The Evolution of an Interdisciplinary Case-Based Learning First-Year Course

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1. Introduction

The current era is marked by an increased demand for employees and entrepreneurs with skills that cut across domain and disciplines, such as creativity and systems thinking [1-3]. Developing these skills in students of undergraduate science, technology, engineering, and mathematics (STEM) remains challenging [4], and many STEM graduates in the US remain underprepared for the current requirements of STEM professions [5]. Moreover, the academic achievement levels of students rarely correspond to their levels of achievement in these domain-agnostic skills [6]. As a result, many education bodies have recognized the need to make changes to STEM curricula and pedagogy in higher education [2,7,8].

The response to the pandemic, which became global in March 2020, has led to the largest disruption in higher education history, with an estimated 90% of the world's student population affected [9]. Studies have shown that most institutions worldwide were either completely or mostly closed in the second half of 2020, with in-class instruction replaced by remote learning [9,10]. Curriculum and in-class instruction had to adapt to various pandemic-related policies, such as remote or hybrid learning, depending on the situation and context [11]. These changes have caused disruptions, but also offered opportunities for experimenting with new teaching approaches utilizing information and communication technology [12]. Indeed, the emergency remote teaching experience also provided flexible learning possibilities and opportunities for instructors to explore different modalities such as hybrid or blended learning and various technologies for remote teaching [9,10,13].

In this paper, we describe how we conceived, designed, implemented, and reiterated a first-year course for a science, technology, engineering, and mathematics (STEM)-centric university, and offer an overview of the outcomes of each iteration of the course, and of the course as a whole. The course began in fall 2020 as a fully remote offering at the height of the COVID-19 pandemic. The course focused on fostering problem-solving skills through case-based, active learning of interdisciplinary case studies.

We begin this paper by providing a short overview of the undergraduate program with which the course is affiliated. We go on to provide theoretical background on the pedagogical approach of case-based learning and its application for teaching thinking skills in [Course]. The next section is the central one of this paper, as it covers the evolution of the first-year course from its launch in fall 2020 through fall 2022. We conclude with a discussion of the lessons we learned and the insights we gained from our experience with the course, our plans for the fall 2023 iteration of the course, and suggestions for instructors and course designers.

2. [Interdisciplinary Undergraduate Program]

[Program], hereinafter also referred to as [IUP] (interdisciplinary undergraduate program), was launched as a pilot program in 2017, as an answer to [University]’s efforts to reimagine undergraduate engineering education. An extra-curricular, cross-departmental endeavor with a focus on integrative, project-centric learning, the program aims to cultivate the essential skills, knowledge, and qualities engineers of the future will need, to address the formidable challenges posed by the 21st century. As of fall 2022, the program has 262 registered students across sophomore, junior, and senior years at [University].

[IUP] was conceived and developed based on four core principles: 1. Student education should focus on preparation for developing new technologies; 2. Student education should prepare them to become makers and discoverers, with engineering fundamentals applicable to both research and in practical careers; 3. Student education should be constructed around the way students learn best and must be both effective and engaging for the current era; and 4. Student education should empower them to think more effectively and learn more effectively by themselves.

The principles of the program are realized through the program curriculum and pedagogy in the following ways: Students in each thread learn how to assemble, operate, design, and test new technologies. Students engage in interdisciplinary R&D in cross-departmental teams, including hands-on project work, applying state-of-the-art methods and technologies. Thread instructors apply a variety of pedagogical approaches and instructional tools, and students from different departments/majors work with and learn from each other by collaborating on scientific research and engineering design projects.

Unlike most undergraduate non-degree academic programs at [University], [IUP] is both multi-year and cross-departmental, allowing students to collaborate on interdisciplinary projects of increasing complexity. These two features of [IUP] help students acquire the required skills in their chosen track. The program is voluntary and is not a degree program or major or minor as offered by the [University]; students joining the program get a certificate.

More information on the program and its history can be found in various publications [14-20].

3. Teaching Thinking Skills with Case-Based Learning

Case-based learning (CBL) is a student-centered pedagogical approach that makes use of specific occasions or ‘cases’ to contextualize the learning of discipline-specific knowledge. CBL originated in professional education, specifically in medicine, business, and law [21] and has since also been applied in science and engineering education [e.g., 22,23].

CBL helps students develop conceptual understanding and thinking skills as they work through and reflect on the process of solving cases [21]. Working on cases in groups can also facilitate the development of students' interpersonal skills [21,24]. Implementations of CBL vary by the degree of student autonomy (control) over their learning, from lecture-based on the low end to problem-based on the high end of student autonomy [25]. When afforded more autonomy, CBL affords students with active learning opportunities for application, reflection, and teamwork [26-28]. Studies in STEM education have shown that active learning facilitates students’ development of a wide variety of skills [29-37].

In [Course], instructors employ interdisciplinary case challenges to train students in methods, tools, and techniques related to problem-solving approaches, three of which were thinking skills: algorithmic thinking, creative thinking, and systems thinking, and one of which was a practical skill of casting and molding. Below, we provide working definitions for each thinking skill we employed in this course.

Algorithmic thinking is often referred to as a part of computational thinking, together with elements like programming [38]. Algorithmic thinking can be described as the ability to work through a well-defined problem to achieve a specified goal by articulating and combining sequential, conditional, and/or iterative operations in reference to data and events [39].

While no consensus exists regarding the standard definition of creativity, the two components of creativity which are most mentioned are novelty and usefulness. Novelty has been described by various terms, such as an idea being rare within a particular group [40], “uncommon” [41, p.478], or unique [42], while usefulness has been defined as utility, “adaptive to reality” [41, p. 479], effectiveness, or valuability [40,42].

In the context of engineered systems, systems thinking can be described as a skill or set of skills enabling the identification, understanding, prediction, and improvement of every aspect of a technological system: its outcome, function, structure, and behavior, and the way these aspects interrelate within the system [43,44].

4. Evolution of [Course] from Fall 2020—Fall 2022

At the [University], first-year students get to explore their academic interests through a special category of exploratory classes, which the course is registered under. These exploratory courses are not graded (pass/no-pass) and are not part of the requirements for majors or introductory courses. Students can register for these courses and drop them halfway through the semester with no penalty vis-à-vis their grades sheet, i.e., it will not show that they have failed the course.

[Course] is a one-semester, three-hour-a-week (one hour of class), first-year course delivered at [University] since fall 2020. Author 1 has been the lead instructor for this course throughout its run till present, while Authors 2–6 and 8 were or are presently co-instructors in their respective sections of the course. Prior to fall 2020, there was a course under the same course ID which consisted of a series of talks introducing first-year students to the program followed by a question and answer session, with a few laboratory visits.

The newly designed course from fall 2020 onward offers students an opportunity to experience the various tracks of [IUP] while developing essential problem-solving skills. Students explore the various tracks of the [IUP] and learn to apply problem-solving approaches to interdisciplinary case challenges, practicing methods, tools, and techniques they can apply at [University] and beyond. [Course] helps expose students to [IUP]. It is also an opportunity for [IUP] instructors to pilot new curricula and pedagogy within the case-based framework of the course. This also helps the program’s efforts to share its educational experiments and developments with the education research community at [University] and beyond.

We next describe the course outcomes we focused on in this retrospective work. We follow with a detailed description of each iteration of the course, outline the outcomes for each one. For a discussion of (some of the) learning outcomes from [Course], see [45] and [46].

4.1 Course Outcomes

In this work, we discuss four outcomes of each iteration (semester) of the course:

1. CO1: Participation rate, calculated by the number of students attending the first class divided by the number of first-year students in [University].
2. CO2: Completion rate, calculated by the number of students who completed the course divided by those who attended the first class.
3. CO3: Submission rate, calculated by the number of actual submissions against the total number of possible submissions for the first assignment of its kind and for the last assignment of its kind, for each kind of assignment. We describe the various types of student assignments for each iteration of the course.
4. CO4: Application rate, calculated by the number of students who completed the course divided by the number of students who applied to [IUP].

Under 4.2–4.6, we detail COs 1-4 for each iteration of the course. Under 4.7, we discuss a fifth outcome (CO5), unrelated to a specific iteration of the course: educational publication rate, or simply ‘publication rate’, calculated by the number of publications describing a curricular or pedagogical development from the course. We have had such publications in 2022 for the first time. We also have publications which were accepted but not yet published in 2022. Under ‘publications’, we included any peer-reviewed papers, presentations (based on accepted abstracts or full papers), or workshops (based on accepted proposals). Students’ learning products and other student-generated data and responses were collected and analyzed with the approval of the [University]’s institutional review board for human subject experiments.

Table 1 summarizes the various iterations of the course from fall 2020–fall 2022 and figures related to COs 1-4 above. For participation rates, we used the figure for the number students who attended the first class of the course, because being a first-year exploratory course without an effect on the students’ overall grade, many students who register to the course end up not attending it at all and subsequently drop from the course register after a few days or a week following the first class.

Table 1. Details of [Course] iterations from fall 2020–fall 2022.

Semester	Number of other first-year exploratory classes available	Class modality	N students in their first year at [University]			
			Eligible to register to [Course][1]	*Participated in [Course]*	*Completed [Course]*	*Applied to [IUP]*
Fall 2020	12	Remote	1,457	61	54	14
Spring 2021	10	Remote	1,403	12	10	7
Fall 2021	14	In-person	1,340	23	14	5
Spring 2022	11	In-person	1,326	5	n/a	n/a[2]
Fall 2022	19	In-person	1,337	13	11	n/a[3]

[1] Since this is a one-semester course, students who completed the course in the fall semester could not register for it again. The overall number is therefore minus the number of students who completed the course in that academic year's fall semester.
[2] This iteration of the course was cancelled by the lead instructor on the second week due to very low enrolment and attendance.
[3] Applications to [IUP] class of 2026 are presently ongoing.

4.2 Fall 2020 Iteration: Remote delivery

In this section, covering the first iteration of [Course], we discuss the conception of the course, its design and delivery during fall 2020, and its outcomes.

Halfway through the Spring 2020 semester, [University] announced a complete shutdown of campus and a pivot to remote teaching. At the end of the same semester, Author 1 was tasked by [IUP] leadership to design a new curriculum for a three-unit pass/no-record course for all first-year students at [University], with the goal of introducing students to the [IUP]'s various interdisciplinary tracks.

Throughout the summer of 2020, Author 1 collaborated with other instructors in the [IUP]—Authors 3–6 and 8–on creating the course curriculum. The instructional team ultimately decided on a 'buffet' approach which consisted of two-week sections, each focusing on one track, one approach for problem-solving, and one or two case-related challenges to be tackled by students. As mentioned above, problem-solving approaches are one of the core principles of the [IUP]. The specific approaches selected were based on what seemed most appropriate to the lead instructor-track instructor pair.

As lead instructor for the course, Author 1 led its design and delivery. Each case study was designed with the respective track instructor. The course curriculum was designed to follow active learning principles, as described under section 1.2 above.

As a first-year course under the ‘exploration’ category at [University], the number of weekly hours for the course was the maximum allowed, which was three. The instructors divided these units into one hour of class at the start of the week and two hours of work outside of class following the class, with assignments usually due on the morning of next week’s class.

In fall 2020, Instructors delivered classes via the Zoom platform. Depending on the week, classes could include mini-talks by instructors to provide academic background and context for the cases, Activity assignments training students for the out-of-class Application assignments, and student team presentations of their work on Application assignments. The two hours out of class were usually dedicated to Application and Reflection assignments. Table 2 provides more details about the course assignments in fall 2020.

Table 2. [Course] assignments for fall 2020.

Assignment	Description	In- or out-of-class	Individual or team	N
Activity	Applying a method, tool, or technique learned in the lesson to a given challenge, and reporting using an online form. Used as training for Application assignments	In	Individual	9
Application	Applying a method, tool, or technique learned in the lesson to a given challenge, and reporting using an online form	Out	8 team 1 individual	9
Reflection	Filling out an online form with open-ended questions/items	Out	Individual	3
Questionnaire	An online form for evaluating understanding of lesson content	Out	Individual	4

As Table 3 shows, the course introduced students to five tracks and five corresponding cases, each with its own challenge and centered on a problem-solving approach. The two-week cases taught during weeks 2-9 followed a similar pattern, with the first class introducing the case and the last class involving student presentations and a reveal of the instructor’s solution to the case challenge. The lead instructor taught Week 1 on their own, and the one-week case was introduced without academic background or context.

Table 3. [Course] schedule for fall 2020.

Week/s	Cognitive approach [IUP] track Track instructor[1]	Case prompt	Problem-solving approach	Method, tool, or technique
1	Creative thinking	Generate ideas for career choice management by creating and using analogies	Generate analogies with the problem and use them for creative ideation	[Anonymized] Method [47,48]
2-3	Creative thinking Smart Cities Author 3	Frame a problem and generate ideas for walking dogs under social distancing rules, by uncovering and challenging implicit assumptions	Generate implicit assumptions about the problem and challenge them for creative ideation	[Anonymized] Method
4-5	Systems thinking Bioengineering Author 8	Design a microfluidic device for drug delivery experiments	Achieve an intended function and benefit for the device by designing an architecture for the device	[Anonymized] framework [46]
6-7	Systems thinking Renewable Energy Systems	Describe and improve the design of a solar-powered grill using the SAFO framework	Achieve an intended function and benefit for the cooker by suggesting modifications to its existing architecture	[Anonymized] framework [46]
8-9	Algorithmic thinking Autonomy and Robotics Author 5	Formulate a strategy (pseudocode) for a mini robot-car to search for balls on a grid	Design algorithms based on list of functions	Create pseudocode and improve with expert feedback
10[2]	-	-	-	-

Week/s	Cognitive approach [IUP] track Track instructor[1]	Case prompt	Problem-solving approach	Method, tool, or technique
11-12	Making Advanced Materials Manufacturing Author 4	Create a cast of a wooden figurine	Use materials from provided kit and follow instructions on a tutorial video	Molding with Alja-Safe™ and casting with Plaster of Paris

[1] Author 1 was present throughout the course as lead instructor.
[2] This week had no case and the class had only a panel of students from [IUP].

It should be noted that this course was particularly complex to design and deliver, especially when compared with a more traditional 'lecture and recitation' undergraduate course. This course involved six instructors, each one teaching a different topic with the lead instructor, students working individually and in teams, using a variety of digital technologies, and the creation and mailing of activity kits to students' mailing addresses for the last application assignment of the course.

To allow course students, whom we had to assume were novices in all the domains of the course, to take part in all the challenges, we had to either provide them with a short introduction to the domain and the central artifact of the challenge, like in the case of the bioengineering section and the microfluidic device, or decouple some of the technical aspects of the domain, like in the case of the autonomy and robotics section, in which we decoupled algorithmic thinking from programming by providing students with an algorithmic design challenge that did not require them to use any coding syntax. Instead, writing their search strategy in 'pseudocode' sufficed.

Attendance, completion, and application rates for this iteration of the course were 4%, 89%, and 54%, respectively (see Table 1 for numbers). Submission rates for this iteration of the course ranged from 67-100%. Table 4 shows submission rates for the different types of assignments in this iteration of the course.

Table 4. Submission rates for [Course] assignments during fall 2020.

Assignment type	Submission rate	
	First assignment	*Last assignment*
Reflection	Week 1: 100%	Week 12: 67%
Application (team-based only)[1]	Week 2: 95%	Week 8: 81%
Questionnaire	Week 3: 100%	Week 9: 72%

[1] These do not include the last Application assignment, which was individual.

4.3 Spring 2021 Iteration: Remote delivery

This iteration of the course had 11 instead of 12 weeks. The same co-authors involved with the fall 2020 iteration of the course were involved with this iteration. The course curriculum and schedule remained the same as for fall 2020, except for the introduction class (week 1 in fall 2020) which was removed from the syllabus.

Attendance, completion, and application rates for this iteration of the course were 1%, 83%, and 70%, respectively (see Table 1 for numbers). Submission rates for this iteration of the course ranged from 40-100%. Table 5 shows submission rates for the different types of assignments in this iteration of the course.

Table 5. Submission rates for [Course] assignments during spring 2021.

Assignment type	Submission rate	
	First assignment	*Last assignment*
Reflection	Week 1: 92%	Week 12: 40%
Application (team-based only)[1]	Week 2: 100%	Week 8: 100%
Questionnaire	Week 3: 92%	Week 9: 40%

[1] These do not include the last Application assignment, which was individual.

As mentioned under 4.2, data collected during this iteration of the course were included together with data collected from the fall 2020 iteration of the course. Studies based on these data have been published [45,46].

4.4 Fall 2021 Iteration: In-person delivery

This was the first in-person iteration of the course. Weekly classes took place in a large (~40 capacity) audiovisual display-supported classroom arranged in rows of long, fixed desks. As per institutional regulations, students and instructors wore masks at all times unless speaking. Every student and instructor were allowed to keep their masks on or take them off while speaking.

The course schedule and assignments and schedule were the same as in fall 2020, except for a new synthesis activity in week 10, which replaced the [IUP] student panel from the previous iterations. This activity presented course students with the challenge of producing a way of advising students on their career choices, using creative and systems thinking tools and techniques taught previously during the course.

Author 6 joined the course instructional team as track instructor for a new Environmental Systems track which subsumed the program's two previous tracks, Renewable Energy Systems and Advanced Manufacturing and Materials. Author 3 was no longer an instructor on the course, replaced by a member of faculty and track lead for Smart Cities.

Attendance, completion, and application rates for this iteration of the course were 2%, 61%, and 36%, respectively (see Table 1 for numbers). Submission rates for this iteration of the course ranged from 64-91%. Table 6 shows submission rates for the different types of assignments in this iteration of the course.

Table 6. Submission rates for [Course] assignments during fall 2021.

Assignment type	Submission rate	
	First assignment	*Last assignment*
Reflection	Week 1: 91%	Week 12: 64%
Application (team-based only)[1]	Week 2: 91%	Week 9: 71%
Questionnaire	Week 3: 87%	Week 10: 64%

[1] These do not include the last Application assignment, which was individual.

No publications resulted yet from this iteration of the course.

4.5 Spring 2022 Iteration: In-person delivery

Author 2 replaced Author 3 during this iteration of the course. We canceled this course in the second week due to very low registration numbers: five students attended the first class, and only two attended the second class.

4.6 Fall 2022 Iteration: In-person delivery

This iteration of the course happened to have 13 rather than 12 weeks. A new assignment was created for this iteration—Preparation, taking the place of the Questionnaire assignment from previous iterations. Preparation assignments included two components: an online document which introduced a problem-solving approach (algorithmic, creative, or systems thinking), and a follow-up questionnaire like those included in previous iterations of the course. Students were asked to submit Preparation assignments before class on weeks 1 (approaches to problem-solving), 2 (creative thinking), 3 (algorithmic thinking), and 4 (systems thinking). Thus, this iteration of the course included three types of assignments: Preparation (four assignments), Application (thirteen), and Reflection (five).

Participation and completion rates for this iteration of the course were 1% and 85%, respectively (see Table 1 for numbers). Applications for class of 2026 have not opened yet. Submission rates for this iteration of the course ranged from 50-100%. Table 7 shows submission rates for the different types of assignments in this iteration of the course.

Table 7. Submission rates for [Course] assignments during fall 2021.

Assignment type	Submission rate	
	First assignment	*Last assignment*
Preparation	Week 1: 92%	Week 5: 100%
Reflection	Week 1: 92%	Week 13: 50%
Application (team-based only)[1]	Week 2: 100%	Week 11: 100%

[1] These do not include the last Application assignment, which was individual.

The materials from this iteration of the course are presently being adapted for storing and sharing in full on an open, public-facing platform operated by [University]. In this way, all the course materials will be available to any instructor with access to the World Wide Web.

4.7 Publication rate

Table 8 shows the publications resulting from the educational experiments and developments taking place during one or more iteration of the course.

Table 8. Peer-reviewed publications, presentations, and workshops resulting from [Course].

Citation and year	Type	Description
[46] 2023	Paper published in an engineering education journal	an initial validation of the [Anonymized] framework for teaching assessing systems thinking in first-year engineering education
[49] 2022	Paper presented in an international online conference	Teaching creative problem-solving in urban science education
[50] 2022	Online workshop conducted in an international hybrid conference	Teaching and assessing systems thinking in first-year engineering education
[51] 2022	Workshop conducted in an international hybrid conference	Teaching analogical reasoning for creative problem-solving in undergraduate engineering education
[52] 2022	Workshop conducted in an international conference	Teaching analogical reasoning for creative problem-solving in undergraduate engineering education
[53] 2022	Workshop conducted in an international conference	Teaching and assessing systems thinking in first-year engineering education
[54] 2022	Workshop accepted for an international conference in 2023	Teaching analogical reasoning for creative problem-solving in undergraduate engineering education
[55] 2022	Paper accepted for presentation in an international hybrid conference in 2023	Teaching analogical reasoning for creative problem-solving in undergraduate engineering education

[56] 2023	Paper published in a science and technology education journal	A proposed pedagogical framework for fostering creative thinking with case-based learning

4. Discussion

5.1 Conclusions

We can draw some conclusions based on participation, completion, submission, application, and publication outcomes of the course.

5.1.1 Participation

We identified a pattern of a decreasing number of students attending the first class of the course from fall semester to fall semester (from 61 in fall 2020 to 23 in fall 2021 to 13 in fall 2022). This decrease coincided with the move from remote teaching in fall 2020 and spring 2021 to on-campus teaching from fall 2021 onward, and with the increase in the number of other first-year exploratory classes being offered, from 12 in fall 2020 to 14 in fall 2021 and 19 in fall 2022. Being back on campus on fall 2021 also afforded first-year student with many more extracurricular opportunities when compared with fall 2020 and spring 2021.

We also noticed a recurring pattern of much lower attendance in the first class in spring iterations of the course compared with its fall iterations: from 59 in fall 2020 down to 12 in spring 2021—an 80% drop, and from 23 in fall 2021 down to five in spring 2022—a 79% drop. Logically, these sharp drops in students showing interest in the course coincided with the [University] requesting students to choose their majors during the spring semester, and the generally higher focus by first-year students on their grades during the second semester (spring) when compared with the first semester (fall).

5.1.2 Completion

Completion rates for nearly every iteration of the course were above 83%, with the sole exception being fall 2021, with a completion rate of 61%. Most students who dropped out of the course did so in its first four weeks. For this iteration of the course, we used the same syllabus as for the fall 2020 iteration, which was delivered remotely. We later realized we could have taken more of an advantage over the fact that students were now present together in the same physical space. It should be noted that the classroom provided by the institute for this course consists of fixed rows of desks and fixed chairs, a setup not conducive to teamwork.

5.1.3 Submission

Submission rates for team-based assignments have been consistently equal to or higher than submission rates for individual assignments.

In every iteration, there has been a drop in reflection assignments from the first to the last assignment, with this drop being particularly prominent in the fall 2022 iteration, when the number of such assignments increased from three in previous iterations to five in this one. We plan to reduce the number of Reflection assignments back to three, while also emphasizing to students how these reflections connect to and help with internalizing the skills they learn and apply in the course.

5.1.4 Application
Application rates varied from 30-70%, with the first in-person iteration of the course (fall 2021) having the lowest application rate. This was perhaps linked, as for the lower completion rate for this iteration (61%), to the under-utilization of the physical space. Students from [IUP] had less exposure to course students in classes since teaching returned to campus, as it has become more difficult to secure their time to attend some or all of that week's class.

5.1.5 Publication
We had four publications in 2022, and four either accepted or already published for 2023.

5.2 Planned changes to the course
Based on our five outcomes, we plan to make the following changes for the next iteration of the course in fall 2023.

5.2.1 Participation
Owing to the large and growing number of other first-year exploratory classes, we plan to dedicate resources toward the promotion of the course among first-semester students, including at [University]-specific events for prospective students and first-week students.

Owing to participation during the spring iterations of the course, we decided to end its spring iterations.

5.2.2 Completion
Starting on spring 2022, we decided to replace the in-class individual Activity assignments with student teams starting the Application assignment together in class. This provided students with more opportunities for teamwork and active learning and provided instructors and students with a way of making sure the Application assignments are clear to each team before they go home and continue working through them.

Another change we made was the introduction of a visit to a maker space where students got to see and ask questions about one of the systems they had worked on as part of the 'systems thinking in environmental systems' section. We plan to look for a new space for the course classes at [University], a space more conducive for teamwork, for example, with round or movable tables, movable chairs, and a large screen with a computer setup.

To allow more time for out-of-class teamwork on Application assignments, we plan to reduce the number of Preparation assignments and of reflection assignments to three in fall 2023.

5.2.3 Submission
We plan to implement the challenge from the algorithmic thinking section of the course entirely in code.org (e.g., Tsukamoto et al., 2017) or a similar codeless programming Web-based platform. Conducting the challenge using this kind of platform will provide students with immediate low-level feedback from the program while they work through designing their pseudocode, along with the higher-level feedback already offered to them by the undergraduate assistants (UAs) on their submitted pseudocode. This will help ensure that novice students are

able to produce work of basic quality such that the UAs will be able to provide them with useful feedback.

5.2.4 Application

To afford students more opportunities for active learning and a more natural interaction with [IUP] students, we plan to remove the introductory and concluding classes from the course. Instead, we hope to get a small team of [IUP] students involved in planning and delivering one week of the course. This change would help introduce the course students to the experiences of the students in the program better than the previous questions-and-answers interactions or feedback-based interactions.

We intend to retain the visit to the maker space described under 4.2.2 while potentially introducing another such visit to a different maker space or laboratory, for example, a bioengineering laboratory for the 'systems thinking in bioengineering' section of the course.

5.2.5 Publication

The change we plan for the challenge in the algorithmic thinking section of the course (see 5.2.3) should allow for easier, standardized data collection. As of spring 2023, the materials for the fall 2022 iteration of the course will be available on [University]'s public-facing platform, and thus open for everyone to view and download. This will facilitate use of course materials by instructors outside of [University] interested in active learning and in teaching thinking skills. This public presence for the course may also help with finding other institutions to collaborate with on educational experiments and developments within the framework of [Course].

5.3 Suggestions for instructors and course designers

- Promote your class and learn what other classes are offering students.
- Identify if any semester is more likely to have increased participation of students.
- Facilitate and provide sufficient time for teamwork, in and out of class.
- Make sure not to provide too many individual assignments in a pass/no-pass course.
- Involve students from your program of interest in course classes with students who are potential candidates for the same program.
- Engage in educational experiments and new developments in your curriculum and pedagogy. Manage a process of documentation, analysis, and authoring of educational research material.

6. Conclusion

In this work, we outline the evolution of a first-year exploratory course in [University]: from its inception as a remote course during the pivot to emergency remote teaching due to institutional regulations implemented during the COVID-19 pandemic, to its recreation on campus as an in-person class.

We learned that adapting a course designed for remote delivery into an in-person class requires one to reconsider curriculum and pedagogy, including how the physical space of the classroom will be used. We are presently looking to find a new space for the class which will be more conducive for teamwork and which we hope will serve to increase the appeal and level of engagement for students.

The course in some of its iterations can be viewed as a viable delivery method for teaching approaches to problem-solving (see Author 1, Author 8, & Colleagues, 2023, in press). It may also serve as a model for other exploratory classes at higher education institutions, as a way to engage students in active learning and in practicing various thinking skills while maintaining variety and interest.

Since each section of the course can be adapted and taught independently, this course can also represent five examples of independent interdisciplinary challenges suitable for the first-year level which can be adapted for various learning objectives.

We hope the reader finds benefit in what we did and what we found.

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