the advent of computers and the internet in the near past, the learning process involved physical classroom interaction between learners and instructors through a blend of lectures, seminars, laboratory experiments, field visits/surveys, educational tours, home assignments, books/journals/notes/handouts, etc. Therefore, blended learning is not a new concept or ideology. The revolution in the learning process has nowadays been observed due to the availability of countless choices of tools and technologies through computers and the internet.

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1.1 Blended Learning Technologies

With the advent and growth of computers and the internet, human beings living in the remotest part of the world can undoubtedly get information on any subject simply by touching the screen. Personal computers, laptops, tablets, smartphones, etc. with high-speed internet facilities have opened new ways for creativity in almost all fields including the learning and teaching technologies for students and instructors in academic institutions. One of the technologies that emerged in the year 2000 is blended learning technology embedded with information and communication technology (ICT) facilities [1,2].

The blended learning technology is further enriched by non-conventional powerful modes of online synchronous and asynchronous interactions between the learners and instructors towards the learning materials.

With time, blended learning technology is enhancing the authenticity of learning, critical thinking, and active participation of learners and the teaching abilities of instructors in the learning process. This is a continuous progressive process toward effectiveness and will never reach perfection due to the involvement of a wide variety of parameters but this transformation is bringing visible changes in the quality, organization, planning, and management of the learning process [3].

A variety of definitions for blended learning technology have been suggested by researchers around the world. For example, (i) a method of providing education using learning techniques, such as online delivery through the web [4], discussion boards and emails, in combination with traditional face to face lectures, seminars, and tutorials [5], (ii) a course that mixes face-to-face and online delivery methods where 30–79% of content is delivered online [6], (iii) a combination of media and tools employed in an e-learning environment [7], (iv) a combination of a number of pedagogic technologies [7,8], (v) a mix of different didactic methods and delivery formats [9], (vi) a combination of multiple delivery media designed to complement each other and promote meaningful learning experiences [10], (vii) a combination of the instruction from two historically separate models of teaching and learning viz. traditional face-to-face learning systems and distributed learning systems with an emphasis on the role of computer-based technologies [11,12], (viii) a mix of the physical class-based method and one any other learning method [9,10,13,14], (ix) a formal education program in which a student learns at least in part through online learning with some element of student control over time, place, path, and/or pace and at least in part at a supervised brick-and-mortar location away from home [15]. Thus, blended learning technology can be defined as a combination of face-to-face and online teaching and/or tool and techniques and/or methodologies [3,16-18] as illustrated in Figure 1.

The reason behind the development of the blended learning technology includes the selection of methodologies from both the conventional and non-conventional processes and the formulation of the best blend of techniques/tools/methodologies for the most effective learning depending upon the types of learners, instructors, course/subject to be taught and the infrastructure/tools available [10].

It has been observed that the blended learning technology resulted in enhanced extent of learning (in the form of academic achievements, ideas, and knowledge), permanence (in the form of retention of learning), student engagement (in the form of mutual interaction between students and teachers as well as between students) and student satisfaction (towards learning activities) [19, 20].

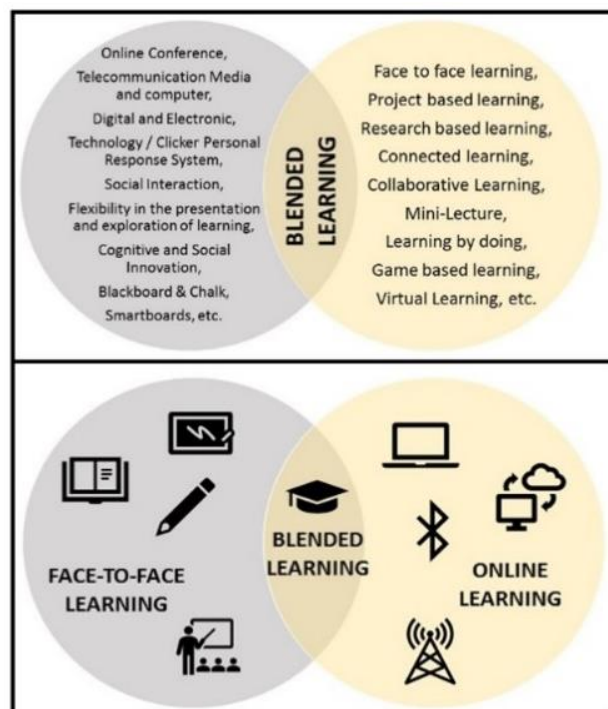


Fig. 1. The graphical presentation of B-Learning

To sum up, blended learning technology may simply be considered the best possible integration of conventional classroom face-to-face learning experiences with any non-conventional online learning experiences. Broadly speaking, blended learning technology is an integration of any two or more

- i. Teaching Methodologies
- ii. Delivery Methods
- iii. Teaching Tools
- iv. Teaching Techniques, etc.

1.2 All India Council for Technical Education (AICTE)'s Recommendations

The All India Council for Technical Education (AICTE) is a statutory body and national council for technical education under the Department of Higher Education of India. It was first established in November 1945 as an advisory body and was later granted statutory status by the Parliamentary Act in 1987. It is responsible for planning and coordinating the growth of India's technical and management education systems [21].

A report, "Model Curriculum for Bachelor of Architecture (B. Arch) 2019", was published by All India Council for Technical Education (AICTE) under the guidelines of "Council of Architecture (COA) Minimum Standards of Architectural Education Regulation 2020". According to the report, Research Methodologies, Research Techniques, Pedagogy, etc. are the conceptual skills required to be developed for the understanding of Architectural Design, Graphic Design, Visual Arts, etc. in the learners. In this report, the committee (a team of five experts to revise the model curriculum of Bachelor of Architecture (B.Arch.) constituted by AICTE) has proposed 7 Program Objectives (POs) and 9 Learning Outcomes (LOs) to be incorporated into the Bachelor of Architecture curriculum in Indian context [22].

To make the learners responsive and sensitive architects in the 5-year Bachelor of Architecture program, the AICTE has aimed to integrate knowledge-based and skill-based pedagogic technologies in a well-balanced manner. With this in mind, AICTE has proposed 7 Program Objectives (POs). The objectives of the program are translated into several learning outcomes directly related to the profession of architecture necessary for academics and professional practice.

The 6th program objective is “Instilling receptiveness to new ideas and knowledge and infusing a sense of scientific research”. This program's objective is to inculcate the attitude of undergraduate-level students of architecture towards scientific research and to increase the receptiveness of new ideas and knowledge to make them responsive and sensitive future architects, ready to go for a higher level of research in academics and profession. This will benefit society in finding the resolutions to their social/public/environmental, etc. issues. The report presented the broad relationship between the program objectives and the learning outcomes of AICTE’s model curriculum for B. Arch as given below (Figure 2).

	LO-1	LO-2	LO-3	LO-4	LO-5	LO-6	LO-7	LO-8	LO-9
PO-1	✓		✓	✓					
PO-2	✓	✓	✓	✓					
PO-3	✓	✓	✓	✓	✓				
PO-4	✓	✓	✓	✓	✓	✓	✓		
PO-5	✓	✓	✓	✓	✓	✓	✓		
PO-6	✓	✓	✓	✓	✓	✓	✓	✓	✓
PO-7			✓	✓	✓	✓	✓	✓	✓

Fig. 2. The relation between the program objectives and the learning outcomes of AICTE’s model curriculum for B. Arch [22]

As evident from Figure 2, the impact of PO-6, “Instilling receptiveness to new ideas and knowledge and infusing a sense of scientific research”, has a clear positive influence on all the learning outcomes right from LO-1 to LO-9.

This has prompted the AICTE to introduce a main subject named “Dissertation” in the 8th Semester of B.Arch. and the same is also suggested by the Council of Architecture (COA). To develop the research attitude in the students of architecture, AICTE has also introduced several “non-semester specific” elective subjects.

1.3 Bloom’s Taxonomy

There are six conceptually different levels of cognitive learning according to the revised version of Bloom's Taxonomy viz. remembering, understanding, applying, analyzing, evaluating, and creating. These learning levels can help develop learning outcomes as follows (Figure 3) [23,24].

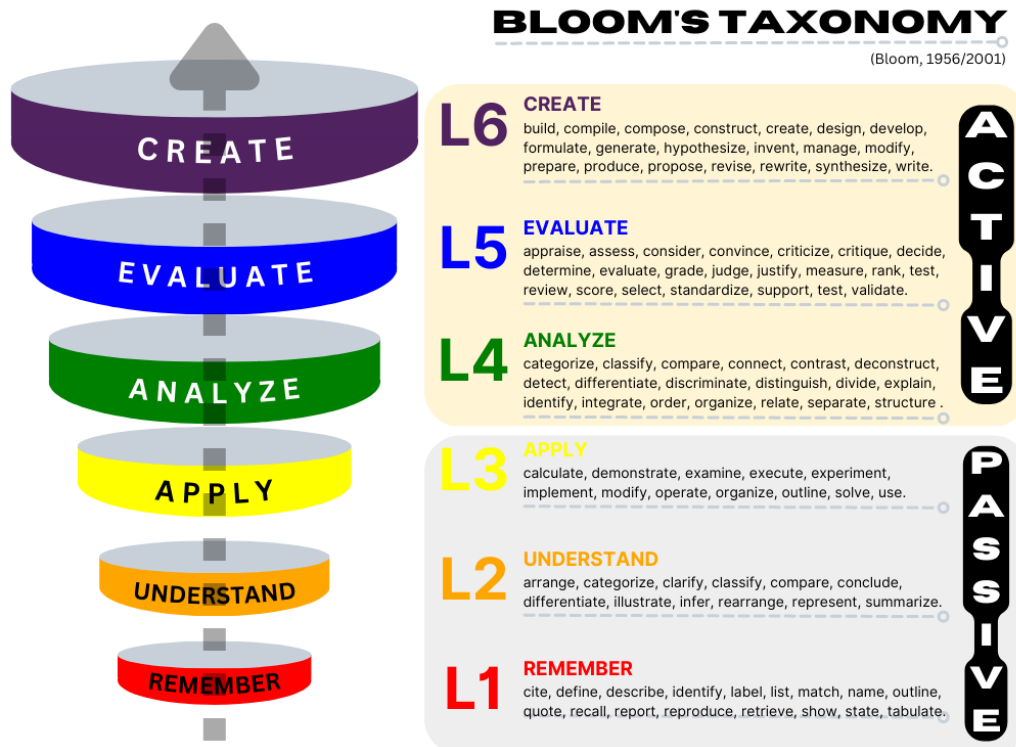


Fig. 3. The learning levels as per the revised version of Bloom's Taxonomy

Because of Bloom's taxonomy in the assessment of learning, research-based learning technology is found to be a very effective approach due to the active nature of this technology [25–30] and, therefore, it is hypothesized that the research-based technology would be the most effective in learning-teaching of architecture engineering at the graduate level.

1.4 Research-Based Learning Technology

The human instinct to inquire and the eagerness for newer knowledge are the basic driving forces for all the types of research and technologies carried out since the very beginning of mankind. The research may differently be defined viz. the efforts made towards the search for newer and newer knowledge, the scientific and systematic search of newer knowledge on a particular aspect of a topic, the scientific investigations on a process or phenomenon or new facts in any subject, knowing the unknown, and so on. To sum up, both the knowledge and the technology for obtaining the newer knowledge may be considered as research. It may also be considered as an original and in most cases new contribution furthering present knowledge through studies, observations, comparisons, experiments, etc. [31].

In brief, the research or the inquiry may be referred to as the systematic methodology for the search for newer knowledge through the detection of a particular problem, collection of the facts or data, formulation of a hypothesis, analysis of the facts or data, and reaching to certain conclusions either in the form of solutions towards that problem or the generalization in the form of formula to solve that problem [32].

Research-based learning technology actively involves learners in the evaluation of the contents, concepts, or issues about the concept relevant to architecture education. Thus, the activities in the classroom may be formulated to make students involve individually or in groups to investigate the contents, concepts, or issues in the class as well as in the field. This technology involves the student-centered teacher-guided approach i.e., students themselves try to find the solutions to the problems

based on a variety of contents, concepts, or issues leading to active learning as well as experiential learning by the students [33].

The research-based learning technology, an active and experiential technological approach [33, 34], in architectural education, may also be treated as a part of the blended learning technological approach produced by the blending of different methodologies.

Curiosity within the learner community is the main driving force for learning and thus the research-based learning technology or inquiry-based learning technology compels the learners to learn new concepts and ideas by themselves. The famous saying of Confucius around 450 BC “Tell me and I will forget. Show me and I may remember. Involve me and I will understand” clearly states the essence of this technological approach [33].

Quite a fair amount of research work has been undertaken on the benefits of the research-based technological approach and the blended learning technological approaches separately [35–38].

2. Research Methodology

Google Forms is an increasingly popular ICT tool used in the classroom. It is a versatile, easy-to-use, and powerful online survey tool that allows users to quickly and easily create forms and share them with others. Google Forms provides users with a wide range of features such as data collection, surveys, and quizzes, and the ability to easily collaborate with others. It is an effective tool for gathering data, conducting surveys and assessments, and gathering feedback on specific topics. Additionally, Google Forms integrates seamlessly with other Google products, allowing users to easily collaborate with colleagues and share data across multiple platforms. With its simple and intuitive interface, Google Forms is an essential ICT tool for educators, businesses, and individuals [2].

A questionnaire was prepared which contains 3 sections to collect responses from architects and students of architecture about their attitude towards the research-based approach in architecture education at the graduate level. The questionnaire was developed by using the web-based Google Forms platform and shared with architects and students of architecture by using WhatsApp and Gmail as the primary source of distribution. The total number of responses received was 703. In Section-1 (10 questions) of the questionnaire, the personal details of the respondents were collected in Q.1 to Q.9. In Q.10 of Section-1, the respondents were asked to specify whether they studied any research-based subject during their bachelor’s degree in architecture. If the respondent answered “YES”, he was directed to proceed to Section-2 of the questionnaire and designated as Group-1. If the respondent answered “NO OR DON’T KNOW”, he was also directed to proceed to Section-2 of the questionnaire and designated as Group-2. Finally, all the respondents were directed to proceed to Section-3 (3 questions) of the questionnaire.

Section-2 consists of five general questions for the respondents who replied “YES” for the Q.10 of Section-1 about their opinion regarding the research-based approach in architecture education and were referred to as Group-1. Section-2 consists of three general questions for the respondents who replied “NO or DON’T KNOW” for the Q.10 of Section-1 about their opinion regarding the research-based approach in architecture education and were referred to as Group-2. Section-3 consists of three more specific questions and the respondents were asked about their opinions regarding the research-based approach in architecture education. The details of the questionnaire are given in the form of a flow chart (Figure 4).

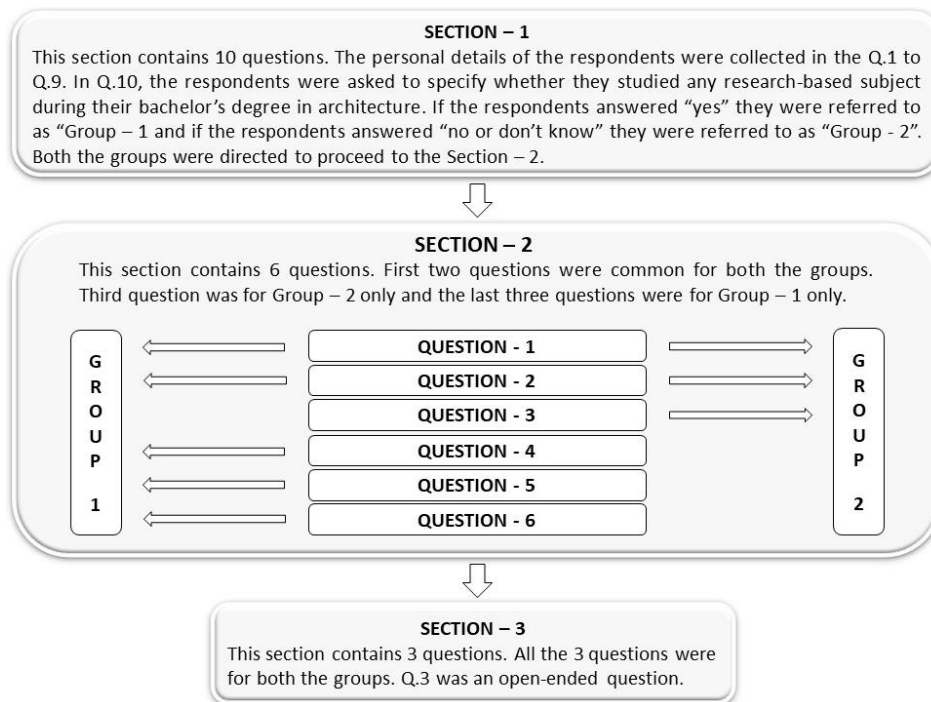


Fig. 4. Questionnaire's flow diagram

The YES/NO/DON'T KNOW response percentages of each question in all the sections were calculated using a simple percentage equation, Eq. (1), where $R_{\text{YES/NO/DON'T KNOW}}$ is the percentage of a particular type of response, $N_{\text{YES/NO/DON'T KNOW}}$ is the number of a particular type of response and N_{TOTAL} is the total number of responses. Thus, obtained questionnaire analysis of questions in tabulated as well as bar graph forms are presented in relevant sections of this paper.

$$\% R_{\text{YES/NO/DON'T KNOW}} = 100 \times \frac{N_{\text{YES/NO/DON'T KNOW}}}{N_{\text{TOTAL}}} \quad (1)$$

Q.10 was designed to know the real status of current architects and students of architecture regarding their experiences and exposure to research-based learning.

This part explains the procedural steps followed by the researcher to collect and analyze the data for the study. This research uses quantitative methods to achieve its objectives. Microsoft Excel was used for the data analysis. The total number of architects and students of architecture in India was 2 lakhs approximately according to the COA website accessed on September 2021. The required sample size was 385 calculated by several online sample size calculators [39] and cross-checked manually by using Eq. (2).

$$S = \frac{\frac{z^2 \cdot p(1-p)}{e^2}}{1 + \left(\frac{z^2 \cdot p(1-p)}{e^2 N}\right)} \quad (2)$$

where S = Sample size required; z = z-score is the number of standard deviations a given proportion is away from the mean which is 1.96 for a 95% of confidence level; p = standard deviation; e = Margin of error (percentage in decimal form); N = population size.

3. Results and Discussion

The first procedural step is the validation of the sample size. The required minimum sample size is calculated to be 385 for the 2 lakhs of architects and students of architecture in India. The sample size used in this study is 703 which is more than the required minimum sample size and thus the response data analysis presented in this study is valid and reliable [39].

3.1 Section-1 (Q.1 to Q.10)

Section-1 of the questionnaire containing 10 questions deals with the personal profiles of respondents. The consolidated data of Section-1 of this study are presented in Figure 5. The total number of respondents who participated in this study was 703 with a gender ratio of about 1:1 (Q.3 of Section-1). Thus, this study may be treated as a gender-average study.

S. No.	Question	Responses			
Q.1	Name (Optional)	Not to be disclosed			
Q.2	Email ID (Optional)	Not to be disclosed			
Q.3	Gender	Male – 364 (51.8%)	Female – 339 (48.2%)	Total – 703 (100%)	
Q.4	Name of the institution from where you are graduating OR graduated.	Respondents were participated from 42 colleges/universities in India.			
Q.5	If already graduated, please mention the year of graduation otherwise skip this step.	Pursuing Bachelor – 245 (34.8%)	Before 1 – 10 years – 323 (46%)	Before 11 – 20 years – 100 (14.2%)	More than 20 years before – 35 (5%)
Q.6	What is the highest degree you have acquired in architecture?	Pursuing Bachelor’s Degree – 245 (34.8%)	Bachelor’s Degree – 299 (42.5%)	Master’s Degree – 136 (19.4%)	Ph.D. – 23 (3.3%)
Q.7	What is your current employment status	Student – 375 (53.4%)	Practicing Architect – 79 (11.2%)	Teaching – 182 (25.9%)	Teaching and Practicing Both – 67 (9.5%)
Q.8	Course pursuing {e.g., B.Arch., M.Arch. (Building Services), Ph.D. etc.}	Pursuing Bachelors – 245 (34.8%)	Pursuing Masters – 112 out of 299	Pursuing Ph.D. – 17 out of 136	Pursuing Post-Doctoral Fellowship – 1 out of 23
Q.9	Level of study (for current students)	Didn’t discuss in this paper			
Q.10	Did you ever take any research-based subject (dissertation, thesis, etc.) during your bachelor’s degree?	Yes – 358 (51%)	No – 302 (43%)	Don’t Know – 43 (6%)	
Total number of respondents – 703					
Note: If the respondents answered “yes” they were directed to proceed 2A of the questionnaire. If the respondents answered “no or don’t know” they were directed to proceed 2B of the questionnaire.					

Fig. 5. The consolidated data from Section 1 of the questionnaire

The status of the seniority of the respondents was asked in Q.5 of Section-1. The number of the respondents follows the order: the group of the respondents (46.0%) who acquired their graduate degree before 1-10 years > the group of the respondents (34.8%) who are pursuing their graduate degree at present > the group of the respondents (14.2%) who acquired their graduate degree before 11-20 years > the group of the respondents (5.0%) who acquired their graduate degree before more than 20 years (Q.5 of Section-1). Thus, this study may be treated as where the major contribution comes from the younger architects (46.0% + 34.8% = 80.8%).

The status of the academic qualifications of the respondents was asked in Q.6 of Section-1. The number of the respondents follows the order: the group of the respondents (42.5.0%) who have graduated > the group of the respondents (34.8%) who are pursuing their graduate degree at present > the group of the respondents (19.4%) who have post-graduated > the group of the respondents (3.3%) who have acquired their doctorate (Q.6 of Section-1). Thus, this study may be treated as where the major contribution comes from younger and budding architects (42.2% + 34.8% + 19.4% = 96.7%).

The status of the current activities of the respondents was asked in Q.7 of Section-1. The number of the respondents follows the order: the group of the respondents (53.4%) who are students > the

group of the respondents (25.9%) who are in teaching > the group of the respondents (11.2%) who are in architecture profession > the group of the respondents (9.5%) who are in architecture profession as well as in teaching (Q.7 of Section-1). Thus, this study may be treated as where the major contribution comes from the architects who are in academics either as students or as teachers (53.4% + 25.9% + 9.5% = 88.8%).

The questionnaire analysis of Q.10 of Section-1 “Did you ever take any research-based subject (dissertation, thesis, etc.) during your bachelor’s degree?” tabulated as well as bar graph forms given in Figure 5 was designed to know the real status of current architects and students of architecture regarding their experiences and exposure to the research-based learning. In other words, this question (Q. 10 of Section-1) was specifically asked to detect the extent of respondents they ever took any research-based subject or not during their bachelor’s degree level.

The total number of respondents was 703. The number of the respondents who ever took any research-based subject (as a student) during their bachelor’s degree is 358 (50.9%), and the respondents who never took any research-based subject (as a student) during their bachelor’s degree is 302 (43%) while the respondents those who are/were not even aware of any research-based subject (as a student) during their bachelor’s degree is 43 (6.1%) (Figure 6).

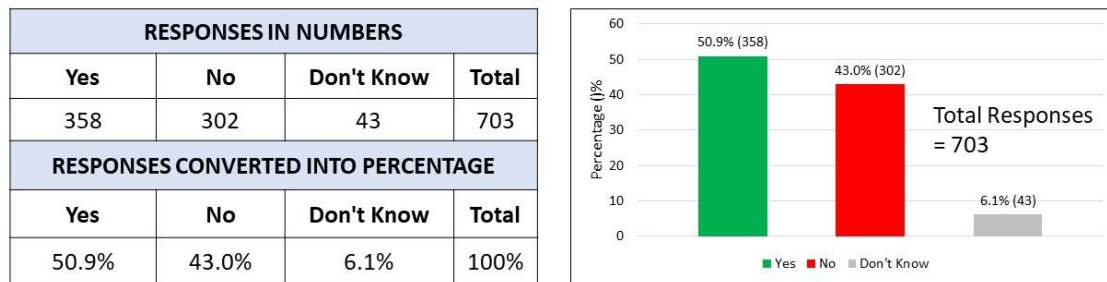


Fig. 6. The questionnaire analysis of Q.10 of Section-1

One of the most interesting and striking observations is that some of the respondents (6.1%) responded “don’t know” which indicates that some architects and current students of architecture in India were/are not aware of the research-based methodology in architecture even at their graduation level and in the profession (Figure 6).

The respondents who participated in this study have a YES: NO/DON’T KNOW ratio of about 1:1 (Q.10 of Section-1). Thus, this study may be treated as a good average study of both the categories of respondents viz. those who took and those who did not take or came across any research-based course at the graduation level.

3.2 Section-2 (Q.1 to Q.6)

From the total number of 703 respondents, the respondents who answered “YES” against Q.10 of Section-1 were 358 (50.9%) and were referred to as Group-1. They were directed to proceed to Section-2 of the questionnaire. While the respondents who answered “NO or DON’T KNOW” against Q.10 of Section-1 were 345 (49%) and were referred to as Group-2. They were also directed to proceed to Section-2 of the questionnaire. The data analysis of Q.1 to Q.6 of Section-2 is given in Figure 7.

S. No.	Question	Group	Responses			
Q.1	Do you feel that the research-based approach in architecture education promotes better understanding of the subject in the students of the bachelor's degree level?	Group – 1 & 2	Responses from Group - 1			
			Yes – 335 (93.6%)	No – 19 (5.3%)	Don't Know – 4 (1.1%)	Total – 358 (100%)
			Responses from Group - 2			
			Yes – 327 (94.8%)	No – 0 (0%)	Don't Know – 18 (5.2%)	Total – 345 (100%)
			Total Responses			
			Yes – 662 (94.2%)	No – 19 (2.7%)	Don't Know – 22 (3.1%)	Total – 703 (100%)
Q.2	Do you feel that the research-based contents should be increased at bachelor's degree level of architecture education?	Group – 1 & 2	Responses from Group - 1			
			Yes – 327 (91.4%)	No – 27 (7.5%)	Don't Know – 4 (1.1%)	Total – 358 (100%)
			Responses from Group - 2			
			Yes – 305 (88.4%)	No – 13 (3.8%)	Don't Know – 27 (7.8%)	Total – 345 (100%)
			Total Responses			
			Yes – 632 (89.9%)	No – 40 (5.7%)	Don't Know – 31 (4.4%)	Total – 703 (100%)
Q.3	Do you think that it would have been better if you had learned research-based subject(s) during your bachelor's degree?	Group – 2	Yes – 240 (69.6%)	No – 36 (10.4%)	Don't Know – 69 (20%)	Total – 345 (100%)
Q.4	Which tools did you use in your research-based subjects (dissertation, thesis, etc.) at bachelor's degree level?	Group – 1	Multiple Select Type Question			
Q.5	What is your opinion about the impact of research-based approach on the bachelor's level students of architecture?	Group – 1	Multiple Select Type Question			
Q.6	Did you face any of the problem(s) from the listed ones in your research-based subjects (dissertation, thesis, etc.) at bachelor's degree level in -	Group – 1	Multiple Select Type Question			

Fig. 7. The consolidated data from Section-2 of the questionnaire

3.2.1 Q.1 (Group-1 and Group-2)

The questionnaire analysis of Q.1 of Section-2 “Do you feel that the research-based approach in architecture education promotes better understanding of the subject in the students of the bachelor's degree level?” for Group-1 and Group-2 is given in Figure 8 and Figure 9.

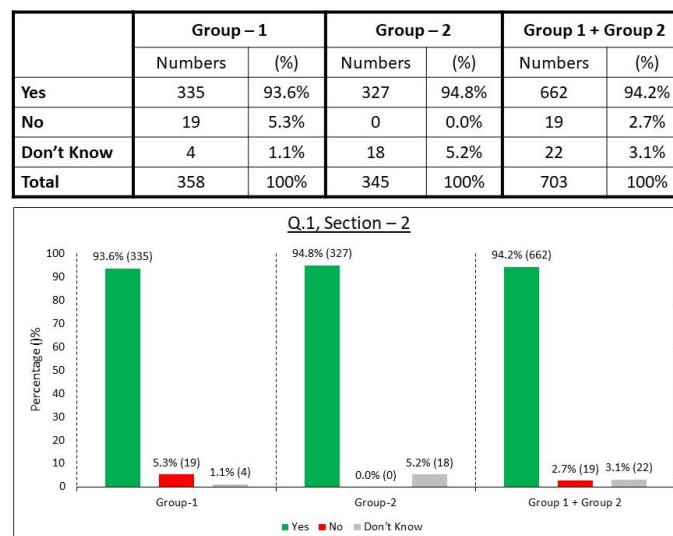


Fig. 8. The questionnaire analysis of Q.1 of Section-2 for Group-1 and Group-2

	Pursuing Bachelors		Bachelors		Masters		Ph.D.		Total	
	Numbers	(%)	Numbers	(%)	Numbers	(%)	Numbers	(%)	Numbers	(%)
Yes	220	89.8%	287	96.0%	133	97.8%	22	95.7%	662	94.2%
No	12	4.9%	5	1.7%	1	0.7%	1	4.3%	19	2.7%
Don't Know	13	5.3%	7	2.3%	2	1.5%	0	0.0%	22	3.1%
Total	245	100%	299	100%	136	100%	23	100%	703	100%

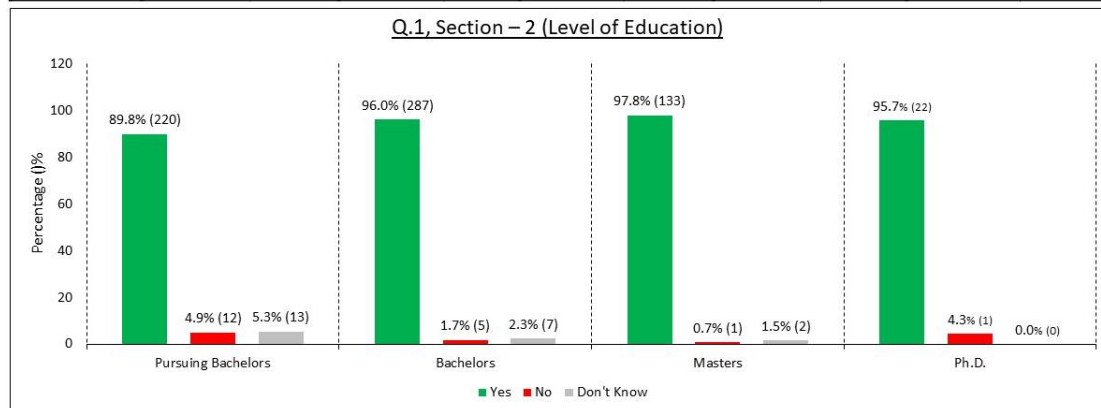


Fig. 9. The questionnaire analysis of Q.1 of Section-2 concerning the academic qualifications of all the respondents

The number of the respondents of Group-1 who replied “YES” is significantly high (93.6%) in comparison to those who replied “no” (5.3%) and “don’t know” (1.1%). It shows that the great majority of architects and current students have a strong feeling that a research-based approach to architecture education at the undergraduate degree level is a better option.

The number of the respondents of Group-2 who replied “YES” is also significantly high (94.8%) in comparison to those who replied “NO” (0.0%) and “DON’T KNOW” (5.2%). It again shows that the great majority of architects and current students who have not come across the research-based approach in architecture education have favorable feelings towards a research-based approach in architecture education.

The overall (Group-1 + Group-2) percentage (94.2%) favoring the research-based approach right from the beginning of their career in architecture is overwhelmingly very high indicating the extremely favorable attitude of all types of respondents.

The impacts of the academic qualifications of the respondents were also analyzed on the “YES” and “NO/DON’T KNOW” responses as given in Figure 7 obtained from data analysis of Q.5 of Section-1 and Q.1 of Section-2.

The number of the respondents saying “YES” follows the order: the group of the respondents (97.8%) who have post-graduated > the group of the respondents (96.0%) who have graduated > the group of the respondents (89.8%) who are pursuing their graduate degree at present. Thus, this study reveals that the understanding of the significance of research-based education in architecture increases with an increase in the academic qualifications of architects. The data seems to be as expected in this aspect concerning the group of respondents who have acquired their doctorate i.e., 22 are in favor out of 23 respondents.

3.2.2 Q.2 (Group-1 and Group-2)

The questionnaire analysis of Q.2 of Section-2 “Do you feel that the research-based contents should be increased at bachelor's degree level of architecture education?” for Group-1 and Group-2 is given in Figure 10 and Figure 11.

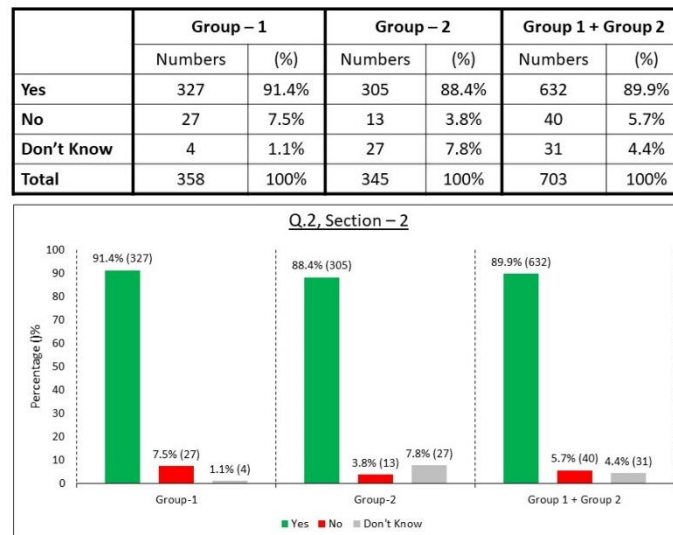


Fig. 10. The questionnaire analysis of Q.2 of Section-2 for Group-1 and Group-2

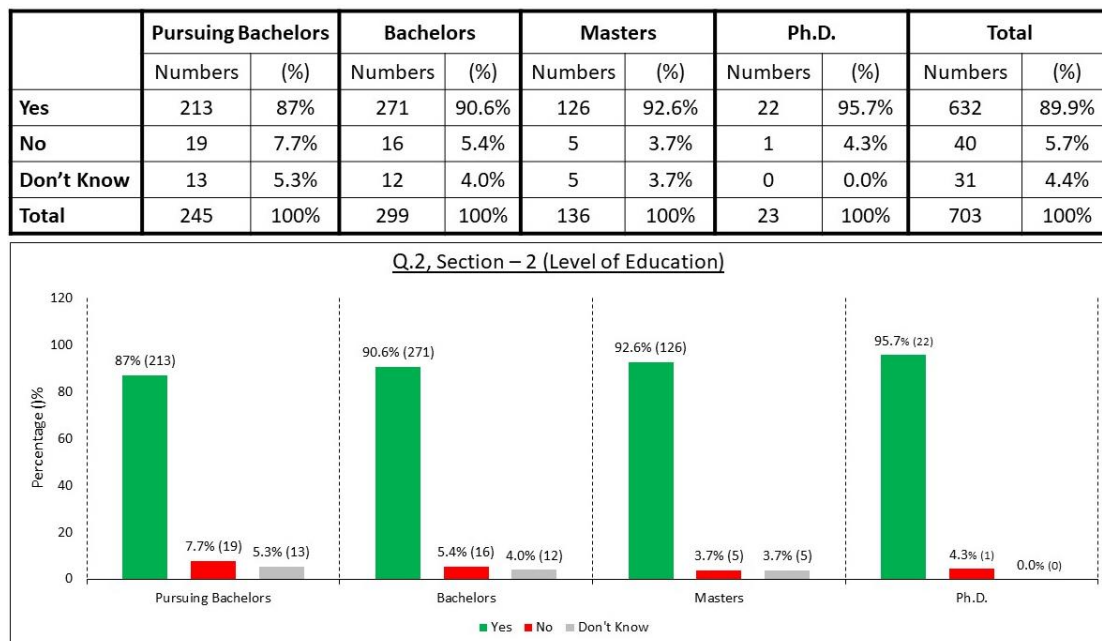


Fig. 11. The questionnaire analysis of Q.2 of Section-2 concerning the academic qualifications of respondents

The number of the respondents of Group-1 who replied “YES” is significantly high (91.4%) in comparison to those who replied “NO” (7.5%) and “DON’T KNOW” (1.1%) in this question as well. It shows that the great majority of architects and current students have a strong feeling that the research-based content in architecture education at the undergraduate degree level should be increased.

The number of the respondents of Group-2 who replied “YES” is also significantly high (88.4%) in comparison to those who replied “NO” (3.8%) and “DON’T KNOW” (7.8%). It again shows that the great majority of architects and current students who even have not come across the research-based approach in architecture education have favorable feelings towards the increase in the research-based content in architecture education. The overall percentage of respondents (Group-1 + Group-

2) is also overwhelmingly very high indicating the attitude of respondents towards the increase in the research-based content right from the beginning of their career in architecture.

The impacts of the academic qualifications of the respondents were also analyzed on the “YES” and “NO/DON’T KNOW” responses as given in Figure 9 obtained from data analysis of Q.5 of Section-1 and Q.2 of Section-2.

The number of the respondents who said “YES” follows the order: the group of the respondents (95.7%) who have obtained their Ph.D. degree > the group of the respondents (92.6%) who have post-graduated > the group of the respondents (90.6%) who have graduated > the group of the respondents (87.0%) who are pursuing their graduate degree at present. Thus, this study also reveals that the understanding of the significance of research-based education and the need for an increase in the research content in architecture increases with an increase in the academic qualifications of architects.

3.2.3 Q.3 (Group-2 only)

The questionnaire analysis of Q.3 of Section-2 “Do you think that it would have been better if you had learned research-based subject(s) during your bachelor's degree?” for Group-2 only is given in Figure 12.

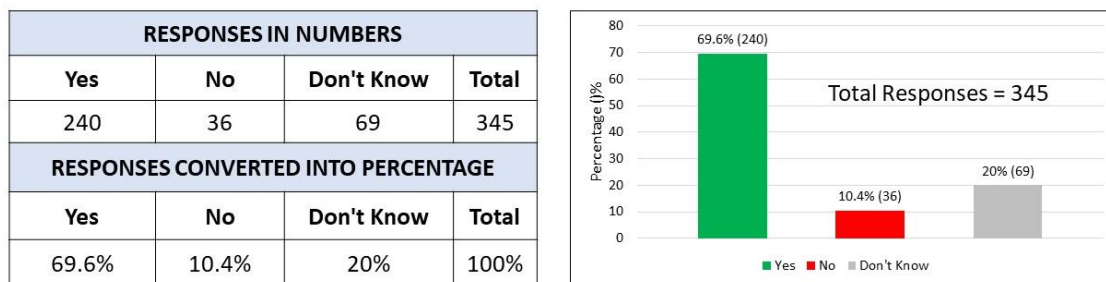


Fig. 12. The questionnaire analysis of Q.3 of Section-2 for Group-2 only

The 345 respondents who answered “NO or DON’T KNOW” against Q.10 of Section-1 were directed to Q.3 of Section-2 “Do you think that it would have been better if you had learned the research-based subject(s) during your bachelor's degree?” The majority of these respondents (69.6%) opined in favor of the research-based approach at their bachelor’s degree level, about 10.4% against and 20% showed indifference to the idea. Thus, the fair majority of the respondents liked the idea of introducing research-based subjects during graduation degree level.

3.2.4 Q.4 (Group-1 only)

The questionnaire analysis of Q.4 of Section-2 “Which tools did you use in your research-based subjects (dissertation, thesis, etc.) at bachelor's degree level?” for Group-1 only is given in Figure 13.

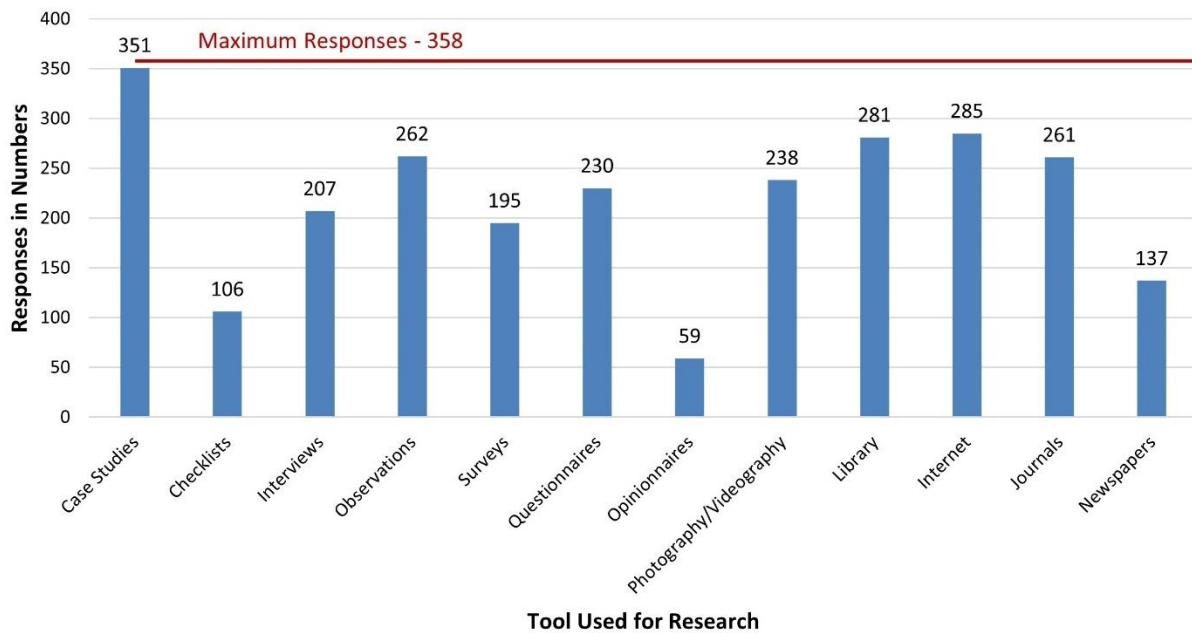


Fig. 13. The questionnaire analysis of Q.4 of Section-2 for Group-1 only

The most popular tools used by the respondents include Case Studies (351), the Internet (285), Library (281), Journals (261), etc. while the least popular tool was observed to be Opinionnaires (59).

3.2.5 Q.5 (Group-1 only)

The questionnaire analysis of Q.5 of Section-2 “What is your opinion about the impact of the research-based approach on the bachelor's level students of architecture?” for Group-1 only is given in Figure 14.

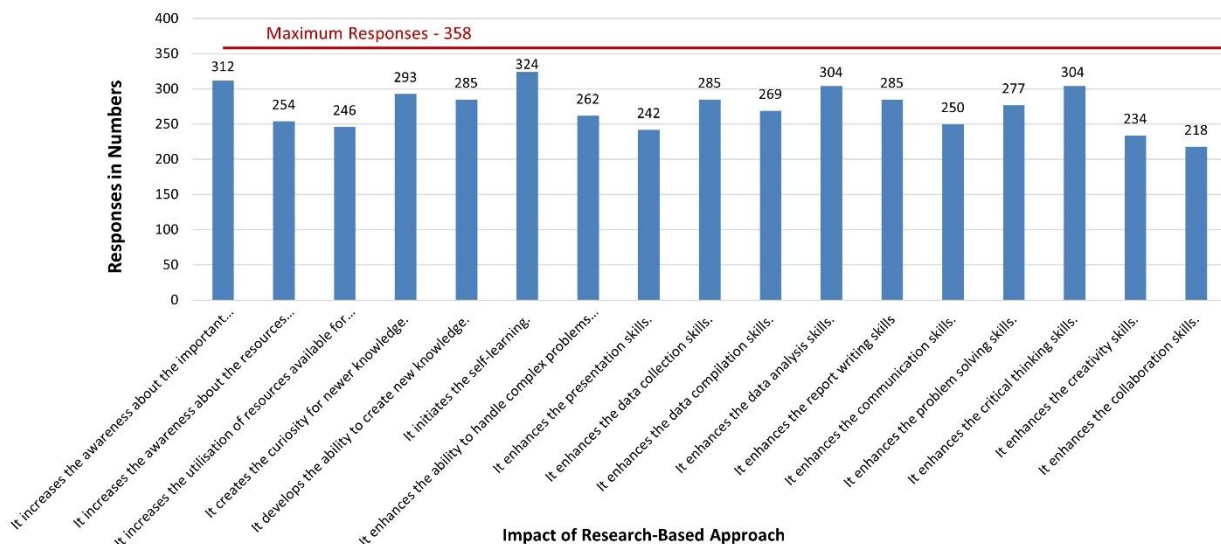


Fig. 14. The questionnaire analysis of Q.4 of Section-2 for Group-1 only

Almost all the respondents opined about the good impact of the research-based approach on the overall learning and skill development of the bachelor's level students of architecture.

3.2.6 Q.6 (Group-1 only)

The questionnaire analysis of Q.6 of Section-2 “Did you face any of the problem(s) from the listed ones in your research-based subjects (dissertation, thesis, etc.) at bachelor's degree level?” for Group-1 only is given in Figure 15.

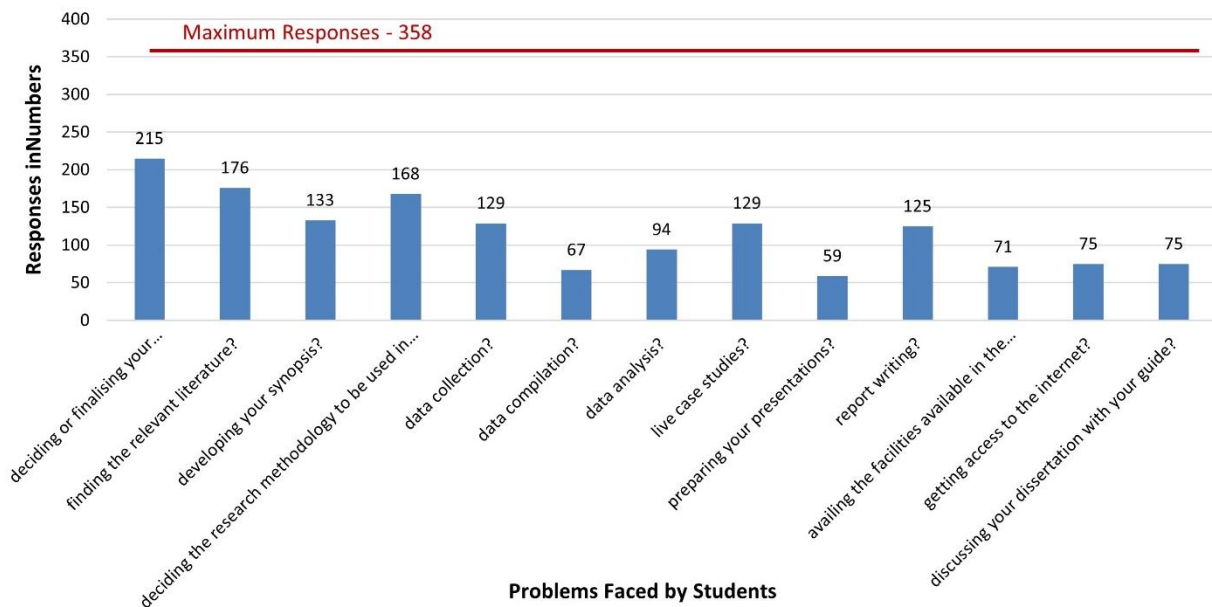


Fig. 15. The questionnaire analysis of Q.6 of Section-2 for Group-1 only

The major problems faced by the respondents during the research-based learning include: deciding or finalizing the topic of the research project (215), finding the relevant literature (176), deciding the research methodology to be used (168), etc. while data compilation (67) and preparing of the presentation (59) were the easiest component of their research activity.

3.3 Section-3 (Q.1 to Q.3)

Before starting an architectural design problem at the bachelor's degree level, every student is required to do some preliminary/prerequisite study of that design problem viz. review of literature, live case studies, literature case studies, data collection, data compilation, data analysis, report writing, etc. In this section, some questions related to this preliminary/prerequisite study will be asked (Figure 16).

S. No.	Question	Group	Responses			
Q.1	Do you consider this preliminary/prerequisite study a kind of research activity?	Group – 1 & 2	Responses from Group - 1			
			Yes – 320 (89.4%)	No – 23 (6.4%)	Don't Know – 15 (4.2%)	Total – 358 (100%)
			Responses from Group - 2			
			Yes – 305 (88.4%)	No – 18 (5.2%)	Don't Know – 22 (6.4%)	Total – 345 (100%)
			Total Responses			
			Yes – 625 (88.9%)	No – 41 (5.8%)	Don't Know – 37 (5.3%)	Total – 703 (100%)
Q.2	Did your architectural design teachers undertake this preliminary/prerequisite study with a research-based approach during your bachelor's studies?	Group – 1 & 2	Responses from Group - 1			
			Yes – 190 (53%)	No – 153 (42.7%)	Don't Know – 15 (4.3%)	Total – 358 (100%)
			Responses from Group - 2			
			Yes – 145 (42%)	No – 177 (51.3%)	Don't Know – 23 (6.7%)	Total – 345 (100%)
			Total Responses			
			Yes = 335 (47.6%)	No – 330 (47%)	Don't Know – 38 (5.4%)	Total – 703 (100%)
Q.3	Any further comments/opinions regarding research-based approach in architecture education at bachelor's degree level.	Group – 1 & 2	Open ended question regarding their opinion/feedbacks for adopting research-based approach at B.Arch. Level. 67 and 24 responses received from Group – 1 and Group – 2 respectively.			

Fig. 16. The consolidated data from Section3 of the questionnaire

3.3.1 Q.1 (Group-1 and Group-2)

The questionnaire analysis of Q.1 of Section-3 “Do you consider this preliminary/prerequisite study a kind of research activity?” for Group-1 and Group-2 is given in Figure 17 and Figure 18.

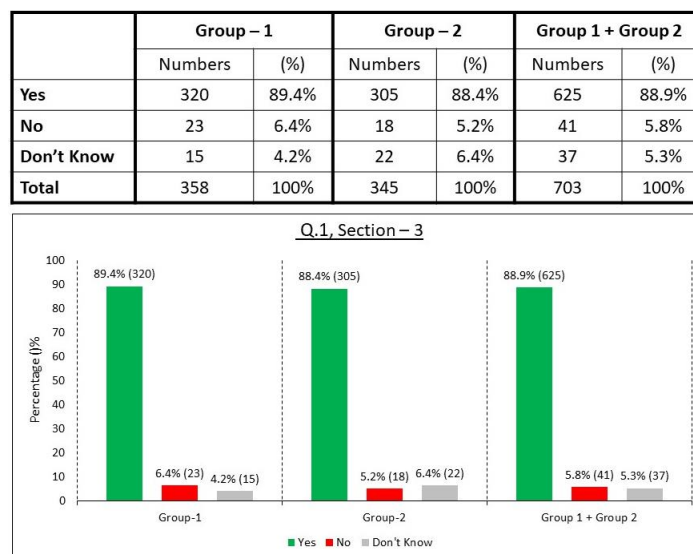


Fig. 17. The questionnaire analysis of Q.1 of Section-3 for Group-1 and Group-2

	Pursuing Bachelors		Bachelors		Masters		Ph.D.		Total	
	Numbers	(%)	Numbers	(%)	Numbers	(%)	Numbers	(%)	Numbers	(%)
Yes	207	84.5%	267	89.3%	128	94.1%	23	100%	625	88.9%
No	23	9.4%	15	5.0%	3	2.2%	0	0.0%	41	5.8%
Don't Know	15	6.1%	17	5.7%	5	3.7%	0	0.0%	37	5.3%
Total	245	100%	299	100%	136	100%	23	100%	703	100%

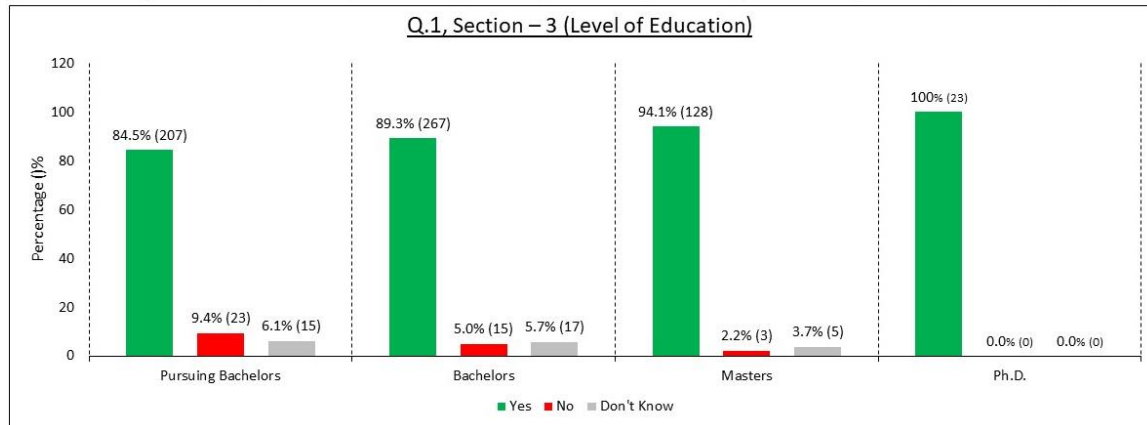


Fig. 18. The questionnaire analysis of Q.1 of Section-3 concerning the academic qualifications of respondents

The number of the respondents of Group-1 who replied “YES” is significantly high (89.4%) in comparison to those who replied “NO” (6.4%) and “DON’T KNOW” (4.2%). It shows that the great majority of architects and current students consider the preliminary/prerequisite study a kind of research activity. The number of the respondents of Group-2 who replied “YES” is also significantly high (88.4%) in comparison to those who replied “NO” (5.2%) and “DON’T KNOW” (6.4%). It again shows that the great majority of architects and current students who have not come across the research-based approach in architecture education consider the preliminary/prerequisite study a kind of research activity. The overall (Group-1 + Group-2) percentage (88.9%) of respondents consider the preliminary/prerequisite study a kind of research activity.

The impacts of the academic qualifications of the respondents were also analyzed on the “YES” and “NO/DON’T KNOW” responses as given in Figure 15 obtained from data analysis of Q.5 of Section-1 and Q.1 of Section-3.

The number of the respondents who said “YES” follows the order: the group of the respondents (100%) who have obtained their Ph.D. degree > the group of the respondents (94.1%) who have post-graduated > the group of the respondents (89.3%) who have graduated > the group of the respondents (84.5%) who are pursuing their graduate degree at present. Thus, this study also reveals that the understanding of the preliminary/prerequisite study a kind of research activity increases with an increase in the academic qualifications of architects.

3.3.2 Q.2 (Group-1 and Group-2)

The questionnaire analysis of Q.2 of Section-3 “Did your architectural design teachers undertake this preliminary/prerequisite study with a research-based approach during your bachelor's studies?” for Group-1 and Group-2 is given in Figure 19.

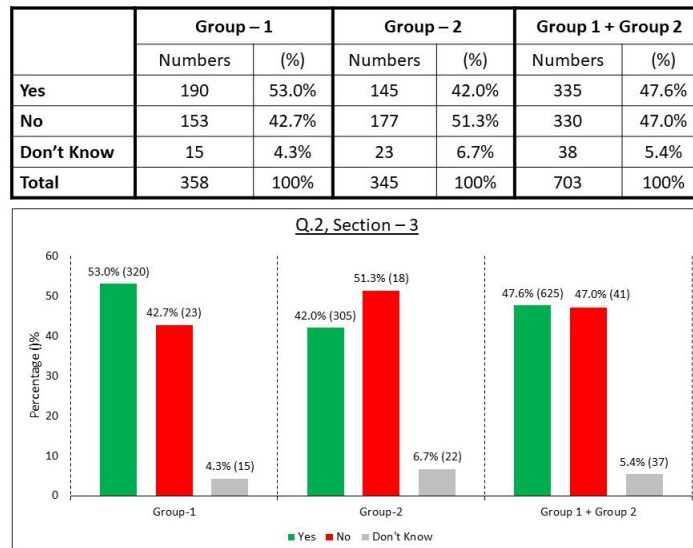


Fig. 19. The questionnaire analysis of Q.2 of Section-3 for Group-1 and Group-2

The number of the respondents of Group-1 who replied “YES” is slightly higher (53.0%) in comparison to those who replied “NO” (42.7%) and “DON’T KNOW” (6.7%). It shows that the respondent's ratio follows the order YES > NO/DON’T KNOW concerning the architectural design teachers undertaking this preliminary/prerequisite study with a research-based approach during the bachelor's studies. The number of the respondents of Group-2 who replied “YES” is slightly lower (42.0%) in comparison to those who replied “NO” (51.3%) and “DON’T KNOW” (4.3%). It shows that the respondent's ratio follows the order YES < NO/DON’T KNOW to the architectural design teachers undertaking this preliminary/prerequisite study with a research-based approach during the bachelor's studies i.e., a reverse order.

The overall (Group-1 + Group-2) respondent YES: NO ratio is 1:1 indicating that the instructors be trained to undertake this preliminary/prerequisite study with a research-based approach and learners to be trained during the bachelor's studies.

3.3.3 Q.3 (Group-1 and Group-2)

In response to the open-ended question, Q.3 of Section-3, 67 comments/opinions regarding the research-based approach in architecture education at the bachelor's degree level of Group-1 respondents were received while 24 comments/opinions of Group-2 respondents were received. The qualitative analysis of this open question (Q.3 of Section-3) will be done by NVivo and will be published separately.

4. Conclusions and Future Research

The present studies conducted on “Innovation of an effective blended learning technology in architectural engineering and its validation by response data analysis” revealed that the major component of respondents in the data sample was from the younger and budding architects belonging to academics either as students or as teachers. It was also revealed that the data sample is gender average and is a good average study of both the categories of respondents viz. those who took and those who did not take or came across any research-based course at the graduation level. The essence of responses to the differently asked questions is that the great majority of architects

and current students strongly favor the research-based approach and increase the research content in architecture education at the undergraduate degree level. The understanding of the significance of research-based education in architecture increases with an increase in the academic qualifications of architects.

The most popular technical tools used by the respondents include Case Studies, Internet, Library, Journals, etc. Almost all the respondents opined about the good impact of the research-based learning technology on the overall learning and skill development of the bachelor's level students of architecture. The major problems faced by the respondents during the use of research-based learning technology include deciding or finalizing the topic of the research project, finding the relevant literature, and deciding the research methodology to be used while the data compilation and preparing of the presentation were the easiest component of their research activity.

A learner must undertake initially the literature studies, case studies, interviews, observations, documentation, and research methodologies to investigate and formulate the requirement of design, area statement, etc. as the preliminary/prerequisite studies of, for example, the core subject of B.Arch., Architectural Design. To achieve better in architectural design subjects, more significance must be given to the preliminary/prerequisite studies in architectural design subjects. In light of the Council of Architecture Minimum Standards of Architectural Education Regulations 2020 Recommendations, All India Council for Technical Education's Report, and Bloom's Taxonomy, research-based learning technology is the recommended methodology to undertake the preliminary/prerequisite studies in the architectural design subjects.

Overall, the respondents also consider this preliminary/prerequisite study a kind of research activity understanding which increases with an increase in the academic qualifications of architects. The instructors should also be trained to undertake this preliminary/prerequisite study with a research-based learning approach and learners to be trained during the bachelor's studies. In conclusion, all the respondents strongly supported the concept of introducing research-based learning technology in architecture education at the undergraduate degree level.

However, the response of a small number of the respondents was observed to be "DON'T KNOW" which indicates that some architects and current students of architecture in India were/are not aware of the research-based learning technology in architecture even at their graduation level and in the profession.

Further research to develop curricula for the undergraduates of architectural engineering in light of this work that the research-based learning technology is the most effective learning methodology has to be undertaken. This study is expected to activate the concerned stakeholders and government agencies to formulate new policies, review the existing policies and implementation on research-based learning technology in India.

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