Creating Learning Environments Within the Constraints of Higher Education - a Case Study of a First-Year Computing Program

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***Abstract*—Designing a good learning environment is key to improve the student experience and ensure learning. However, it is becoming increasingly challenging to create such environments due the growing number of students and the push to optimize the use of learning facilities. The increased administration of higher education creates a limited room for action for educators to innovate and develop effective educational designs. This paper describes a case study of how one group of educators attempted to solve certain challenges within one university's constraints. The problem observed was that the first-year students were exposed to fragmented scheduling and limited access to collaborative spaces, resulting in a reduced sense of belonging and ineffective study behaviors. At the same time, these students were enrolled in large introductory courses from various departments where we did not have the mandate to make any substantial changes. The solution we came up with was a Study Day Initiative where all the first year computing students were invited to participate in a low threshold study day where teaching assistants were prepared to help with any and all assignments. We were able to clear a full day in the students time table and found an appropriate area within the department's lab spaces. The Study Day Initiative has been in place for three years, receiving very good feedback from students who report being satisfied, making friends and having improved study habits. In this paper we will describe the process behind this initiative, how the constraints of a large university were overcome and present results from the surveys of the participating students.**

***Index Terms*—Computer Science Education, Computing Education, Higher Education, Study Behavior, Educational Design, Learning Environments**

I. Introduction

Students within the computing and engineering disciplines often follow an educational design consisting of lectures, labs, and assignments to do individually or in groups. These are the explicit design parameters implemented by educators. In addition, these designs imply a substantial individual effort in processing lecture notes, preparing for labs, working on assignments, and other individual study behaviors. In order to be successful in these activities, students need continuous time, physical space, and enough support, all key elements of an effective learning environment. Educators' ability design and impact the learning environment across and between courses is constrained by the the current trend of increased administration in higher education does. This paper will describe a case study of how one group of educators attempted to solve certain challenges within one university's constraints.

Educational psychologist John B. Biggs described the learning environment process in his seminal work on student learning processes in the 1980s. In his Presage, Process, and Product (3P) model of learning in higher education, he described how "students undertake, or avoid, learning for a variety of reasons; those reasons determine how they go about their learning, and how they go about their learning will determine the quality of the outcome" [1, p.5]. An important part of the presage is the teaching context, which, in addition to the learning environment, includes the curriculum, assessment, and teaching methods. Common for these factors is that the institution controls them, whereas the other aspect of presage, the student characteristics, exist prior to the learning and relate to the student. The final two parts of the model, process, and product are related to the students' approaches to learning and the learning outcome, respectively. In the current study, we focus on one of the presage factors, namely the learning environment. Students' perceptions of the learning environment influence how they learn as well as the context is self [2]. Furthermore, there exists learning environments within each course in addition the class environment [3]; however, in this case we will only be examining the *student-driven learning environments* created outside the organized classrooms and between scheduled lectures.

As educators, we aim to implement the most effective educational designs and pedagogical activities for our students in order to ensure they learn the content and skills needed. Even though educators have the best pedagogical intentions, they must often make decisions based on organizational and structural constraints. Educators must navigate in a jungle of rules, guidelines, deadlines, best practices, and educational innovations. This jungle, or educational context, is different from institution to institution. The current case study illustrates how one group of educators navigated one institution's jungle of constraints in order to solve a pedagogical problem of

fragmented student learning. With this work, we aim to explore a framework for discussing educational design parameters so that educators across institutions can communicate more effectively about structural innovations and their effects. Hence, the research question *how can educators develop educational designs to improve students' learning environment within the constraints of a large university?*

A. The case

The problem in the case presented in this paper was that the first-year computing and engineering students were exposed to fragmented scheduling and limited access to collaborative spaces, resulting in a reduced sense of belonging and ineffective study behaviors. At the same time, these students were enrolled in large introductory courses from various departments where we did not have the mandate to make any substantial changes. The concern was that these ineffective behaviors would develop further and become a challenge for the students later on, and limit their general competency as future engineers and professionals. These worries were backed up by data from the annual The National Student Survey, where the learning environment indicators were below the national average for computing students [4]. Through evaluation questionnaires and focus groups, local investigations into this phenomenon found that the fragmented study week was one possible problem.

The solution we came up with was a Study Day Initiative (SDI) where all the first-year computing students were invited to participate in a low threshold study day were teaching assistants (TAs) were prepared to help with any and all assignments. We were able to clear a full day in the students' timetables and found an appropriate area within the department's lab spaces; however, this required some intricate scheduling negotiation and room allocation trickery. Both this process and the student's experience will be systematically examined through a case study approach. In the next section, we will briefly explore related work on the connection between educational design constraints and the student learning experience. Following that, we describe the methodology and results, ending in discussion and implications.

II. Educational design innovation and constraints

Previous research by the authors has explored the relation between educational design and study behavior within computing education, aiming to model the intricate relationship between learning activities, pedagogical design, and the learning outcomes [5]. The results of this initial work is the model presented in Fig. 1, which illustrates the structure of the student-driven learning environment. On the left side, the model depicts the tacit dispositions, and behaviors students input into the various planned and implemented teaching and learning activities (middle). The students' study behaviors interact with the educational conditions, and the outcome is learned skills, knowledge, and competency. In relation to Biggs' 3P framework, this model of computing students' study behavior depicts the interaction between presage and process. For the purpose of the current case study, the educational conditions are of main interest. These are the aspects of their study day and week students are focused on, and it is what drives their study behavior and learning process.

Taking a closer look at these conditions, it is interesting to differentiate where the control lies in the institutional ladder. For example, at the case institution, the scheduling of lectures lies on the institution level, whereas the course teacher sets the content of the lecture. These distinctions are important because when educators aim to develop and implement holistic educational innovations that take into account the whole educational experience, they must know who has the deciding power. Although these structures and control dynamics may be different from institution to institution, the framework presented in Table I describes the general parameters and how they relate to the current case. In this framework, education is viewed at three levels: institution (macro), program (meso), and course (micro) [6]. The institution level describes the central or highest level, which varies in size and control. The program level here refers to wherever the students are enrolled. In some educational contexts, this might be a school of engineering or a major; however, students are organized into study programs in this case. Lastly, the course level is perhaps the most universal construct. Although higher education institutions are organized in many different ways, this framework aims to incorporate most designs and highlight the interconnected complexity [6].

Previous research has found that institutional policies and mechanisms are central to the student experience, and design parameters such as class size and physical learning environment can either support innovation or present significant barriers to it [7]. Furthermore, institutions need to cultivate

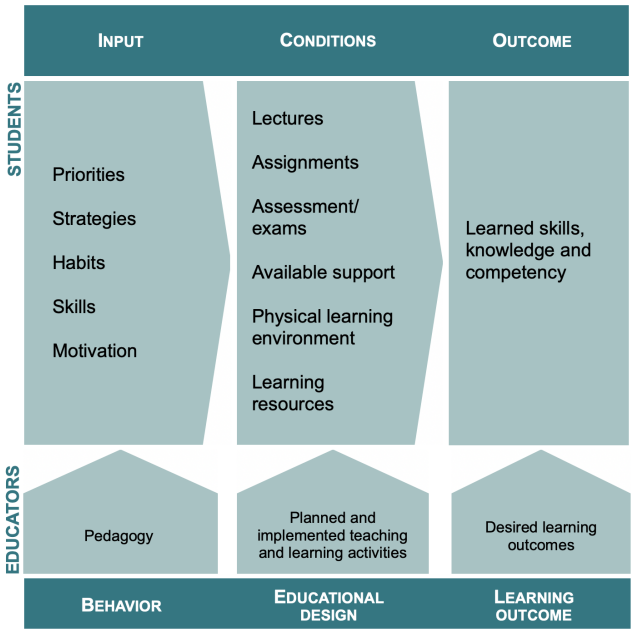

Fig. 1: Model of student behavior and educational design.

TABLE I

Level of control	Description	Parameters
Institution	Admission	Prerequisites, enrollment structure
Rector/pro-rectors,	Learning environment	Campus layout
central administration	Scheduling and timetables	Lecture and lab time slots
Program	Program design	Number of semesters
Program leaders, dean		Weight of a course (number of credits)
		Enrollment and admission regime
		Parallel vs. modular courses
Course	Course structure	Open or closed enrollment
Course teacher,		Number of students
department head	Learning activities	Pedagogical design
		Number of lectures
		Number of assignments and/or projects
		Individual or group-based activities
	Assessment	Type of assessment and exams

and stimulate a culture for innovation among educators, which involves supporting practices that conflict with institutional design [8]. There are interconnected complexity and conflicting visions among the course, program, and institution levels, which need to be thoughtfully navigated in support of innovative assessment and pedagogies in higher education [6].

III. Methodology

Case study methodology is a good way to describe, explain, or explore a phenomenon [9]. The case study presented in the current paper has a holistic design with one unit of analysis investigated over three years and be characterized as evaluative [10]. The unit of analysis is the development of the Study Day Initiative (SDI), implemented in order to meet certain student needs within the constraints of one large university in Norway. Furthermore, the case investigated is the population of students who participated. The case study is reflective in nature, looking back at various data points in an integrated way, providing opportunities to transform teaching and learning practices.

A. Data Sources and Analysis

In order to answer the question of how educators can develop new educational designs within the constraints of a large university based on this case, the analysis and results section will be divided into two parts: the design and implementation of the SDI (1) and the evaluation of the initiative (2).

Part 1 will be analyzed using the design tensions paradigm developed by Tatar [11]. The design tensions paradigm provides a concrete framework to understand design decisions in complex systems while emphasizing the balance of considerations in producing an entire system, especially the user group experience. Specifically, the design tensions highlight the vision of what *is* and what *ought to do be*, and illustrates the constraints of getting from one to the other. The use of design tensions is inspired by similar studies, where this framework was used as a productive tool to understand design and implementation challenges that exist in practice [6], [12].

Part 2 will look at student feedback and observations to evaluate the student perspective and the authors' reflections in relation to Part 1. It is also important to document the impact of the initiative, as it is part of the cost benefit assessment of developing new educational designs.

The data comes from three sources. In order to describe the challenges and solutions, we rely on the educator's descriptions of the process, in this case, the authors. Questionnaires from the students provide the measurement to investigate the student experience. In addition, we have a set of structured observations done by teaching assistants (TAs) in the last semester. These sources combined provide the grounds to explore how educators can develop new educational designs within the constraints of a large university.

B. Participants

The participants in this study includes both the students who were the target of the SDI as well as the educators and TAs involved in designing and implementing it. There were two educators in charge of the project (the authors) as well as 8-12 TAs for each semester. The number of TAs grew as the project grew. Most TAs were involved over several years which was very beneficial for the transfer of knowledge and improvements. As for the students, we invited a new class of approximately 300 students each year. Out of this population, 60-120 students showed up every week. It varied somewhat from week to week and semester to semester how big the turnout was. For ethical reasons, we had no way of counting 'unique users' every week, so we unfortunately do not know for sure how many of each 300 class attended at least one Study Day. Our estimation is that approximately 40% of the total student population attended at some point. In our attempts to increase attendance, several efforts were made to 1) reach students who were not there and 2) find out why and what we could do to reach them. Although, we could not seem to significantly improve the number of students attending we learned that the students who did not attend the SDIs reported that they did not see the need.

IV. Part 1: Design and implementation of the Study Day Initiative

The overall goal of the Study Day Initiative was to improve the academic and social learning environment of first-year computer science and engineering students. The solution we identified was to create a full day where students could come together and work on all their courses. This might seem like a modest idea; however, putting this into practice was not a simple task. Because of the university's overall organization, working across courses in this manner involves a complex network of administrators, course teachers, and support systems.

All courses are scheduled at the university level in order to ensure that the students' timetables are collision-free and allocated appropriate rooms. In practice, this means that educators at the program level, trying to design a pedagogical study week, do not have the mandate to schedule lectures or labs. With a little bit of luck and a good amount of negotiating with individual course teachers, we were able to clear six hours in a row each semester of the project. The next step was to recruit a number of teaching assistants who could support the students in all courses. This meant finding older students who were comfortable in a role with no insider information in any course. They would have to be able to answer questions about both introductory programming

TABLE II: The Study Day design tensions

VISION	**Is:** Students experience a fragmented learning environment	**Ought:** A holistic study experience, with alignment between courses, activities and support.
APPROACH	**Project drivers:** Centrally administrated planning based on courses, bureaucratic distance between educational innovators and decision-makers.	**Values:** Student-centered schedules, a community of educators and decision-makers.
PROJECT TENSIONS	Pedagogical intentions vs. structural constraints. Educator vs. system. Cost for educator vs. benefit for students.	
AS CREATED SCENARIO	Creating a student-centered learning environment for students.	

and computing, calculus, discrete mathematics, and scientific philosophy, which were the mandatory courses in the first semester. In practice, this meant the TAs had to take on a learning facilitator role, often helping students help each other or sitting down and doing the whole assignment with them. Lastly, we had to broadcast this initiative and ensure participation among the students. On the one hand, we emailed all students, used the courses we could influence to broadcast the initiative, and had student counselors communicate it in their channels. We also used another trick; serving food. We started each Study Day with a simple breakfast prepared by the TAs, hoping to motivate the students to get up in the morning and at the same time building social bonds. In summary, there where four items on the 'to-do-list' when implementing the SDI:

1) **Scheduling student time tables:** First, try to get the SDI on the formal schedule (Institution level). If that does not work, find the least full day and attempt to move all activities from that day to other days (Course level).
2) **Scheduling a room:** First, try to get a room booked for SDI through the central room reservation system (Institution level). If that does not work, use the rooms allocated to 'your' course, or negotiate with other courses in your department (Course level).
3) **Hiring and training TAs:** Using normal channels, aim to hire outgoing, proactive students with adequate performance in the central courses. Training the TAs includes supporting them in implementing the study day every week.
4) **Informing students:** Using whatever channels you have, make sure the students know when and where the SDI happens, as well as communicating that all students are welcome to work on any course. If you have the budget, serve food and coffee.

The first implementation of the SDI kicked off in 2017 and has been going strong since then. Every year, the educators in charge must be proactive and make sure the time and location schedule is in place. Weekly implementation of the SDI was mainly done by the TAs. The authors only had to be there in the first few weeks but tried to drop by as much as possible. Every week, the TAs set up the room, ordered and prepared the food, and most importantly, helped the students. During the study day, the TAs were instructed to go around to all the participants and interact with them individually, even if they did not request help. Furthermore, since the students could work on many different courses, the TAs developed an internal competency map, where they would send the most proficient TA to help students in any given problem. Every week, we would do a short stand-up meeting, where we discussed student challenges and decide on future interventions. Often these discussions were mostly about what questions and assignments the TAs struggled to help the students with and then designating one TA to do some research into that before next week.

From the educators' perspective, it was the design and preparation of this initiative that was challenging, not the weekly implementation. Using the design tensions framework, Table II outlines these constraints. The authors identified three tensions that provided the main hurdles for the innovative process. Firstly, the educators' pedagogic intentions were met with significant structural constraints (scheduling and room allocations). In attempting to navigate that situation, the educators were obstructed by a system that did not facilitate cross course designs. The system is aimed towards course teachers, and there is no support for educators operating mainly in the program level. For example, we reached out to the central coordinators for time- and room scheduling to get the SDI into the formal system; however, we were told that it would not be possible to add the SDI to the schedules because it was not a course. We then attempted to go through our local people, contacting course teachers, the department head and dean, but eventually were directed to the same central coordinators. This back and forth process went on for over a year, while we continued to adjust and negotiate the schedules in parallel so we could run the SDI. No matter how important the people forwarding us to the central coordinators were, and how adamant their emails were we never got SDI into the formal system. The closest we got was one cooperative scheduler who promised to try his best to keep one day cleared for our group of students. Again, we were reliant on individuals and their good will.

The cost of going around the system and negotiating with the structural constraints was, in this case, outweighed by the perceived benefit for the students, which will be further described in the next section. The created scenario here is a system in which the students' study experience is in the center of the design, opening up for holistic approaches such as the SDI.

V. Part 2: Evaluation and student experiences

In order to fully explore the effect of the initiative on the students, we also examine the student experience through the questionnaire and observational data. Questionnaires were distributed to the students during the last two weeks of the semester. TAs distributed the questionnaire on paper to all students participating and transferred the data into a digital format after the fact, providing total anonymity for the students. In addition, this ensured that all participating students answered the questionnaire. The questionnaire consisted of three sections: their participation and use of the traditional educational design elements (i.e., lectures, labs, TAs), their experience of the learning environment, and their use and evaluation of the SDI. In total, we received 136 responses over three years.

The analysis of the questionnaire data found that students' were very positive about the initiative. Two questions were asked about their study habits, one asking about their level of efficiency and one about their level of study compared to other days of the week. In addition, one question was asked about their level of motivation during SDI, if they had made a stronger connection to their peers and if they received the support they needed. The mean score for each of these variables was between 3.5-4.2, where 5 is the highest. As depicted in Fig. 2, there seemed to be little difference between genders. A chi-Squared test confirmed no statistically significant difference between male and female students on these variables (95% confidence interval). Taking a closer look at these answers, we found that 74% of the students reported that they were more effective during the study day compared to other days of the week, and 61% said they studied better. Furthermore, 72% reported that they were more motivated on the study day, and 66% said they made new friends. 90% reported getting the help they needed, and 98% wanted a similar initiative next semester.

It is evident from the evaluation results that the participating students were very content with the initiative, and according to their reports, we seemed to hit the mark. Students studied efficiently, made friends, and to a large extent, got the support they needed, indicating a good academic and social learning environment. It is also of interest to try and explain why this initiative seems to be successful among the students and what is actually going on. In addition, the 2019 implementation of the initiative included a structured observation performed by the TAs. At some point during the study day, TAs were asked to count the number of students in total, how many were working alone and in groups, what courses they were working on, as well as describe the general mood in the room. Every

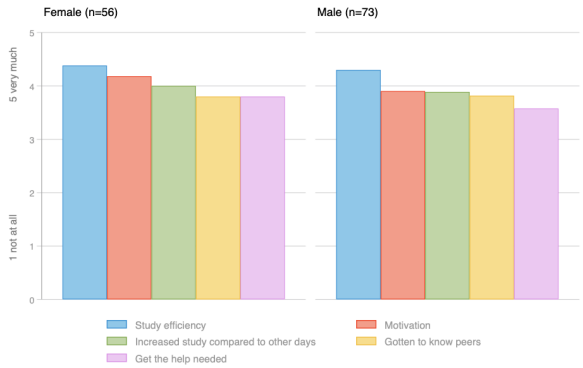

Fig. 2: Mean score of student experiences by gender.

week, there was a distribution of students working alone, in small groups, and in bigger groups. However, there seemed to be a link between this distribution and the course most students were studying. Some weeks more students were working on collaborative assignments, and therefore more students were working in groups. Furthermore, the room was set up with mostly group tables, so even though students were working individually, they were studying together with their peers. When it comes to what courses students were working on, that seemed to be largely driven by what assignments were due. TAs observed that the same students worked on different courses from week to week and reported what deadlines the students were talking about. Lastly, TAs were asked to give a report on the mood in the room, describing the efficiency and stress levels. With the exception of the last week, the stress level seemed to be moderate and the efficiency high. The last week was also the last week before exams, which probably accounts for the increased stress level.

Lastly, the questionnaire also included an open text question asking students to elaborate on what was good about the SDI and what needed improvement. Some students described why they participated with some very enlightening words. One student wrote about the availability of help and support:

> *When you're surrounded by three people who want to help you, study days are awesome!*

Another student also talked about the security of knowing you can get help if you need it:

> *Study days are brilliant because you just come here, and you know that there is someone here that can help you with everything and anything.*

Other positive comments were similar, while most of the improvements were directed towards the food services.

As the SDI project has continued from semester to semester over the last three years, these student perspectives have motivated the continuation. Seeing and hearing from the students how this initiative seems to have greatly improved their learning environment has encouraged us to keep organizing it. However, the overhead of negotiating time tables and room allocations ahead of each implementation is larger than it

should be. We are currently attempting to transition the SDI from initiative to permanent activity, but this has proved challenging for the same reasons.

VI. Discussion

In this paper, we have explored the design and implementation of a Study Day Initiative for first-year computer science and engineering students and evaluated their experiences in order to shed some light on how educators can develop new educational designs to improve students' learning environment within the constraints of a large university. STEM higher education programs and majors are often built on the same foundation of courses, making the first-year complex both for students and educators. Students have courses in core engineering subjects such as mathematics and programming, in addition to their engineering disciplines. This often leads to large courses with students from different programs, which further creates a fragmented learning environment for the individual student. In the current case, the computing students had no courses where they were only computing students. In such circumstances, it becomes even more important to create time and spaces for students to come together and learn in a computing learning environment.

A. Educational Design Tensions

We can conclude that the SDI was a welcome improvement for the students. However, the overhead of implementing this for the educators within the constraints of large universities is not a sustainable organization for everyone. For one, this process was largely reliant on individual educators and their efforts to be proactive and negotiate solutions outside of the formal university structure. The role of the authors, in this case, was that we wanted to create a better learning environment for a specific class of students at one study program. In other words, we had to consider all their courses and were therefore operating at the program level (Table I). However, the educators were outsiders here, seeing as how we were on the course level, influencing only one of the courses. It turned out to be a major challenge that the initiative-taking educators were positioned at the program level, where their influence was limited. This was not a realization we had going into the project, and the driver was a vision of what ought to be. Retrospectively, the design tension analysis provided the terminology and framework to identify the issues at hand. Based on these experiences, we conclude that there is a need to move the perspective from courses to study programs in order to ensure the students' learning environment.

When it comes to the process of navigating the constraints of a large university, the educators had to manage three dimensions; time scheduling, physical space allocations, and availability of resources. In this specific case, the latter was the least complicated since the computing department has been part of a nationally funded center for education. Time and space allocations, however, were substantially more complicated. Similar to other larger universities, these processes are managed on the institution level, meaning the individual educator has limited to no influence on these outcomes. In this case, we were able to negotiate with individual course teachers to create room in the schedule and on campus to organize the SDI as planned. This is, however, not a sustainable solution in the long term.

B. The Student-Driven Learning Environment and SDI

The evaluation of the SDI indicates that the project was successful in enhancing their learning experience from the student perspective. The reason for the initiative was based on the fragmented learning environment created by the conditions of the educational design, and the holistic approach of the SDI met that challenge. The SDI provided a space where students could come together and work on assignments, learn and get support, combining many of the conditions driving learning identified in Fig. 1. According to the evaluation questionnaires, students were more efficient and motivated, as well as making stronger academic, social bonds. The SDI is not in itself the most revolutionary innovation; the notion of providing time, space, and support for students in the same place every week is at its essence very similar to many traditional designs. However, previous research on the effects of learning environments can provide some insights into why this relatively simple design seems to be so successful. Research has shown that how students perceive the learning environment and the way they approach their learning in relation to these perceptions are major intervening factors between teaching and learning outcomes [3], [13]. In this case, the SDI served as a stable, constant, and low threshold space where the students had positive learning experiences; hence their perception of the learning environment was improved. Without the SDI, the students would be on their own, filling the time between organized learning activities and finding help and support themselves.

There exist projects similar to the SDI both in design and effect on the students. One notable example is the redesign of the Electronic System Design and Innovation study program (ELSYS) at the Norwegian University of Science and Technology. Although this was a much larger initiative, one key element was the project-based course in the first semester, which consisted of one full day of integrated teaching activities and project-based learning [14]. The ELSYS-educators have reported success in creating an improved learning environment, specifically fostering self-efficacy and socialization [14], [15]. To the authors' knowledge, they have not reported on the design and implementation process, beyond the fact that the approach to create a holistic learning experience has been successful in the student learning process as well as a positive experience for the educators. What the ELSYS example has in common with the SDI is that the organized learning activities and the student-driven learning environment are integrated across courses and student-centered. One could also argue that learning communities [16] and program integrating courses [17] do much of the same for the students in creating learning environments across courses. Although, these examples were not focused on educational design constraints or learning

environments directly, they suggest flipping the narrative of higher education design can benefit the students. Creating a learning environments centered on the student and their journey, instead of students having to from course to course, does improve the student experience.

C. Implications

Practical implications for the individual educator from this study is a tool for identifying the room for action in order to improve the student-driven learning environment: combining time, physical space, and support resources. Depending on the institution, these constructs may be easier or harder to identify and control than the case presented; however, the framework presented in Table I and II can provide an example and starting point.

For those in power, the key takeaway here is to flip the design process to put the learning environment in the center. The current case is an example from one institution; however, the general constraints of most larger universities are similar. Our recommendation is to move the cost of implementing educational innovations away from the individual educator by flipping the design process. If the educators on the course and program level are free to design holistic learning environments, combining the organized learning activities with the student-driven learning environment, the benefit of the student experience can be improved, as exemplified by this study. There should be a system in place to ensure that educators with good pedagogic intentions are able to implement interventions without having to negotiate and navigate outside the formal system.

D. Limitations

There are some important limitations with the SDI as well as the current study to consider. The biggest limitation of the SDI is that it benefits only the participating students, and there was never 100% attendance. As this was intended as a low threshold initiative, we were reluctant to enforce participation, even if we could. However, we are confident that information was not the main constraint for students who did not attend. Efforts were made to gain insight into reasons for not participating, but these students were hard to reach. Although the participating students seemed very content with the SDI, we do wonder if we were able to reach the students who 'needed it' the most.

When it comes to limitations in the research design, there are always concerns with rigor and generalizability with case studies. By describing the context and unit of analysis for the current case, we aim to reach an adequate level of analytic generalizability [9], [10], where other researchers and educators can extract information for their context.

VII. Conclusions and future work

Although there were many obstacles to being able to organize the Study Day Initiative, the effects of the intervention have been positive. The goal of the initiative was to ensure students had an appropriate learning environment, which was achieved. The room for action we had as educators was limited by scheduling challenges, restricted physical spaces, and constraints on resources; however, the pedagogical intention of creating an effective learning environment was successful by the metrics at hand. It is a fact that for many educators, the practical constraints often outweigh the pedagogical intentions. We believe this case study can illustrate to other educators and researchers how relatively small design changes can be influential and how one can effectively navigate the constraints of a large university.

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