

The Effect of the Application of Feedback and Reflection on an Iterative Student Design Challenge

Mrs. Andrea Atkins, University of Waterloo

Andrea Atkins is a lecturer in Architectural Engineering at the University of Waterloo. Previously, she was a structural designer at Blackwell Structural Engineers in Toronto.

Alison McNeil

Dr. Rania Al-Hammoud, University of Waterloo

Rania Al-Hammoud is a lecturer and the current associate chair of undergraduate studies at the civil & environmental engineering department at university of waterloo. Dr. Al-Hammoud has a civil engineering background with research focusing on materials and the rehabilitation of reinforced concrete structures. She also has passion for engineering education and has published widely in this area. She cares about the success and well-being of her students, thus always being creative with the teaching methods in the classroom.

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Abstract

In its fifth year, the Architectural Engineering Design Days challenge at the University of Waterloo (UW) returned to a fully in-person format in 2022. The event has evolved after being online in 2020 and hybrid online/ in-person in 2021. For the first time last year, instructors have integrated a second phase of the design challenge into a studio course. The two-phased version of the challenge has provided an opportunity for the authors to study the student work developed before instruction, and the influence of design critiques and feedback on the results of the second phase.

The Design Days challenge for 2022 was for students in groups of 4 to design a piece of outdoor furniture for a given site on campus. Student teams were tasked with building a full-scale working mock-up of their design using limited supplies. At the end of a 48-hour design sprint early in the term, student teams presented their mock-ups to panels of professors and industry guests to receive feedback.

One month later, the project was reintroduced to the same groups of students, but this time integrated into a design studio course. As part of the introduction to the second phase of the design challenge, the instructor presented a lecture on universal design. Students received two weeks of design development time, and two sessions of instructor and TA (Teaching Assistants) feedback to advance their design during the second phase. The final products of the second phase included updates to the original concepts in terms of design and construction, but also considerations of diversity in user experience.

In this paper, the authors review the improvements made to the Design Days Challenge as it returns to an all in-person event. Also included is an overview of the perceived advances in project results from phase 1 to phase 2 from the course instructors. Most importantly, the results of a student survey will share the students' reflections on the modifications they made to their projects based on the receipt of feedback and course instruction during phase 2 of the Design Days challenge.

Introduction

Engineering design is an important aspect in STEM education [1]. Students need to have the ability to integrate knowledge from several courses during their undergraduate education to learn to implement a successful design [2]. Unfortunately, engineering courses are normally taught in silos, not allowing students to visualize the complete aspects of a design [3]. Their designs are also normally assessed based on the aspects related to the specific course in which the projects are being implemented. It is not until their final year when engineering students compose their final year projects that students are encouraged to connect information from different courses. There is the need to encounter similar design projects and challenges earlier in a student's education to help their learning process. Design Days have done that and have been proven to aid students' learning in this goal [4] [5] [6].

The University of Waterloo's engineering design days organized by many UW engineering faculties, engage participating students in unique collaborative challenges that utilize approximately two days of class time. Inspired by the hackathon model, these 'days' present

specialized problem-solving challenges to undergraduate engineering students. The challenges are intended both to enhance their learning while additionally encouraging them to experiment and apply a wide range of knowledge and concepts in the hands-on development of creative solutions [7]. These challenges given outside of the classrooms enables freedom from academic pressures as often there are no grades attached to these events¹. The University of Waterloo (UW) began implementing design days in 2015 first in the mechatronics engineering program [8] [9], after which this methodology grew to include all fourteen engineering programs at University of Waterloo to impact nearly 10,000 students to date. Depending on the program, the design days may be conducted during the first, second, or third year, but across all of them they work so that by the time students reach their final year, they have experience in integrating knowledge from many sources into a single design project.

Background

Since 2018 the Architectural Engineering program (AE) at UW implemented design days for first year students. Design days were spread over two days at the beginning of the term for AE students. During these days, students were placed into groups of 4 for a series of events and challenges. Most AE design days have challenged groups to draw, design, and fabricate site-specific structures that function as indoor or outdoor furniture. In the first two iterations, 2018 and 2019, the students had to design, build, and test an actual size furniture piece that they had to integrate within a defined space on campus [10]. With the goal of encouraging students' engagement in their own learning process the events were deemed successful. In 2020, AE design days was adjusted and switched online due to COVID. In this adjusted event students were teamed with upper year students to create a 3-D computer model [11]. New learning and experimentation were encouraged both in digital modelling, as well as adapted physical modelling. The teaching team adapted physical modelling guidelines by choosing materials that were readily available at home for this task. This was done with special consideration that these models were completed individually rather than in groups, and under diverse work-at-home conditions, in some instances in different countries and time zones. In 2021, AE design days was conducted in a hybrid model due to unique COVID restrictions. The AE design days challenge returned to building a site-specific furniture piece, with in-person students teamed up with online students, the event made sure that safety guidelines and distancing due to COVID were met in this instance.

In 2022, AE design days activities returned to a fully in-person model, complete with design-build-test phases for the furniture pieces alongside other tangential activities. 2022 also marked the year that the AE design day challenge was blended into the first year design studio course through an iterative design approach. Each groups' final furniture design from design days was carried forward as a 'first edition' of a studio project later in the term. This is important to note as previous design days events were stand-alone events and missed a critical opportunity for the students to reflect on their learning and improve their designs. While this dual change of being

¹ While AE has never given out grades based on the work produced during Design Days, there have been occasions in other engineering programs where a participation grade was awarded.

fully in-person once again, and the planned integration into a design studio project marks 2022 as unique to the previous years, it benefitted greatly from the design days immediately preceding it.

The first benefit from previous AE design days' online and hybrid activities was the addition of multiple published documents, such as schedules, instruction guidelines, and location maps to make the day's plan clear to students. This stemmed from the online experiences in 2020 where due to the fully online format it was easy to quickly share documents and announcements to a collection of students, but reception of messages in a digital 'room' of students quickly presented as unreliable due to individual notification settings and the unpredictability of students' behaviours. The more structured documentation from 2020 was used as a starting off point for authoring the documents for 2022 and will continue to form the foundation of our documentation for years to come. This benefit, however, was not seamlessly felt when in person. A limitation of this structured documentation strategy was that once in-person, these highly detailed handouts were multi-page paper documents. Documents which students seemingly found inconvenient as dozens of handouts would be found discarded shortly after students received them. However, it was also evident that a fully digital document would be similarly impractical as the team did not want to have students standing around trying to read full sized PDFs on tiny phone screens. In 2022 a compromise was implemented where a few copies of the handouts were printed and placed in identified locations around the room, as well copies of the pertinent parts of the handouts were projected on the wall during activities. This compromise was workable but could use more development in future events.

The second benefit of our online and hybrid experiences was our ability to pivot quickly and adapt to change. During the 2022 AE design days, some groups of students decided to discontinue participation in the planned activities, as attendance was not mandatory with design days being a voluntary event. Although one planned activity required students to compete head-to-head with another team, this activity was reasonably and quickly adapted to be a timed activity instead and further met its goal encouraging teamwork and excitement of competition. The comfort level of the design days team with this adaptation was significantly fortified from experiences in past years and the near-constant adjustments required in online teaching and learning.

Rationale

As established, 2022 was the first year AE design days was utilized as a first round of design for a studio design project. It evolved from a project completed before their studio classes commenced to kickstart their first design project in their first AE design studio. This is done with the goal that the common first year design experiences of "too much too fast" would be alleviated as a large part of the first attempt at design is already completed. Further, students benefit from getting a first round of critique sessions during design days thus reducing much of the intimidation that the studio critique model imposes. While they are tasked to redo and modify their project, they are given more guidelines, and since it is at later point in their first term, students then understand the set expectations of the design process. This model helps students to better understand outlined project deliverables as they have done it once before in the low stakes

environment of design days. This allows students to focus on their learning and implementation of better design practices and considerations.

Not only does the re-use of the project in design studio introduce students to the structure of solving a design problem, it also offers opportunity for increased iteration in design. The iterative design process has been proven to improve the learning experience of students. It helps target the areas required for improvement and allows students to visualize where they can improve in their design [12]. “An iterative design process includes initial design, analysis, evaluation and redesign.” The idea is to come up with the “best” design at every stage of the iteration in order to achieve the “best” final design [13]. Iterative design will help reinforce learning for complex problems, as it will allow students to learn one new thing every iteration until reaching the ultimate design wanted [14]

Design/Project

PHASE 1

During AE design days, design development conducted by the groups during the short timeline is accelerated by meetings between the groups of first year AE students and volunteers, which consist of upper year AE students and UW faculty, helping to guide the design process (Figure 1). The final structures are designed and built using informal materials, some of which are provided in a ‘base set’ while additional materials are ‘bought’ with tickets earned throughout the multi-day event. Tickets are earned over the course of the ‘days’ events in many smaller mini challenges which are conducted in addition to this larger design challenge. The smaller events consist of a wide range of challenges such as TriviAE, a ScavAEvenger Hunt, and a ObstacAEle² Course. These events are arranged to foster teamwork, promote learning more about the university, and, most importantly, distribute tickets. While simple participation in these events earn tickets, the top placing teams win additional sets of bonus tickets. These tickets are used during the construction phase of the larger design challenge to buy additional materials beyond the base set provided. Teams are warned of limited materials early on, promoting excitement amongst student to earn as many tickets as possible from as many avenues possible.



Figure 1 Feedback from UW faculty on one of the designs

² The smaller event name all including some form of AE pun into the otherwise familiar events of trivia, a scavenger hunt, and an obstacle course.

The primary AE design days activity was, as previously outlined, an accelerated design-build-test project with limited supplies and limited construction time. The base set of materials included standard-issue 1" thick cardboard panels and packing tape, but teams who earned large amounts of tickets were able to 'purchase' more materials including 1/4" thick cardboard pieces, 2" thick cardboard pieces, 1/4" foamcore, twine, 2" and 4" diameter cardboard packing tubes, and coloured duct tape. The construction of the team's designs with these materials was completed in a large workshop-like space over the course of two days (Figure 2). Students using exacto blades were permitted to cut only the 1/4" thick materials, while staff, faculty, and graduate students used specialized tools to cut the thicker or round materials. The rapid nature of the construction phase and the withholding of glue lead to some interesting connection designs and construction methods. The material availability or lack thereof also contributed to some unexpected design changes in the last moments of the build session.



Figure 2 Building stage of the design days

On the final day, the final furniture mock-ups were tested and presented by student users, where the majority of the designs could support their intended occupant load (Figure 3). During the presentations, groups presented to a panel of guest reviewers consisting of industry professionals and UW faculty (Figure 4). This acted as likely the first time these students had ever received a

design critique³, and specifically done in an environment free from perceived academic pressure or the formality of the classroom. Separate from academic impact, the collected review panel scored presentations over the course of these critiques. The day concluded with these scores being collected, tallied, and following closing remarks, prizes and AE ‘swag’ were presented to the winning design teams.



Figure 3 A group presenting their furniture piece while one of the judges is sitting on it



Figure 4A group presenting in front of judges consisting from industry professionals and UW faculty

³ **Design Critiques (Crits)** common in architectural education worldwide, occur as the final opportunity to present a design project to a panel of experts and receive instant feedback on it. Drawings, models, and any supplementary evidence are organized and presented to a panel of professors and guest critics who in turn provides instant feedback in the form of comments, questions, and critiques of the presented project directly to the student.

PHASE 2

Phase 2 of the site furniture project refers to its incorporation into the studio curriculum. It is important to note that prior to 2022, the AE design day events were stand-alone events thus missing out on a key opportunity for the students to engage with an iterative design process by reflecting on their learnings and improve their designs. Used as a jumping-off point for a studio project, students were asked to re-work their designs building from the guidance received from the design days critiques and final presentation reviews. Students who had elected not to participate in the 2022 AE design days simply didn't benefit from this experimentation and began their designs from scratch. In the studio project, additional guidelines, guidance and reviews were conducted throughout the term, resulting in an overall learning experience where students were able to apply reflections from many stages throughout the term.

The biggest difference between how the students began their designs in Phase 1 (Design Days) and continued the designs in Phase 2 (the course project) was that materials were no longer limited in quantity or availability, and a 1:1 mock-up was not required in Phase 2. The students used their Phase 1 mock-up as a first iteration and adapted their concept to be potentially fabricated from something that was appropriately durable for outdoor use. Considerations of fabrication methods were no longer key to the project overall, though some groups elected to include it as a key design focus and then became central to those specific designs (Figure 5 and Figure 6).

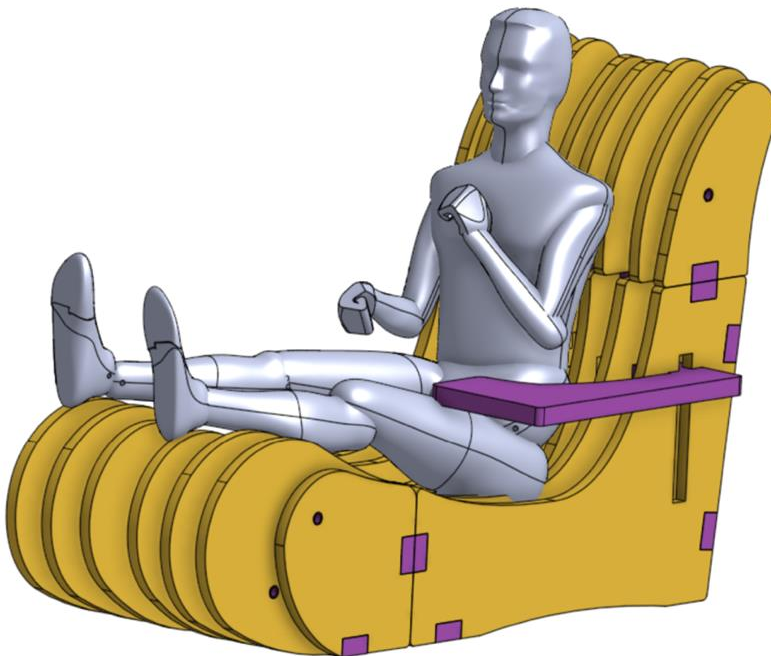


Figure 5 Front view of the improved final design

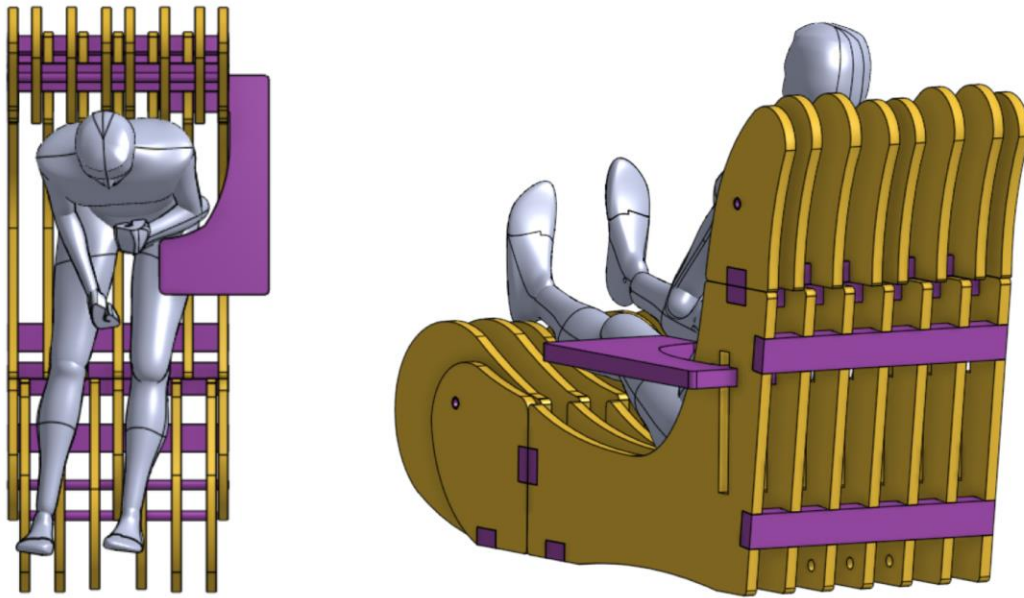


Figure 6 Top and side view of the improved final design

Results

The choice to re-visit the design days project as a studio project provided the teaching team with a head-start at the iterative design process. Due to time constraints, students would have limited opportunity to iterate on their initial designs for a project if it started from a blank slate during the studio course. By implementing the site furniture design project instead as a “phase 2” of the design days project, the students started off not only with a first draft of a design, but also a mock-up, experience with how challenging the fabrication would be for that first design, and the feedback from their final presentations at the end of design days. The instructors felt that this was an opportunity not to be missed.

The anticipated timesaving in using the design days projects as a first draft for the design was easily implemented. However, the perceived benefits to the teaching team were negated by the number of students who were uninterested in revisiting a previous design. There were students who wished to change their groups since they had made new friends, or their design ideas, especially after having several weeks of course experience which they felt made them better designers. It was expressly communicated to students the intention of a “phase 2” of the design days activity was to accelerate the initial brainstorming time required in the course project. This conflict between professor intention and student frustration was not anticipated and seemed unavoidable if “phase 2” was to indeed use the design days project as a spring-board.

The benefit of having a mock-up of their design days project and the experience learned from trying to build that mock-up out of cardboard and tape did not have as much of a benefit as was expected. With the expectation of fabrication materials changing to durable structural materials from the cardboard and tape of phase 1, most student groups changed their designs so much that

they no longer referenced their initial mock-up. There were some Phase 1 projects that were intentionally fabricated to limit the use of tape, using slotting or fitted joints- sometimes these methods of joining materials no longer made sense in the durable structural materials and so this reference was abandoned.

The uptake of feedback from presentations during the final presentations at design days was considered a success by the instructors. Having that one additional round of feedback to kick start their next phase of work both made the final presentations of design days more meaningful, but also gave an even larger pool of voices to the feedback loop beyond the teaching team. Similarly, the addition of in-class critiques for phase 2 with instructors and teaching assistants gave students more material for the editing, improving, and correction of their designs. It was critical that student groups received feedback directly from the teaching team for phase 2 since this would be a graded project for the studio course.

Lastly, the influence of the weeks of course instruction between design days and the start of phase 2, including material covering universal design and user-centred design undoubtedly had a positive effect on the design decisions of students during phase 2. Many student projects were more considerate of the diversity of user experience, size, and physical ability than were seen at the conclusion of phase 1. These results were simply based on exposing students to the concepts of universal design – there was no mandatory requirement that the project had to be inclusive, nor any criteria in the grading that would benefit a more accessible design. In terms of visual communication, the manual orthographic drawing and AutoCAD instruction that students had received between the two phases allowed groups to better express their complete ideas in drawings since there was no mock-up requirement in phase 2.

Student Survey Results and Analysis

At the end of the AE studio course students were asked to review the overall course in a survey, with the goal feedback would be used for future course improvements. This survey covered each assignment from the course, including the site furniture project. An optional written section in the survey provided direct reflections from the students. The following section presents selected comments followed by relevant measured survey responses. They have been selected and grouped from the overall course responses for their relevance to the measured responses of the survey, mentions of the site furniture project, or relevant grievances.

Repeated Work

“One thing I wish was different was the site furniture project, as it felt like we did the same project twice after design days, and I would have rathered design something new, with a new group.”

Group Difficulties

“... Aside from that, after design days, lots of groups had an understanding that they may not mesh as well with the people they were in a group with. To have to work with the same individuals for site furniture was a little difficult, especially when it was fairly clear that reaching a fair ground with said individuals was difficult...”

“... One thing I'd change is the "choose your own groups" for the Tiny Retreat. Groups should be assigned. Towards the end of the term, I felt as though the program became clique-y and most people stuck to their Tiny Retreat groups.”

Program specific AutoCAD:

“...things that came to mind to improve on are...making sure AutoCAD assignments are in line with assignments as the orthographic site furniture CAD made us learn everything before the AutoCAD lecture...”

“...Also I felt that the AutoCAD assignments would have been better if they were always regarding a particular part of a project we were already working on...”

“...The site furniture autocads were hard to page plot and were taught the week after the assignment was due. Plus it was hard to coordinate especially over the [reading week] break making it quite hard to keep all the cads consistent without one person feeling overwhelmed”

“I did not however like how the site furniture project was set up. By the time deliverables were to be submitted, I did not think that the autocad assignments (the lecture style for autocad is not the best way I think we could've learned) equipped us well enough to complete it in the best way we possibly could have...”

“How well did each deliverable contribute to your overall learning in AE100? (How much did you learn):

5 - Very Well 4 - Fairly Well 3 – Somewhat 2 – Slightly 1 - Not at all

Site Furniture Project



Fig 1. AE 100 exit survey response site furniture Learning

“How satisfied were you with the following projects? (How much did you enjoy them):”

Site Furniture Project

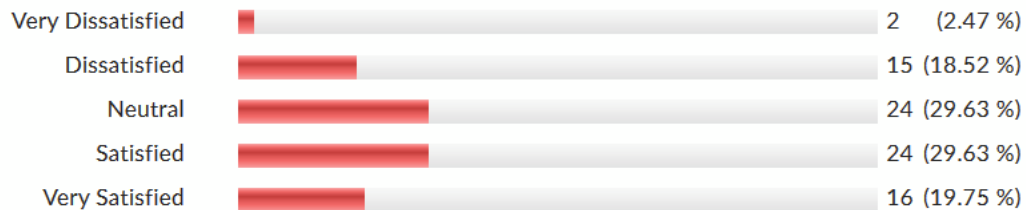


Fig 2. AE 100 exit survey response site furniture satisfaction

When compared to results for the other projects, such as the Tiny Retreat project, these measurements fall short and reflect the sentiments of the written responses. Which isn't to imply all responses were targeted towards the site furniture project, nor were they all negative. Overall, most of the comments received were in line with previous responses to a design studio. There were frustrations of contradicting design guidance, dense lecture material, and an overall enjoyment of desk crits but difficulty with deliverables. As above, what was specific to the site furniture frustrations were difficulty with technical knowledge of AutoCAD within the timeline of the course, interpersonal difficulties with group work, and some annoyance revisiting their previous design day design and groups.

Overall, the studio teaching team had perceived the use of the design days exercise evolving to a studio project to be successful in the goal of accelerating first year design students' experimentation and exploration of design. A large part of this perception stems from the diverse results of the exercise displaying students' creativity in a space that had alleviated significant pressure by initiating design in an informal setting. One hypothesized reason for this discrepancy between the teaching team's perceptions and student experience is interpersonal in nature and originating from the initial groupings. For the 2022 AE design days, as in previous AE design days, the students did not explicitly select their own groups but instead were grouped together quickly in an informal method. These initial somewhat random groupings created a wide range of cohesion within groups from those that presented visible frictions, though these were a small number, to those that appeared united and happy. This is in line with continued difficulties of creating groups in academic settings and may need to be reviewed for the next iteration of design days.

Future Work

As seen in the results of this paper, there were both successful and unsuccessful aspects of this two-phase version of design days. At the discretion of the instructors of the first-year design studio in subsequent years, this version of design days could continue to develop as a benefit to student outcomes beyond those of previous years. Based on the less successful aspects from 2022, as evidenced by instructor and student perceptions, improvements can be made, both in terms of design innovation and student experience.

The constraints of material scarcity and structural capacity bred invention and creativity in the design days phase of the project. However, this was lost in phase 2 when the materiality opened up to more structurally sound materials for outdoor permanent site furniture. Considerations of materiality no longer were about what was available, but still had to be appropriate for an outdoor, public space. Because of the reduction in material constraints in phase 2, the finished projects more closely resembled products that are readily available on the market than novel designs. An improvement to the second phase would be to implement some additional constraint to maintain that innovation from phase one. This could perhaps be a limit on budget- though this will require more resources to teach students about material and fabrication costs. This could be an additional rule which limits the space that the furniture occupies- maybe a maximum length of material or a maximum weight, or a flat-pack-only requirement. And lastly the additional constraint may be something entirely new like a requirement that the furniture must perform at

least 2 different uses or it must transform, or be able to be easily stored indoors for winter. All these potential improvements assume that the results of phase 2 in 2022 would be improved if there had been more constraints, however, it should be recognized that more constraints could create negative student perceptions and thus negate any intention to improve the project.

Finally, an opportunity for improvement in future years would lie in the realm of improving the student experience in phase 2. This may begin by better explaining the benefits of doing a second round of design on the same project as design days. By exposing students to the pedagogical intent of an activity, we may in turn increase student understanding. Alternately, we may give students the chance to re-design any of the student projects from phase 1, instead of limiting them to their own work. By shifting the focus from their original design we are also able to change the group formations which should relieve the majority of the negative responses to phase 2. The benefit of kick-starting phase 2 with a first draft already completed would remain, but the benefit of iterating based on feedback received at the end of phase 1 would be lost in this proposed improvement. It is possible that students may have witnessed the feedback that another group received at the end of phase 1, but it is unlikely that this will be consistent enough across the class to guarantee the application of that first phase feedback. More consideration is required, coupled with further discussion with the student participants to gauge their perceptions of these potential changes.

Conclusions

The AE design days event of 2022 was considered a success by both students and volunteers. The coordination of the event was greatly benefitted by the previous years of design days and was able to gently introduce students to engineering design and project critiques without the pressure of grades or academic performance. The integration of the design days project into a site furniture design project within the first-year design studio course took advantage of some perceived pedagogical opportunities and resulted in some unexpected findings. Based on the 2022 student and instructor perceptions, the design days project will continue to be improved in coming years, with special attention being paid to group dynamics as well as greater student exposure to pedagogical intent and the desired project learning outcomes.

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