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MAKING & BREAKING: CURATION OF AN EXPERIMENTAL EXERCISE TOOLBOX FOR TEACHING BUILDING STRUCTURES ONLINE

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Abstract

The ability to understand the physics of structures is pivotal for a career in architecture [1]. Yet to have a first-hand learning experience became a significant problem during the disruption of pandemic teaching, where students and instructors cannot be in the same space for experimental demonstration dew to the imposed contact restrictions. This project showcases an experimental exercise toolbox for teaching building structures in Architecture. An essential aspect of learning about the performance of building structures resides in understanding the structural behavior of materials and structural systems under load [2]. Experiencing first-hand the deformation and failure of structural models is an important and, therefore, long-practiced, didactic exercise applied in architectural studies of higher education [3]. However, the online teaching and learning environment imposed by the global covid-19 pandemic has deprived architecture students of this crucial experience in their careers. Now hybrid teaching has become the norm for an unforeseeable future and makes it necessary to adapt, redesign and invent practical exercises that allow students to develop their cognitive skills in creating and understanding building structures.

Keywords: Structural Design, Hybrid Teaching, Experimental Learning, Empirical Cognition

Description of the Innovation

Following the 4th Industrial revolution, this toolkit devises practical exercises that allow students to develop their cognitive skills in creating and understanding building structures. This toolbox curated variety of tasks to induce an intuitive understanding of how loads, forces, and materials in building structures can be tested anywhere. The toolbox includes exercises such as listed below with examples of the students' work shown in Figure 1 and 2:

- Structural Yoga: a gymnastic exercise where students form a structure using their bodies.
- Structural Origami: a material exercise making use of origami paper folding techniques.
- Spaghetti Bridge: a structural exercise testing the strength of a self-build spaghetti bridge.
- TrussMe! [4]: a gamified exercise using an educational freeware app to test 2D structures.
- Mini Dome: a constructive exercise designing, building and testing a geodesic dome at home.

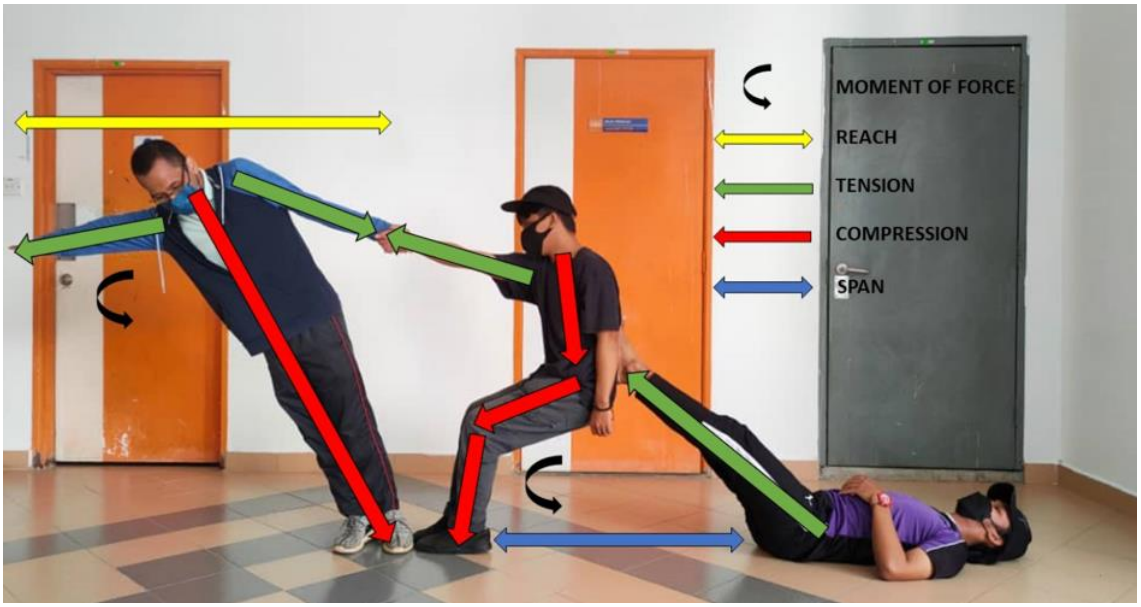

Figure 8: Structural Gymnastics practical exercise tested by architecture students.

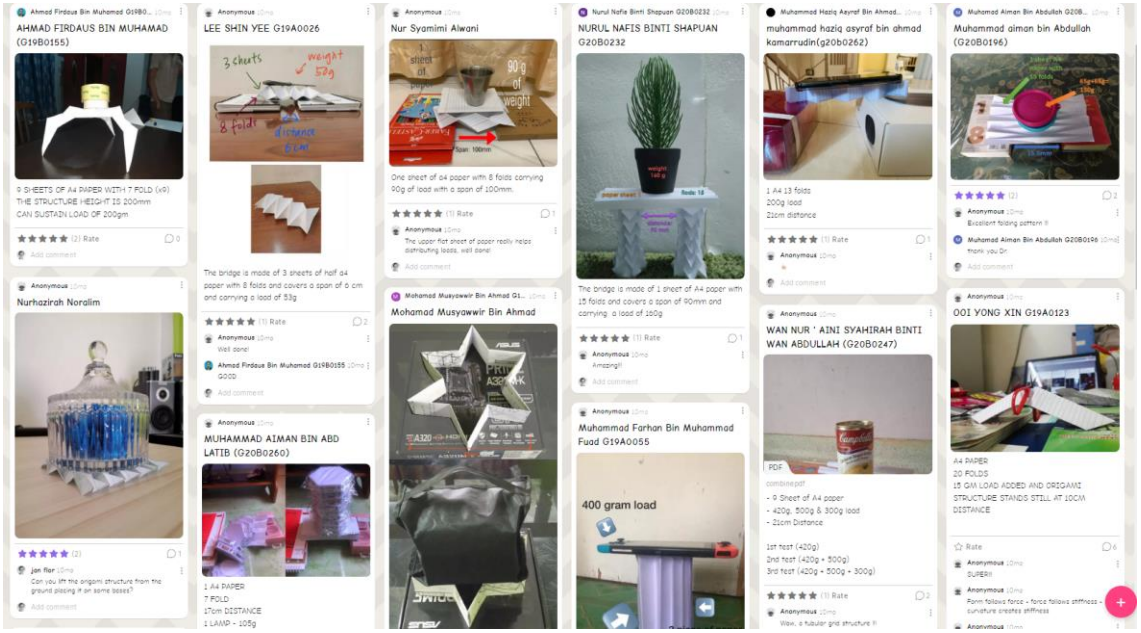

Figure 9: Structural Origami exercise student projects displayed on a digital platform.

Significance of the Innovation

The significance of the developed toolbox consists in the potential of providing architecture students in a hybrid teaching setting with learning tools that allow in a self-taught manner exploring the structural behavior of building systems. The exercise toolbox has been applied and tested in hybrid learning environments in 2021 and 2022 in class and online. Evaluation of the exercise results showed evidence that the tasks achieved the objective for intuitive understanding of loads, forces, and materials in building structures. Together with the overall goal to instill an experimental and investigative attitude in architecture students through hands-on exercises, the toolbox empowers students to be experimental in their learning, regardless of the absence of a classroom or lab.

Impact of the Innovation Towards Education

The primary impact of this toolkit relates to students' enhanced learning experience and deepening of understanding of building structures in a hybrid learning context, where learners are deprived from in person instructional teaching settings. The impact on the learning experience was measured on a pilot group of students (n=29) from year one, two and three of a Bachelor of Science in architecture, at the Universiti Malaysia Kelantan, self-reporting overall positive influence of the toolbox exercises on their learning performance. An outtake of the collected data is shown in Figure 3. Personal reflections on experience with the toolbox exercises supported the results:

Student A: *"This course [toolbox] helped me understand more about the construction structure of a building. At the same time, it really helped me to use the knowledge I gained for my design and in later work."*

Student B: *"I learn how to make a structural design so that I can learn about the design of the structure clearly. With this workshop [toolbox] I can improve my design after this."*

Student C: *"I learned about structure building using right material."*

Student D: *"I learn about the structure of the building, learn about the load of the structure and how to strengthen the structure."*

Figure 10: Student Self-reported learning outcomes with toolbox contribution to learning.

Commercialization Potential

With the potential for future developments and commercialization it is hoped that this toolbox can become an essential part of the exercises deployed in the technical area of architectural study curriculums. A purchasable online program in the format of a mobile or web app distributed at scale among national and international institutions dedicated to teaching architecture is seen as viable development that could be exploited commercially.

Conclusion

Applied exercises in architecture for enhancing structural understanding have a long tradition in higher education. However, these exercises have not been collected in compiled set curated for online or remote hybrid learning settings. The developed toolbox has been applied and tested in realistic learning environments in 2021 and 2022 at the Faculty of Architecture and Ekistics, Universiti Malaysia Kelantan during the COVID-19 pandemic. Evaluation of the exercise results combined with students' feedback showed evidence that the exercises achieved the objective of helping to induce an intuitive understanding of loads, forces, and materials in building structures. The main conclusion that can be drawn is that the experimental learning experiences assisted enhance architecture students' understanding of building structures. And it implies that for hybrid and online learning environments traditional architecture class exercises require a specific adaptation and new approaches. Potential for future work and developments is seen in designing a scalable online learning program around the toolbox that can be exploited commercially or serve as an open-ended educational exercise.

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TrussMe! http://www.scientificmonkey.com/software.html (last accessed, 2022)

"Innovating Education for a Better Tomorrow" is an e-proceedings which presents evidence from in-class and out-of-class settings that reflect e-learning values as a medium for advancing student learning. The 163 papers presented showcase the dynamic culture of innovation in e-learning within the teaching-learning landscape in higher education and schools. This e-proceedings are intended for individuals with vested interest in e-learning. It is the aim of this e proceedings to provide a resource to help readers gain insights into e-learning content and innovations, and to inspire readers to recognise developing prospects for genuine innovation perspectives.

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