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RESEARCH ARTICLE

# Examining the impact of students' attendance, sketching, visualization, and tutors experience on students' performance: a case of building structures course in construction management

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## Abstract

The aim of this paper is to examine students' performance in a computation-based course by evaluating the effects of key factors including sketching, visualization resources provided to them during the lectures, their attendance and tutors' experience. A systematic review was conducted including 192 articles published during January 2010 to December 2019. Further, a case study has been conducted in which 633 students from non-engineering backgrounds were taught a core course of construction over three-yearly sessions from 2017 to 2019. The performance has been assessed through two quizzes of 10% weight each, assignment of 40%

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weight and a final exam with 30% weight in 2017-18 and 40% weight in 2019 were utilized with an attendance criterion of below 75% as low attendance. The statistical result highlights that a clear difference of 14% overall marks exist between the students with less than 75% attendance and the ones with 75% and above in 2017 and a 10% gap in 2018. Students with high marks in sketching secured higher overall marks as compared to others highlighting that the sketching skill is useful to construction students. The findings contribute to the body of education knowledge by evaluating key influential factors and provide a useful benchmark to other educators in the field.

## Keywords:

**Student performance, construction education, experienced vs novice tutors, students' attendance, student Sketching, visualization, construction management.**

## Introduction

Historically, teaching, and educational approaches are reliant on higher attendance as a guarantor for better academic performance. However, modern education methods and approaches do not necessarily limit the academic performance to attendance only. Instead, modern education systems are more focused on the long term and sustainable student academic performances which includes other aspects in addition to attendance (Etemadpour et al., 2020). The additional features and assessors include visualized resources and their utilization for enhancing in class and online visualizations and conceptualizations of the students. Other assessors include student sketching as their assessments for better conceptualizations of the pertinent systems and subcomponents. Especially due to the sudden shift towards online teaching on a mass scale due to the COVID-19 outbreak, digital technologies such as Big data, virtual and augmented realities, artificial intelligence and other tools are increasingly adopted in different organizations (Ullah, Sepasgozar and Ali, 2019; Ahmed, Allaf and Elghazaly, 2020). Thus, it is imperative to explore the importance of visualization and sketching as well as the possibility of in class visualizations in interactive environments (online or in person).

Students' attendance can be considered as a traditional measure of higher academic performance. It has been discussed that lower attendance rates produce declining academic performance that is especially prominent in school going children where a decline in academic performance is observed with an increase in absence rates (Hancock et al., 2013). Thus, it becomes critical to control the rate of absence in schools. According to Gershenson, Jackowitz and Brannegan (2017), student attendance is an important but understudied aspect of the educational process. Many studies have discussed different ways of improving students' attendance such as using flipped classrooms, the use of recorded lectures and using incentives for attendance (Awidi and Paynter, 2019; Astuti, Sugiyarto and Ikhsan, 2020; Etemadpour et al., 2020). However, in the modern education system for ensuring sustainable student performance, this should not be the only criterion.

Sustainable academic performances enable students to improve their skills and abilities. These include Retention, Technology Usage, Leadership, Ethical Development and Problem Solving (Van den Bogaard, 2012; Knight and Novoselich, 2017; Ullah et al., 2018; Ullah et al., 2019). Such skills help produce better-equipped engineers who can take the initiatives, be firm on ethical grounds and apply a problem-solving approach to the emergent issues in

fields. Specifically, no work has been found till date in the field of construction courses such as Building structures when taught to students from mixed academic backgrounds. Additionally, the relation between tutors' experience and student's sustainable academic performance has not been addressed in construction domains. These gaps provided an impetus for conducting the current reach where the core objectives are: 1) to investigate the effects of student attendance on sustainable academic performance and analyze it statistically, 2) to statistically investigate the relation between student sketching and their overall academic performance for ensuring sustainable performance, 3) To get a student perspective on the usage of visualized resources for in-class and online visualizations and its effects on sustainable academic performance and finally 4) to statistically investigate the relation of tutors' experience and its effects on sustainable student performance. It is expected that the results of this paper will help the academics redesign their courses to include more visualized resources to give an immersive experience to the students and incentivize them for attending the lectures. Especially in the current times when most of the courses are moving online, it is getting tougher and tougher to retain the exiting numbers of students due to lack of motivation, social distancing, and attending lectures in non-academic environments. To achieve the objectives of the current study, a systematic literature review has been conducted to highlight key assessors of the three key contributors of sustainable academic performance: sketching, visualized resources, and attendance. Results are compiled, and pertinent discussions presented about how these assessors and contributors enhance sustainable academic performance and key skills acquired through them.

## A systematic analysis of the literature

For conducting the systematic literature review, PRISMA guidelines were followed. A comprehensive search process was devised to be all-inclusive and give equal opportunities for selection to the available literature. The search process utilized online literature search engines and databases such as Google Scholar, American Society of Civil Engineering (ASCE) Library, Taylor & Francis Library, Emerald Insight, Science Direct, Web of Science, and Scopus. All the search engines are included in group 1 (G1) except Web of Science and Scopus, which are named group 2 (G2) and group 3 (G3), respectively, as shown in Table 1. As a result of the comprehensive and systematic literature review, a total of 210 scientific publications were retrieved including 192 journal articles, nine conference papers, and five book chapters and other publications. Both semantic and keywords-based search techniques were utilized. The keywords used in the first step of the study consisted of "Student sketches", "Student attendance", "Student performance" and "Student visualization" that yielded 1,272,676 results in total which includes 1,170,091 results for G1, 94,513 for G2 and 8,072 for G3 respectively. In the next step the keywords "construction and education" were introduced to limit the search results construction disciplines only and yielded 19,480 results. In the third step, the limit of the English language was imposed to yield 13,418 results. In the fourth step, articles were limited to the period of 2010 and onwards. This step aimed to limit the focus to recently published articles only that yielded 371 results. In the fifth step, editorial, erratum, letters, notes, and comments were excluded to limit the results to 314. Finally, duplicated articles were removed to yield a total of 192 articles: 77 from G1, 58 from G2 and 57 from G3 as shown in Table 1. Overall, the highest number of papers was yielded by G1, followed by G2 and G3, respectively. The reasons for excluding an enormous number of articles were their pre-2010 focus (outdated), absence of the keywords in the title or abstract, non-English language, excluded article type, or duplications. Based on the

pertinent literature review, this study explores the relationship among the student's sketches, attendances, and visualized resources (key contributors) provided to them with their academic performance (assessor). The conceptual framework is shown in Figure 1 which shows the subcomponents, the three key contributors and assessor, and the skills acquired through sustainable academic performance. In the figure, three independent variables such as sketches, visualization, and attendance are shown. The key skills acquired through academic performance as evident from the literature include Retention, Technology Usage, Leadership, Ethical Development, and Problem Solving.

Table 1 Literature search engines, strings and articles retrieved.

Search Engine	Strings and Filters	Articles Retrieved	Duplicates
G1	TOPIC: Student sketches OR Student Attendance OR Student Performance OR Student Visualization	1,170,091	
	TOPIC: Student sketches in construction education OR Student Attendance in construction education OR Student Performance in construction education OR Student Visualization in construction education	18,180	
	English Language Only Limit	12,530	
	2010 and onwards	162	
	Editorial or erratum or letter or note or comment Limit	127	50
	Remove Duplicates	<b>77</b>	
G2	TOPIC: Student sketches OR Student Attendance OR Student Performance OR Student Visualization	94,513	
	TOPIC: Student sketches in construction education OR Student Attendance in construction education OR Student Performance in construction education OR Student Visualization in construction education	919	
	LANGUAGE: (English)	772	
	DOCUMENT TYPES: Article OR Abstract OR Book OR Book Chapter OR Meeting Abstract OR Proceedings Paper	529	
	Indexes = SCI-EXPANDED Timespan = 2010–2020	93	35
	NOT Duplicates	<b>58</b>	

Table 1 continued

Search Engine	Strings and Filters	Articles Retrieved	Duplicates
G3	TITLE-ABS-KEY (Student sketches OR Student Attendance OR Student Performance OR Student Visualization)	8,072	
	TITLE-ABS-KEY (Student sketches in construction education OR Student Attendance in construction education OR Student Performance in construction education OR Student Visualization in construction education)	381	
	PUBYEAR AFT 2010 AND LANGUAGE (English)	116	
	DOCTYPE Limit Not Duplicates	94	37
		<b>57</b>	
Grand Total			<b>192</b>

Note: ABS: Abstract; KEY: Keywords; DOCTYPE: Document type  
 G1 is group 1 and includes Google Scholar, American Society of Civil Engineering (ASCE) Library, Taylor & Francis Library, Emerald Insight, Science Direct. G2 is group 2 that includes the Web of Science whereas G3 is group 3 that includes Scopus search engine.

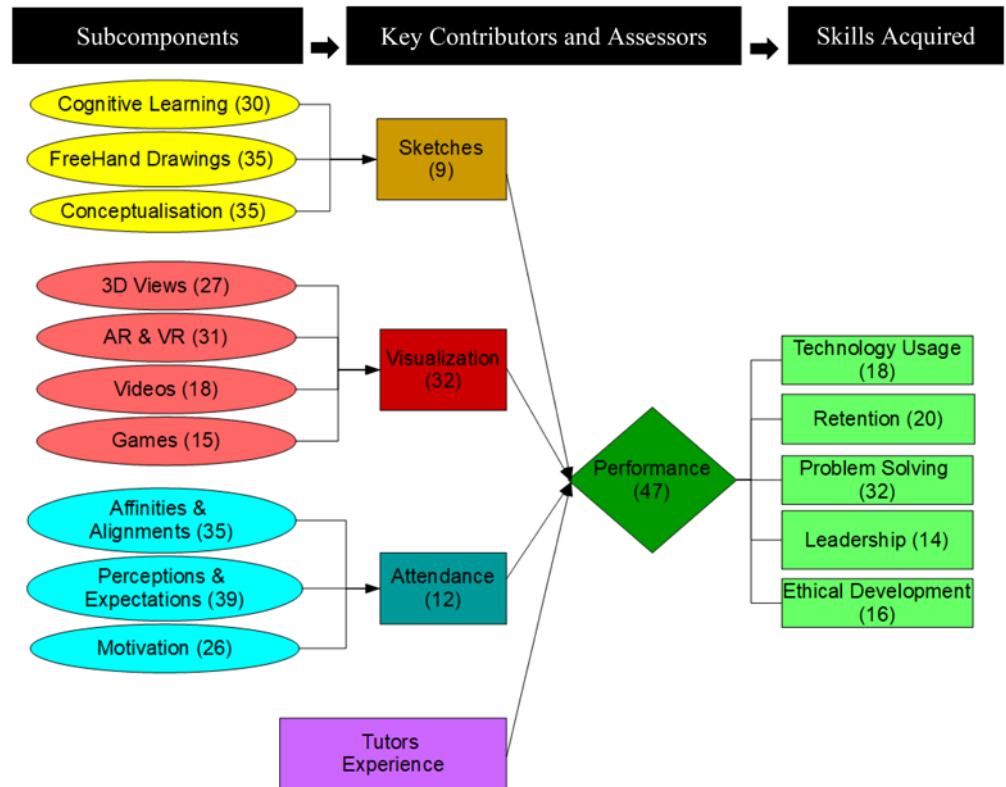


Figure 1 Subcomponents, key contributors, and independent variables of student performance (Note: The numbers in brackets show the percentage contributions of the criteria overall and sub-criteria to the original criteria based on the papers reviewed.)

Table 2 presents the results of the journal-based analyses along with their focus in terms of the criteria focused in the current study. Journal of Professional Issues in Engineering Education and Practice (JPEPE3) leads the table followed by the International Journal of Construction Education and Research (UICE20). Similarly, the Journal of Engineering Education (JEE), European Journal of Engineering Education (CEEE20), International Journal of Engineering Education (IJEE), and others are also included in Table 2. The codes used for the journals are the official acronyms used by the publishers and are adopted from their websites. The table also shows that there is a dearth of papers on construction sketching as evident by only 17 out of the 192 publications focusing on it. Overall, the majority of the papers focus performance followed by visualization, attendance, and sketches, respectively.

Table 2 Top journals publishing papers on construction and engineering education and their focus from January 2010 to December 2019.

Journals	Focus				Total
	Sketching	Attendance	Visualization	Performance	
Journal of Professional Issues in Engineering Education and Practice (JPEPE3)		3	24	27	54
International Journal of Construction Education and Research (UICE20)		4 <sup>+</sup>	14	23 <sup>-</sup>	40
Journal of Engineering Education (JEE)	1	2	7	21	31
European Journal of Engineering Education (CEEE20)	1 <sup>+</sup>	7	12 <sup>-</sup>	6	25
International Journal of Engineering Education (IJEE)	2	3	4	5	14
Others	11 <sup>++</sup>	2 <sup>+</sup>	7 <sup>--</sup>	11 <sup>-</sup>	28

Note: "+" and "-" shows the number of multi-focus publications. The one with + shows where the paper has been counted whereas the - shows the other focus that has not been counted.

Interestingly the top two journals in terms of overall paper count that are JPEPE3 and UICE20 have no published paper on construction sketching considering the search strings used in the current study. The most balanced approach can be seen in IJEE and CEEE20.

Overall, the focus is dominated by performance criteria followed by visualization. Whereas attendance and sketching are the least focused areas in terms of construction education. Therefore, the need for a holistic study such as the current study remains desired for contributing to these aspects of construction and engineering education. Similarly, further analysis as shown in Figure 1 represents the percentage of criteria focused on the total 192 papers from January 2010 to December 2019. Figure 1 displays both criteria and sub-criteria with percentages shown in brackets. The highest focused criterion is “performance” with as much as 47 percent of papers (90 in total) relevant to it. This clearly highlights the importance of student performance in construction courses. However, as discussed previously, it is astonishing to see no paper talking about sustainable performance in construction courses making this area more important than before. Further, attendance is focused on only 12 percent of the retrieved publications (23 papers in total). The distribution for the sub-criteria is led by Perception and Expectation with nine papers followed by Affinities and Alignments (8) and Motivation (6) respectively. Lastly, the lowest focused criteria in all retrieved papers is that of sketching with as low as 9 percent focus. This shows the dearth of literature and the potential exploration area in the context of construction education. Overall, this criterion is almost equally focused in terms of its sub-criteria. This can be associated with the lower number of retrieved publications; the gap is expected to grow with more publications.

## Critical factors

Since the focus of the current study is to investigate three key aspects of sustainable student performance, the literature section is subdivided to discuss these critical aspects. The section introduces the definitions of the key terms used throughout the paper followed by a detailed discussion on the critical aspects of sustainable student performance.

### STUDENT ATTENDANCE AND ENGAGEMENT

There is an argument of whether there is a positive relationship between academic success and school attendance in terms of student engagement. But, in terms of establishing the empirical evidence between input factors and their relation to academic outcomes, very few investigations exist that try to precisely assess the relationship between individual attendance and engagements, and students’ achievements (Gottfried, 2010; Aluko et al., 2016). Massingham and Herrington (2006) investigated various aspects of students’ non-attendance and lack of participation in lectures and tutorials in the University of Wollongong Australia. The results of their study indicate that there are valid reasons for nonattendance that are both in the control of learners and teachers but if the students attend these classes, they will surely have benefits. Similarly, Edwards and Clinton (2019) argue that attendance has a direct and positive influence on student performance and failing to attend and engage in activities regularly amounts to a deteriorating performance of students.

Deane and Murphy (2013) explored its prospects in medical fields and concluded that among fourth-year medical students completing an 8-week gynecology course, the relevant attendance and engagements at both clinical and tutorial-based activities are positively correlated to overall examination scores. They further concluded that 60% of failing students had lower attendance and engagements than the set limit of 80%. Similarly, Gershenson (2016) investigated the linkage among student attendance, student performance, and teaching quality in North Carolina for primary school students to highlight that attendance has substantial statistical relation with students’ performance. Ladwig and Luke (2014) in their

study of indigenous education policy in Australia highlighted that current federal government policy initiatives in Australian aboriginal education and social welfare reform are conventions based and assumes a linear relationship between increased attendance and increased student performance. The authors empirically explored the relationships between patterns of students' attendance and achievements in schools to highlight that reforms and policies around attendance have not, and are unlikely to, generate patterns of improved achievements. Nevertheless, attendance should not be taken at the face value, instead, it is a holistic term that incorporates engagement. Thus attendance (be it physical or online), needs engagement as a necessary factor for the students to produce better results. To enhance student engagements and attendance in the current era of online teachings especially after the outbreak of COVID-19, certain strategies such as increased visualized and immersive content, virtual and augmented realities based content, and online tools are required. Christie and Morris (2019) highlight the use of blogging as an enhancer of students' engagement and attendance. The authors, based on student interviews, including discussion of how blogging enables students to develop their own voices as part of the writing process suggest that a broader understanding of student engagement depends not only on the complex interaction between students and assessment practices but on understanding the role of students' investment in the learning process which can be increased through online tools such as blogs. Similarly, machine learning based student engagement analytics can help track student performance and provide individual improvement strategies (Vytasek, Patzak and Winne, 2020). Further, due to the shift to online means of education, concepts of m-learning or mobile learning are increasingly explored. Alioon and Delialioğlu (2019) explored the implementation of m-learning and their comparison of the results from two semesters revealed that the improvements in the immersive content of the activities and instructional process increase the collaboration among students as well as their interaction with the instructor leading to better academic performance. In this context adoption of online tools for education coupled with a relationship management approach to enhancing the relationship quality between students and instructors can help increase students' attendance and engagements (Snijders et al., 2020).

These useful studies have explored various aspects of students' attendance and established relations with their performance in different fields, but this goes unexplored in the field of construction. More specifically, the relation between attendance and student performance, and the tutors' experience have not been explored in the field of construction. Furthermore, the research gap increases when construction course is taught to students of non-engineering background.

## STUDENT SKETCHING

Construction sketching is the focused creation of visual depictions and marks that initiate thinking, learning, and communication (Forbus et al., 2011; Sepasgozar and Leonhard, 2012; Ullah et al., 2018). Student sketching can be in the form of digital or manual sketching. The current study focusses on freehand sketching regardless of the medium. Student sketching has not been assessed in the context of students' sustainable academic performance previously. Similarly, the empirical relation between student freehand sketches and performance has not been explored to date. This gap is targeted in the current study along with other objectives. Sketching has been traditionally used as a standard practice in the engineering profession. However, according to Siew and Bernold (2013), it has succumbed to digital drafting software used for engineering designs. While many recent studies argue that the use of digital software for sketching is an important asset for modern engineering, researchers



such as Uziak and Fang (2018), believe that freehand sketches regardless of the media play a critical role in enhancing problem-solving and engineering design conceptualization skills of the students. Various assessment components for sketches include cognitive learning, conceptualization, and freehand drawings (Uziak and Fang, 2018; Thurlow, Ford and Hudson, 2019). According to Forbus et al. (2011), sketching is a powerful means for generating subsequent communications of ideas. It involves the utilization of visual, conceptual, and spatial knowledge that makes it challenging and a good candidate for cognitive learning. Johnson and Reynolds (2005) stress the need for concept sketches for enhancing the students' conceptualization. The authors argue that active learning and more student immersion can be achieved through concept sketching. The sketches generated by students and subsequent explanations and presentations to their peers can help consolidate their knowledge and induce deeper understandings. Similarly, such conceptualizations can induce critical thinking in the students (Astuti, Sugiyarto and Ikhsan, 2020). Uziak and Fang (2018) argue that freehand sketching is a must skill for professional engineers. The authors conclude that overuse and reliance on computer-based technologies are robbing the students of their artistic and imagination skills which are an asset for construction and architecture students. Similarly, Mao et al. (2020) provides evidence of cognitive chunking in freehand sketching during design ideation and argues that novel ideas produce chunks that can help improve the engineering designs. By measuring the information stored in a sketch chunk, other parameters such as information generation rate and the impact of other external variables on this rate could be measured, giving an indirect metric for cognitive ability or design creativity of designers. In the era of online teaching for providing student-specific feedback, Hilton et al. (2019) discuss the concept of instructor-taught sketching with an online sketching tutor that utilizes artificial intelligence to provide human-like feedback to user sketches who can improve their spatial visualization skills at a level equivalent to students who had more practice with pen-and-paper sketching.

## STUDENT VISUALIZATION

Visualization is the process of using videos, animations, and other tools to communicate a message or process (Fogarty, McCormick and El-Tawil, 2017; Munawar et al., 2020). Different tools are used for visualization including games (Ebner and Holzinger, 2007; Ullah, Sepasgozar and Wang, 2018; Ullah and Sepasgozar, 2019), 3D views (Sampaio et al., 2010; Ullah and Sepasgozar, 2019), simulations, augmented and virtual realities (Ullah, Sepasgozar and Siddiqui, 2017; Ullah, Sepasgozar and Wang, 2018), and videos (Sampaio et al., 2010; Astuti, Sugiyarto and Ikhsan, 2020). The use of visualized resources for construction education has been discussed at length by different researchers. Astuti, Sugiyarto and Ikhsan (2020) conclude that students who used 3D visualization had better results in critical thinking skills and scientific attitudes. 3D views are essential components of the visualized resources. Glick, Porter and Smith (2012) discuss the importance of 3D models for students' visualization in undergraduate construction management education. The authors argue that computer-based 3D models provide an opportunity to the students to enhance the visuospatial skills that can help them understand new and complex systems and course materials. Further, students lacking such visualization skills will have difficulties in understanding and visualizing construction systems and their components. Construction processes such as masonry, steel erection, and others can be easily understood with the help of 3D visualizations (Etemadpour et al., 2020).

## TUTORS' EXPERIENCE AND STUDENTS' PERFORMANCE

Apart from the key assessors of sustainable academic performance and skills acquired through it, another focus of the current study is the assessment of the relation between tutors' experience and corresponding student performance. Liu and Loeb (2019) argue that effective teaching strategies along with experience and impact of the teaching staff have a positive and constructive effect on students' motivation and pertinent academic performance. According to Prosser et al. (2003), dissonance in teaching methods to which the tutors are used may be indirectly imparted to their students who often complain about the teaching style and experiences. Also, students are more willing and happier to attend lectures of teachers who can teach at easier level and tone down to students' levels. Thus, some fresh tutors display better performance than senior teachers. Students of such senior teachers are better in reproduction but not in learning. However, Podolsky, Kini and Darling-Hammond (2019) have a differing view and argue that teaching experience is positively associated with student achievement gains throughout much of a teacher's career. So, when teachers gain experience, their students are more likely to do better on measures of success beyond test scores. Similarly, Outhred and Chester (2010) highlight the need for trainings and role explanations to the tutors to have consistent results. According to the authors, five key themes must be the focus during tutors' training: regulation of the peer tutored groups, role exploration, harnessing the peer tutors' role, sharing responsibility, and community. Other factors that influence the transfer of knowledge are culture and language barriers. According to Kadiwal and Rind (2013), culture, language, and religion can affect the offshore education and corresponding understanding of students. In this context tutors capable of speaking native languages and hailing from the same cultures can enhance student learning and performance. In order to enhance the students' understanding of the course contents, Santhanam and Codner (2012) recommend a training module for teaching assistants, sessional staff, and academic tutors to enhance undergraduate engineering education quality. The argues conclude that implementation of such a system enhances students learning through proper guidance of the support staff. This can make the students' performance more sustainable and help them secure better grades. Thus, students' performance is positively affected by effective intervention and trained tutor's guidance.

## Materials and methods

In order to identify and evaluate critical factors influencing students' performance in a computation-based course, a set of firsthand data collected from students' words for three years. The data includes students' sketches from a selected building showing the structural loading and elements. Students' assessments were also collected and analyzed. The attendance and sketches were statistically analyzed to find out their effects on overall students' performance whereas the visualized resources are covered through students' interactions with an online interactive platform called Moodle. The chosen research method is a case study, so details of the selected course were collected and considered in the analysis. All relevant data related to Building Structures course offered by the Faculty of Built Environment at the University of New South Wales; Kensington Sydney Campus was considered. The course was taught to a class of 633 students over three years from 2017 to 2019. The 2017 session included 195 students whereas the 2018 session included 217 students and the 2019 session comprised of 221 students. The course is designed for the Construction Management program as a core course that is offered to students with mix academic backgrounds. The course covers a variety of concepts pertinent to building structures from the strength of materials to concrete, steel, and timber structures' design. These concepts require an understanding of civil engineering core courses as well as strong mathematics and

physics concepts. The contact hours of the course involved one hour of lecture and two hours of tutorials every week. Additionally, in-person one on one consultation services were also offered to the students struggling with the course and its concepts. All the correspondence was made in the English language. The lectures were conducted by the senior lecturer and the two-hour tutorials were managed by six tutors with varying levels of experience in 2017, seven tutors in 2018, and four in 2019. Three of the tutors in 2017 were experienced having more than five years of teaching and industrial experience whereas the remaining three were fresh graduates with little (2 years) or almost no experience of teaching or the industry. In 2018, three experienced and four novice tutors were involved whereas two experienced and two novice tutors were involved in 2019. Students were randomly assigned to the tutors based on performance clusters of their academic performance using an automated program. This academic performance was based on previous course results. Thus, it was ensured that students from all grade categories including High Distinction, Distinction, Pass, and others were equally allocated to all classes. The grades were classified as high, medium, and low-level performers. On average each tutor had around 30 to 40 students per session with students from performance clusters of high, medium, and low. Thus, fair and equal distribution and allocation of students with all capabilities and understanding levels were ensured. In terms of the contents, the course content was distributed over a total of 13 weeks starting in July 2017 and 2018 to October of the same year and 10 weeks in 2019 as shown in Figure 2.

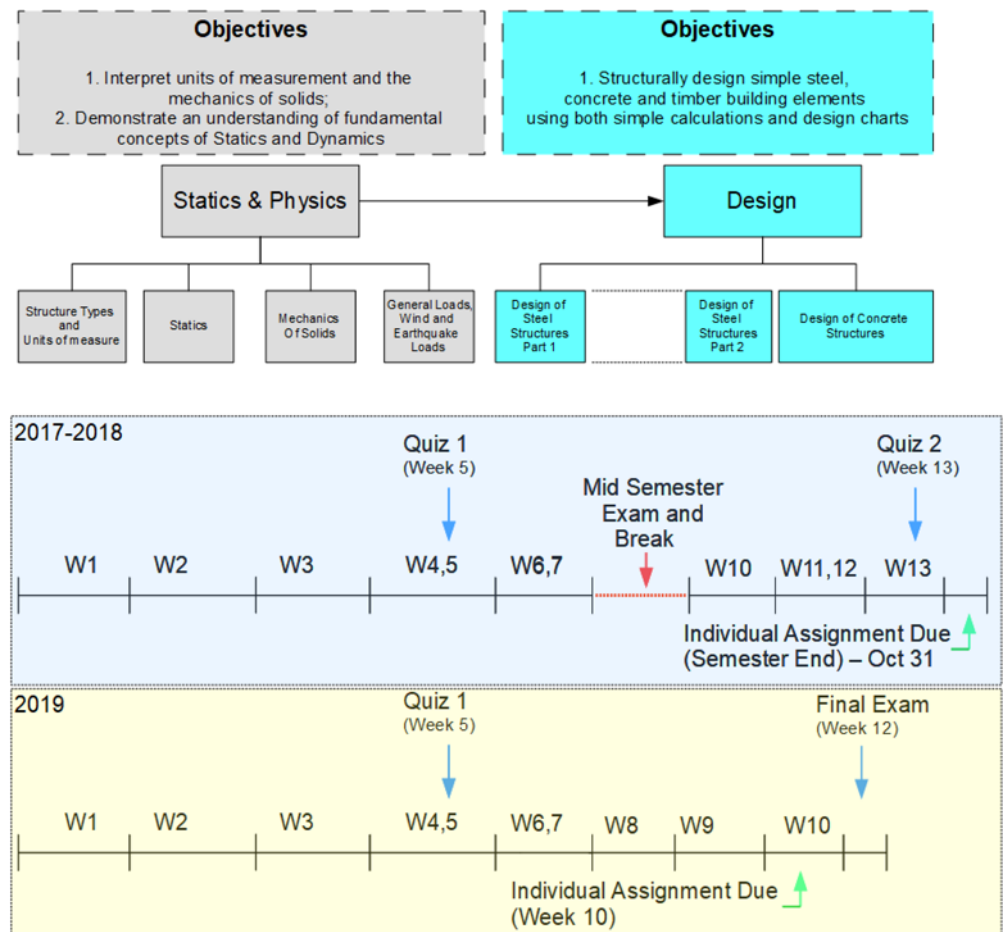


Figure 2 The selected case details including course objectives, contents, and weekly distribution, note: W refers to week.

For assessing attendance, a limit of 75% was imposed as good attendance whereby the students attending more than 75% of the lectures either in person or online were categorized as students with good attendance and vice versa. Based on this, different statistical assessments are conducted to highlight the relationship between attendance and sustainable academic performance. Apart from the attendance related assessment, the experience of tutors was also statistically analyzed to see any relation with the sustainable academic performance of the students. A total of six tutors in 2017: 3 fresh and 3 experienced were assessed in terms of their students' performance and statistical results are drawn accordingly. Whereas for 2018 the number of tutors was seven: 3 experienced and 4 novices. Similarly, in 2019 the number of tutors was reduced to four with multiple sessions.

### SKETCH ASSESSMENT

For assessing the students' sketches a comprehensive sketch assessment matrix was developed as shown in Table 3. The total marks assigned to sketches were four. The matrix comprises four assessment categories: Excellent with four marks, Good with three marks, Average with two marks, and just acceptable with one mark only. The excellent category was comprehensively drafted to include all the focal items as identified from previous studies due to the systematic literature review. Other categories were marked relevant to the excellent category. Similarly, six assessment criteria were focused on marking including scaling, essential components, linking, structural stability, visualization, and sketcher's efforts as shown in the matrix. To get full marks a student had to score an excellent grade in all the six assessment criteria otherwise the marks adjusted accordingly. For the overall marks' calculations, Equation 1 was used.

$$\sum_{i=1}^n \frac{\text{Score of a Category}}{\text{Total Criteria}} \times \text{Number of Categories Obtained} \quad (1)$$

Whereas score of a category is the assigned marks of a category: Excellent (4), Good (3), Average (2), and Just Acceptable (1). The total criteria are six in number. The number of categories obtained may vary with each student. For example, a student obtaining Excellent in all six categories will have a perfect four score as shown since  $4/6 * 6 = 4$ . Similarly, a student obtaining two Excellent, two goods, and two average marks will have a total of three marks  $((4/6*2) + (3/6*2) + (2/6*2) = 3)$  and so on. All the marks were rounded to the nearest greater whole number, so students were given the advantage. For example, if a student scored 2.15, their marks were increased to 3 since the objective was never to be strict to the students rather the aim was to encourage them to sketch and secure marks for efforts.

Table 3 Sketch Assessment Matrix

Criteria	Excellent (4)	Good (3)	Average (2)	Just Acceptable (1)
Scaling	1. Fits properly on page. 2. Drawn to scale relevant to components size. 3. Scaling factors specified. 4. Consistent line angles	Any one component of the excellent category missing.	Half of the excellent category components missing.	Meets at least one of the excellent criteria.

Table 3 continued

Criteria	Excellent (4)	Good (3)	Average (2)	Just Acceptable (1)
Essential components	<ol style="list-style-type: none"> <li>1. All the required elements are in place (columns, beams).</li> <li>2. The load transfer mechanism is shown correctly (from columns till ground)</li> <li>3. Attention has been given to details (column sizes, beams, loads)</li> <li>4. All arrows, texts, and diagrams labelled and relevant</li> </ol>	Any one component of the excellent category missing.	Half of the excellent category components missing.	Meets at least one of the excellent criteria.
Linking	<ol style="list-style-type: none"> <li>1. All elements are linked accurately</li> <li>2. The support provided is sufficient to carry the weight of the structure.</li> <li>3. The components are properly placed</li> <li>4. Relevant codes mentioned</li> </ol>	Any one component of the excellent category missing.	Half of the excellent category components missing.	Meets at least one of the excellent criteria.
Structural stability	<ol style="list-style-type: none"> <li>1. The structure is stable.</li> <li>2. The components show appropriate sizing for strength (moments and forces).</li> <li>3. All the components adhere to the law of physics.</li> <li>4. Safety and strength codes mentioned</li> </ol>	Any one component of the excellent category missing.	Half of the excellent category components missing.	Meets at least one of the excellent criteria.

Table 3 continued

Criteria	Excellent (4)	Good (3)	Average (2)	Just Acceptable (1)
Visualization	1. Proper colours are used. 2. The shading accentuate materials properly i.e. different shades for columns, beams 3. No unnecessary artistic features 4. The load flow can be seen.	Any one component of the excellent category missing.	Half of the excellent category components missing.	Meets at least one of the excellent criteria.
Sketcher's efforts	1. The sketch is drawn with care and has sharp lines 2. The final product is clean, clear, and presentable to a future employer. 3. Unnecessary material left out and concentration on key points 4. The sketcher show artistic sophistication and Aesthetics (top, front, side views)	Any one component of the excellent category missing.	Half of the excellent category components missing.	Meets at least one of the excellent criteria.

Note: 1,2,3,4 in brackets show the marks assigned to the category.

For assessment purposes, students were asked to sketch two figures in one of the assessment modules and a free body diagram in the mid-semester exam. As explained, A total of 4 marks each were allocated to the sketches. Zero marks were assigned if the figures were not sketched. The students were supposed to sketch and show loadings and reactions. These marks have been assigned based on the assessment matrix. The criteria include scaling, components, linking, structural stability, visualization, and sketchers' efforts. When assessing, ticks were marked in a tabulated excel sheet against specific criteria, and marks are added accordingly as per equation 1. Once the results were finalized for all students, statistical analyses were conducted to observe the relation between student sketching and sustainable academic performance.

### VISUALIZATION OF STRUCTURAL ELEMENTS

Different visualized resources were displayed in the class for enhancing the concepts and visualization skills of the students. Different videos and animations were played both in class and uploaded on Moodle for online access at homes. Figure 3 shows different loadings and failure modes in different segments of videos played in class that was also uploaded to Moodle. The videos were paused as and when a concept was being explained to discuss it with the students and initiate a conceptual discussion.

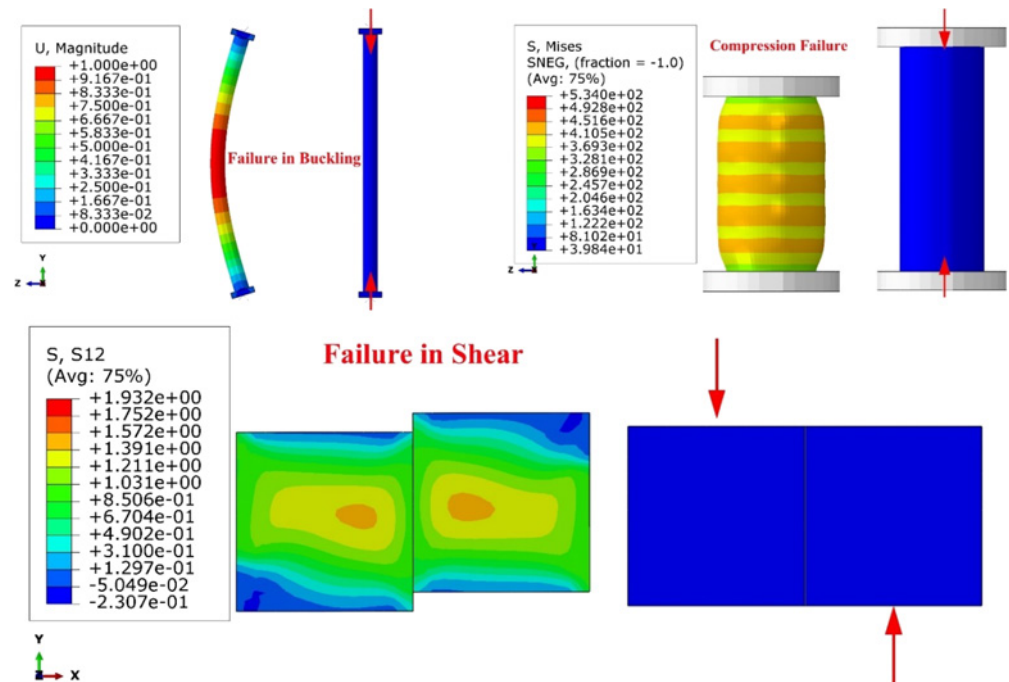


Figure 3 Different types of loadings and failures using Abaqus a finite element analysis software.

Similarly, animations were also used for visualizing different concepts. Figure 4 shows three different types of animations that were made available to the students online as well as played in class. The sample shows animations related to loading transfers where the pictures were aided with moving arrows in direction of loads. Different load components for angular forces were represented in different colours and moving animations. Similarly, user-controlled oscillatory materials were also visualized in class to replicate the movements in columns subjected to horizontal loads such as wind and earthquake. Another type of animations included the load transfer mechanisms observations in real-time. The software was used to demonstrate this to students. Figure 5 shows how an angular load impacts a hooked connection and the points of extreme and moderate loads. Thus, it became easier for students to observe how the real-life weight and load distributions act, and the occurrence of failures was realized in different shapes. The advantage of Moodle is that students can change the loading conditions and play the animations over their mobile devices and cell phones thus helping them understand the concepts easily.

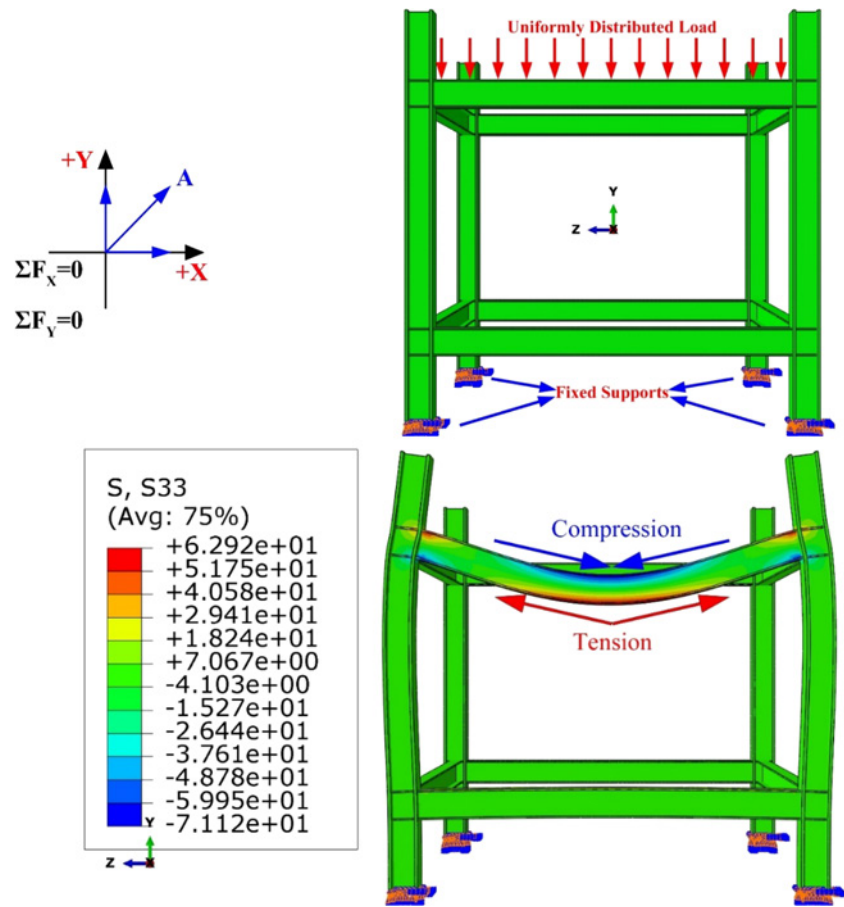


Figure 4 Animations showing load transfers and load components.

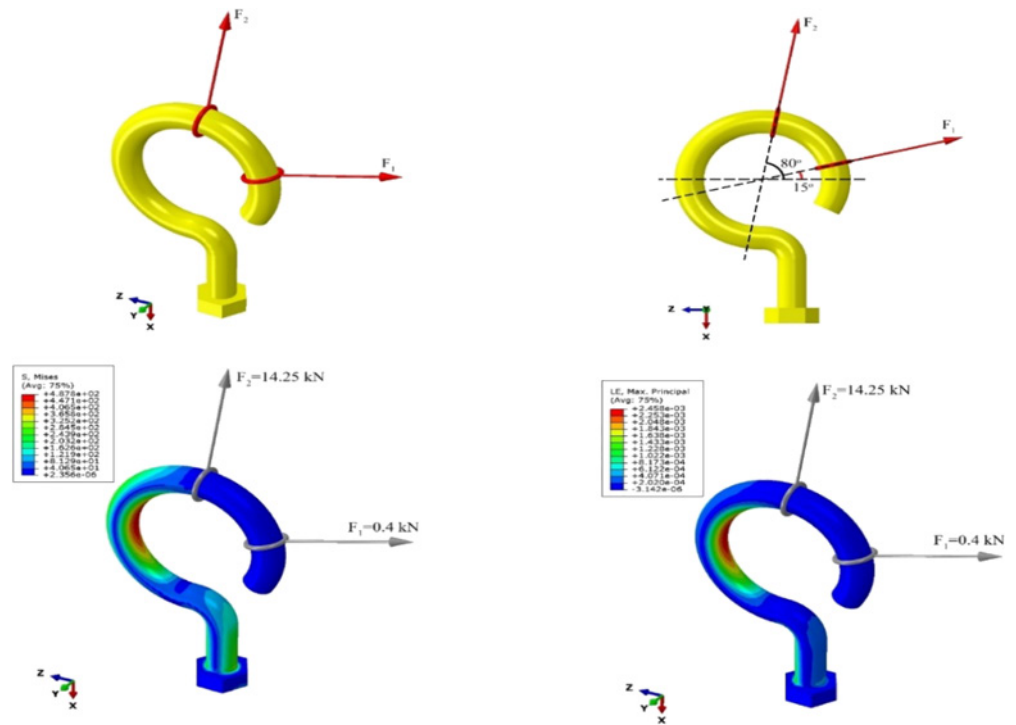


Figure 5 Connections subjected to angular loading.



Additionally, case studies were provided and explained through animations to the students over the interactive Moodle Platform. Figure 6 provides an illustrative case study and example explained to students through Moodle where the load transferring and complex interaction between the different engaging elements in a bridge is elaborated. The figure shows the interactions of various elements and the natural frequency of walking on the bridge that produces tremendous pressure and loads on the center of the bridge making it susceptible to collapse.

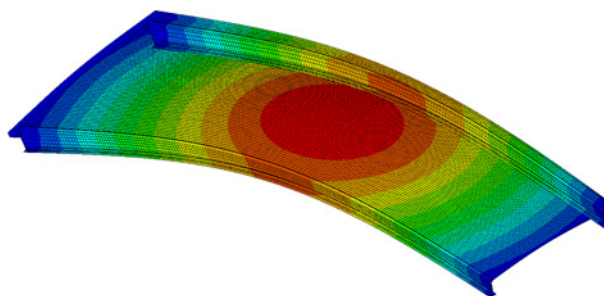


Figure 6 A possible excessive dynamic excitation of a composite bridge.

## Results and discussions

### ATTENDANCE AND ENGAGEMENT

In the case study, firstly the attendance was focused. A minimum of 75% attendance was set as the base limit for student assessment. Anything on or above 75% of attendance was considered as good attendance and vice versa. Further, the subject passing criteria were set at a minimum of 50% overall marks. Table 4 shows the count of students having below or above 75% attendance and their failing number. In 2017, the average marks scored by 41 students with less than 75% attendance were 53.35 which is very close to the pass mark of 50%. A total of nine students among these 41 were declared as failed as per the set criteria giving a fail ratio of 22%. On the other hand, only 4 out of the 154 students with attendance of 75% and above failed giving a ratio as low as 2.5%. The average marks for the students with above 75% attendance were 67.40%. Thus, a clear gap of 14.1% absolute marks is highlighted in this study among the students having below 75% attendance, and the ones with 75% and above. A clear empirical evidence is established for students' performance regarding their attendance due to the above results. The Shapiro-Wilk Test was utilized, and the Sig. value of the Shapiro-Wilk Test is below 0.05 ( $P=0.00$ ) showing that the data significantly deviates from a normal distribution. The normal Q-Q plot was also produced showing that the data is not normally distributed since the data points are not mainly close to the diagonal line. Similarly, Mann-Whitney Test was utilized which shows that the students who attended the tutorials regularly have achieved more marks on the exam ( $p=0.00$ ). The results do not show any evidence to conclude that the assignment marks for both groups of students are different. Further, it is imperative to discuss that only one of the nine failed low attendance students missed the assignment. This assignment was a key component with 20% marks, yet the failure ratio is considerably higher than the students with good attendance. This is because of their lower performance in almost all assessment components. On the other hand, among the four underperforming students in good attendance, three of them did not submit the assignment and would have passed the course by a good margin had they submitted it.

Similarly, in 2018, nine students of the 38 with attendance lower than 75% failed the course giving a percentage of 23.68. On the other hand, 10 out of the remaining 179 with 75% and above failed the course giving a percentage of 5.5 only. This highlights the importance of attending the lectures in the context of scoring well in the course. In 2018, following the same trend as previous year, the final marks were 57.89% and 67.32% for low and high attendance students, respectively. This gap of around 10% overall marks highlights the advantage of having more attendance in terms of getting higher academic scores. The attendance was not calculated for the year 2019.

Table 4 Student attendance, average marks and fail count for 2017.

Criteria	Attendance Group	N	Mean Rank	Sum of Ranks	Failing Students	P value
<b>Attendance</b>	<75	41	20.00	780.00		0.00
	=>75	154	111.50	16056.00		
	Total	195				
<b>Total Marks</b>	<75	41	53.88	2101.50	9	0.00
	=>75	154	102.32	14734.50	4	
	Total	195				
<b>Assignment</b>	<75	41	76.08	2967.00		0.32
	=>75	154	96.31	13869.00		
	Total	195				

### SKETCH ASSESSMENTS

The sketch marks as per the criteria shown in Table 3 were assigned and marked accordingly as shown in Table 5. Table 5 shows that there is a considerable difference between the total marks of students scoring 50 percent and below for the sketching activity and those scoring above 50 percent. In 2017, a total of 49 students scored 2 or below out of 4 and the average of their overall course marks is around 59 percent. On the other hand, students with marks above 2 amounted to 134 in total with an overall average of around 72 percent. Thus, there is a considerable difference of above 13 percent between the overall marks of students with 2 and below marks in sketches and the ones with above 2 marks.

Table 5 Students sketch marks for 2017 and 2018.

Session	Marks	Average	Count	Combined Average	Count Total
2017	0	43.55	5	58.92	49
	1	68.50	7		
	2	64.71	37		
	3	74.74	38	72.38	134
	4	70.02	96		

Table 5 continued

Session	Marks	Average	Count	Combined Average	Count Total
2018	0	35.7	10	52.12	118
	1	57.19	32		
	2	63.50	76		
	3	71.85	74	74.33	
	4	76.82	25		

Similarly, in 2018, the average of the overall marks is 52.12% for students with 50 percent marks in sketches compared to 72.38% for the students with above 50 percent marks. This gap of at least 14% up to 22% in the overall marks highlight the link between good sketching and better academic scores. One of the reasons for this improved scoring is the fact that students with better sketches are thought to have more imaginative powers and are thought of as keen observers of details as opposed to the students with a more casual approach as highlighted by Siew and Bernold (2013) and Astuti, Sugiyarto and Ikhsan (2020). The sketch marks were not captured for the year 2019 due to question type changes and modifications of the course contents. Figure 7 plots the average marks of students with 0 to 4 marks in sketches for both the 2017 and 2018 sessions. The trendline established shows an increasing pattern with increasing sketch marks. In general, students with 2 and below marks are scoring less than 70 percent marks whereas students with above 2 marks in sketches are getting above 70 percent marks on average. Overall, for both sessions, an increasing trend is observed with increased sketch marks. Thus, students with more marks in sketches perform better than their colleagues with lower marks in sketches. This can also be associated with the notion that students with better sketches have better imagination, conceptualization, and better understanding thus performing better as compared to the ones with poor or bad sketches (Forbus et al., 2011; Astuti, Sugiyarto and Ikhsan, 2020).

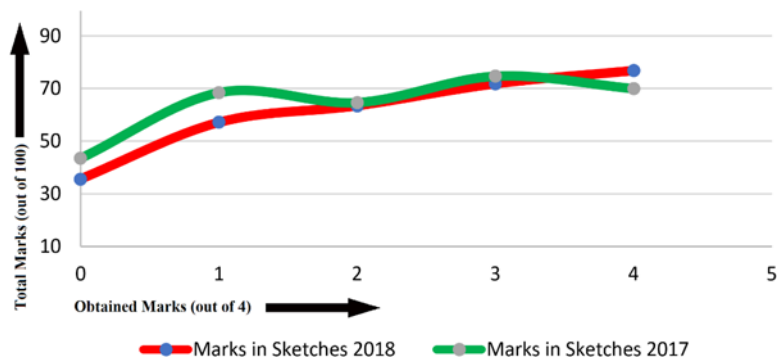


Figure 7 Students average marks vs marks in sketches.

**TUTORS' EXPERIENCE AND STUDENTS' PERFORMANCE**

Another key component of the study is the comparison of the sustainable students' performance with experienced and novice tutors. As previously mentioned, there were a total of 6 tutors involved in the course: 3 of them were novices while three were experienced in 2017. Whereas in 2018, a total of 7 tutors were involved: 3 experienced and 4 novices

and two each from both categories in 2019. Table 6 shows the statistics for experienced and novice tutors for all three yearly sessions. From Table 6, a clear lead can be seen for novice tutors as compared to the experienced ones in 2017. The overall average of students for novice tutors is 67.47 whereas for experienced it is 62.91 thus a difference of around 5 percent exists. This difference exists for almost all assessment criteria except the attendance where it is around 7 percent, thus further strengthening the argument of attendance affecting the overall students' performance. On average, around eight students each of experienced tutors were reported to have short attendance whereas for novice tutors the number fell to only three on average. This indicates that the students enjoy attending and interacting with fresh tutors compared to experienced ones. Based on the 2017 evidence, the authors thought that students' performance is inversely proportional to experience, however, based on 2018 results, the supposition was rejected as it showed opposite results to 2017. Hence the authors have more solid evidence now that is "the performance is related to attending the lectures" not the experience of the tutors. As the same material was provided to the tutors and training provided by the same lecturer, it was expected to get similar results, however, the 2017 results suggested that academic performance might be inversely proportional to the experience of tutors. However, this supposition, based on 2018 results is rejected and stronger evidence is captured for the reliance of academic performance on students' attendance. In 2019, there is a balance performance for all tutors again highlighting the fact that experience may not impact the performance of students by much rather it is the attendance that matters more. As evident from Table 6, in 2017, 22.5% of students were missing the lectures of experienced tutors compared to 9.66% of fresh tutors thus the performance of experienced tutors' students was not as good as the fresh tutors' students. Similarly, looking at the 2018 session, a total of 12.39% of students missed the lectures of experienced tutors as compared to 25.23% of fresh tutors' students thus the performance of experienced tutors' students was better than the fresh tutors' students this time around. This provides clear evidence that attendance dictates students' performance instead of the tutors' experience provided the tutors are trained in similar environments. A Kruskal-Wallis H test was utilized showing that there is a statistically significant difference in students' marks of different groups (e.g. tutorials) for Assignment, Final Marks, and Quiz 1. The Kruskal-Wallis H test showed  $\chi^2(\text{Assignment}) = 13.35, p = 0.020$ ;  $\chi^2(\text{Final Marks}) = 26.87, p = 0.000$ ;  $\chi^2(\text{Quiz1}) = 13.52, p = 0.019$ ; and  $\chi^2(\text{Quiz2}) = 10.75, p = 0.056$  with a mean rank marks of 15.76 for Assignment, 66.60 for Final marks, 9.39 for Quiz1 and 9.32 for Quiz2. There is not enough evidence to reject the null hypothesis that students' group are all equal in quiz 2.

Table 6 Comparison of students' performance for novice and experienced tutors.

Year	Tutor Type	Tutor ID	Average (Total mark out of 100)	Average (Final exam out of 30)	Average (Quiz out of 10)	Average (Final project out of 40)	Average (Attendance)
2017	Experienced	1	67.79	17.05	9.50	28.96	83.81
		2	59.31	20.18	8.66	31.78	69.14
		3	61.63	19.02	9.28	29.31	82.10
		Average	62.91	18.75	9.14	30.02	78.35

Table 6 continued

Year	Tutor Type	Tutor ID	Average (Total mark out of 100)	Average (Final exam out of 30)	Average (Quiz out of 10)	Average (Final project out of 40)	Average (Attendance)	
2018	Fresh	1	70.09	19.17	9.88	33.00	89.06	
		2	65.20	18.38	9.57	29.41	96.08	
		3	67.12	19.32	9.18	31.94	71.97	
		Average	67.47	18.95	9.54	31.45	85.70	
	Experienced	1	69.68	20.90	9.09	30.61	90.61	
		2	65.53	19.66	8.98	28.94	90.48	
		3	64.66	19.40	8.75	29.20	81.50	
		Average	66.62	19.99	8.94	29.58	87.53	
		Fresh	1	66.24	19.87	9.19	27.60	89.34
			2	69.93	20.98	9.78	30.79	78.01
			3	56.91	17.07	8.11	25.97	63.74
			4	58.90	17.67	8.13	26.60	90.90
Average	64.36	18.90	9.03	28.12	77.03			
2019	Experienced	1	84.39	28.55	9.68	26.76	-	
		2	83.95	28.23	9.59	25.49	-	
		Average	84.17	28.39	9.64	26.13	-	
	Fresh	1	83.10	27.47	9.61	26.13	-	
		2	84.32	28.44	9.67	26.62	-	
		Average	83.71	27.96	9.64	26.38	-	

## Conclusion

This study aimed to investigate the key factors contributing to students' academic performance by exploring the relationship between student attendance, sketches and tutors' experience, and their overall performance. Starting with the systematic review of 192 research articles published on the student academic performance from January 2010 to December 2019 and establishing the key performance indicators, the study went through a case study of construction management students to observe the relation between students' academic performance with their attendance, sketches, and tutors' experience. A total of 633 students in the Construction Management program with different backgrounds were taught Building Structures, which is a core course of civil engineering. Their performance was assessed in comparison to their attendance, sketches, and tutors' experience over three yearly sessions of 2017 to 2019 with 195, 217, and 221 students, respectively. For 2017, the results for 41 students having less than 75% attendance show average overall marks of 53.35% as compared to the students' marks of 67.40% for students with 75 and above attendance. Further, a total of 22% of students for low attendance failed the course as compared to only 3% of students with 75% and above attendance. Similarly, in 2018 the average marks for 38 students with lower attendance are 57.89% as compared to 67.32% of the students with good attendance. Thus, clear empirical evidence is presented by the results of this study related to student attendance and their academic performance. Students need to regularly attend lectures and tutorials to get

better marks. This is also important for academic administrators to formulate strict attendance rules for better performances of students.

In terms of tutors' experience, the novice tutors' students in 2017 outperformed the experienced tutors' students by 5% in all assessment criteria on average, the main reason was the average 7% higher attendance by students of novice tutors. However, the scores were inverted in 2018 showing that instead of the experience the performance largely depends on the students attending the course. Thus, experienced tutors' students outperformed the novice tutors' students because they attended more as compared to the novice tutors' students. Whereas in 2019, the performance for both groups is similar pointing to the lack of influence of tutors' experience on students' performance. Further, a relation between students' sketching and their academic performance exists which has been assessed for two sketches of four marks. Students scoring two or below marks are securing less than 70% marks in general and 58.92% on average in 2017. On the other hand, students with three or above marks, score above 70% overall marks in general and 72.38% on average. Similarly, following the 2017 trend, in 2018, the students with two or below marks secured 52.12% marks compared to the students performing good in sketches with 74.33% marks on average. Thus, a clear empirical relation is observed between students having good sketches and their better academic performance. This stresses the need of improving student sketches and encouraging them to use their manual sketch skills for enhancing their vision and perceptions.

The current study compares the results of students taught by experienced and novice tutors. However, the study is limited since additional information is required to be able to interpret the data and measure students' perceptions. For this purpose, semi-structured interviews will be conducted from random students and tutors in the following years' sessions to identify underlying factors affecting the performance of students and tutors. The current study is a case study approach, which can be enhanced in the future to explore more theoretical aspects and underpinning theories of pedagogy and curriculum design. Since the study is a case study, its research implications are limited. Instead, more practical nature of the study for enhancing student performance through increased attendance, improved visualizations, better sketching, and influence of tutors' experience has been investigated using a case of building structure course for three years. As another agenda for future studies, the reverse causality of selected factors can be examined in different courses.

Based on the results, it is recommended to ensure more attendance and student engagements in the lectures. The students do not need to be present in the classes in person, rather innovative technologies can be used to get them involved from homes to ensure better engagements especially in the era of shifting towards the online mode of teaching. Thus, the main concern should be the presence of students and their engagement when the course contents are being discussed, be it in person or online. Interactive platforms such as Moodle, Canvas, and other learning management systems (LMS) are very helpful in this context to provide an immersive visualized environment to the students. This will not only keep them involved in the course but will also ensure that the students get a more playful and experimental platform to interact with the course, an aspect usually missing in traditionally designed courses.

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