Participatory Governance in the Computer Science Theory Classroom

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ABSTRACT

We implemented pedagogical strategies designed to give students greater control over the use of class time and grading methods in a major-required computer science theory (CST) course. Our methodology addresses the challenges inherent in transferring more power to students in a lecture-based class with a curriculum that requires the sequential mastery of formal mathematical concepts.

We offered students increased control over four classroom variables: the *degree of interactivity*, the selection of *in-class activities*, increased *emphasis on standards-based outcomes* as opposed to averaging over all coursework, and the *granularity of the grading schema* used by TAs. In this experience report, we present our methodology, report on our classroom experience, and conclude that increasing student control over the undergraduate CST classroom via participatory governance can increase student motivation and encourage critical reflection in budding computer scientists.

CCS CONCEPTS

• **Social and professional topics → Computer science education**; **Model curricula**; *Student assessment*.

KEYWORDS

participatory governance, computer science theory, student-centered teaching, experience report, critical pedagogy, course design

> "I needed to know that professors did not have to be dictators in the classroom."
>
> bell hooks, *Teaching to Transgress*

1 INTRODUCTION

Computer science theory (CST) is typically among the most mathematical courses required for the computer science major. This is

the case in our department, where the course centers around mathematical proofs as opposed to coding. Theory topics are presented sequentially in an order determined by the content: for example, the fundamentals of discrete mathematics are required to formally define data structures and automata; a mathematical model of computation is necessary to place complexity theory on a rigorous foundation; etc. As a result, CST classes are lecture-focused, with course content presented in the "theorem-proof-theorem-proof" style typical of mathematics courses.

This course architecture can easily lead to a rigidly structured, hierarchical classroom environment. For the student, the class entails passively absorbing lecture content and engaging actively with the course material only when the time comes to apply new knowledge to a problem set. This format has certain advantages, including allowing the instructor to present a large volume of material in an organized manner. However, it specifically advantages students adapted to the passive lecture model, while discouraging others—especially students with inconsistent mathematical backgrounds, students who have difficulty following spoken lectures, and students whose habits of learning are adapted for interactive, collaborative, and community-oriented learning environments. This is the central motivation for our work: to what extent is it possible to engage and empower students in the curricular context of CST?

We take inspiration from extensive prior work in the CS education literature. At a high level, the paradigms of *active learning* [3, 24] and the *flipped classroom* [1, 2] have been successfully applied to supplement and replace passive receptivity with interaction and connection (for CS applications, see, e.g., [5, 11, 18, 19], among many). The models of *peer instruction* (PI) [8], *cooperative learning* (CL) [22], *peer-lead team learning* (PLTL), and *process oriented guided inquiry learning* (POGIL) increase student autonomy by incorporating various teaching and collaborative responsibilities into the learning process and have also been successfully applied to (theoretical) computer science (see, e.g., [4, 6, 23, 28] for PI and CL, [12] for PLTL, [15] for POGIL).

In short, the CS teaching literature provides an overabundance of promising interventions. This leaves instructors to determine which tactics will be most successful in a particular curricular and social context. In response to this challenge, we implemented a *complementary* intervention to mediate between innovative pedagogy and the specifics of our setting. We offered students increased control over several classroom variables, including the use of class time, the style of TA feedback, and the method of calculating final grades. We refer to this strategy as *classroom participatory governance*, as distinct from theories of participatory governance for academic institutions and society at large.

Our study joins other recent interventions centered on increasing student control and critical reflection in the computer science

classroom. For example, Krings recently reported on the effects of an AI course co-designed and organized by students [14]. This work was specifically motivated by the challenges of overenrollment, and informed by the model of *contributing student pedagogy* [10]. In the context of a non-mandatory independent study, YeckehZaare, Chen, and Barghi implemented a curriculum guided by student-generated questions [27], increasing student autonomy. Our goal of encouraging critical reflection on the college learning environment is inspired by the framework of *critical pedagogy* [9]; practices of other CS educators influenced by this approach were recently documented in an illuminating study by Mayhew and Patitsas [16].

Experience Report Objectives. We evaluate the effectiveness of our approach with respect to three outcomes for students:

(1) Engagement: increase motivation to learn and interest in the course material.
(2) Empowerment: foster an increased sense of personal agency and control over one's own learning.
(3) Critical reflection: encourage students to consider the structure of their learning environment, including the organization and presentation of knowledge and the power relations between the course staff, their peers, and themselves.

Student responses indicated significant improvement in each of these dimensions, with the most striking results in the area of engagement. We believe our results may be of interest to a wider range of CS educators, specifically those engaged in teaching heavily mathematical or otherwise cumulative curricula, and those interested in engaging mature learners in critical reflection.

2 CONTEXT

Our classroom setting is the CST course at a highly selective research university in the northeast United States. CST is a mandatory course in the CS major that serves as an introduction to the application of proof-based mathematics in CS; discrete mathematics is a required prerequisite. It introduces students to several automata including Turing Machines and culminates with computability proofs and a brief overview of the foundations of computational complexity. Students taking the course are in the later years of a B.A. or B.S. in computer science from one of several undergraduate schools. The course also attracts a small number of non-majors and students in graduate programs attached to the university.

The specific course we consider is the condensed offering of CST in the summer semester, which operates on an accelerated six-week schedule. Each week of the course consists of two class periods of 3 hours and 10 minutes each, roughly double the amount of class time per week as in the fall and spring semesters. This increased pace presents both opportunities (students' attention is focused and consistent due to the accelerated pace of the class) and challenges (the short semester leaves less time for students to respond to instructor feedback, and vice versa).

The class composition of the summer course is different from the fall and spring offerings in two other significant respects. First, the class is smaller: while CST enrollments during the regular semester are often over 100, resulting in a large lecture experience, summer enrollment is lower. In the summer of 2023, 34 students were enrolled after the deadline to add and drop classes, all of whom completed the course. The second is the predominance of students from an undergraduate degree program specifically targeting returning and nontraditional students. Approximately two thirds of the class fell into this category. These students come to CST with a variety of prior experiences including employment in industry, military service, and entrepreneurship, and are older on average than their peers in the course.

2.1 Anticipated Challenges

In preparing the class, we anticipated several features of the student population and curriculum that could prevent our intervention from succeeding. These included:

(1) *Student expectations and prior experiences.* Almost all our students had previously experienced rigid, lecture-oriented classroom environments. We expected them to have adapted their learning strategies to this setting, and potentially to experience anxiety at the prospect of change.
(2) *Student incentives.* In a previous iteration of CST, students were asked to rate their motivations for taking the class on a 5-point scale from "Mostly intrinsic (personal interest, curiosity, desire to gain skills, etc.)" to "Mostly extrinsic (grades, major requirements, etc)", in accordance with Self-Determination Theory [20]. A majority of respondents rated their motivations as more extrinsic than intrinsic, while just 15% rated their motivations as more intrinsic than extrinsic. Thus we expected students' preferences to be shaped by the desire to achieve a good grade and pass the class, rather than the desire to maximize their learning experience.
(3) *Sequential structure of curriculum.* The topics considered in CST include discrete finite automata, pushdown automata, Turing Machines, computability and undecidability, and complexity classes including P and NP. Success on each subsequent topic depends on mastering the previous topics. This means that early conceptual struggles can turn into major problems as the course progresses. When considering which aspects of the course to turn over to student control, we were conscious of the risk that changing early material could significantly impair students' progress later on.
(4) *Class speed during the short semester.* As mentioned above, the summer session of CST is compressed into a six-week period. This makes exchanging feedback between students and the instructor more difficult: for example, the time required to assign, collect, grade, and respond to the first assignment is a substantial fraction of the course.

These challenges and opportunities informed our implementation of participatory governance in CST. Roughly, we attempted to design a course to solve the following optimization problem: achieve the goals of engagement, empowerment, and critical reflection while minimizing confusion, anxiety, and perverse incentives.

3 METHODOLOGY

We limited student control to four specific variables in order to mitigate the anxiety students might feel when confronted with changes to the class structure.

At the end of the first class period, the instructor introduced each variable, contextualizing and explaining the practical significance of each possible change to the course. Students then gave their

feedback on each of the four variables via an anonymous survey administered outside of class. On the survey, student preferences on each variable were assessed using a 5-point scale, with the 1st and 5th options representing extreme values. During the second class period, the instructor summarized student feedback and offered suggestions to the class. After discussing each variable in turn, the class adopted a course structure by consensus resolution (see Sections 4.1 and 4.2 for details).

We gave students control over the following variables:

(1) *Degree of interactivity.* Options ranged from a heavily lecture-based class at one extreme to a "semi-flipped" class with significant pre-class reading, collaborative activities, worked examples and supplemental short lectures on the other. The first lecture was designed to balance between the two extremes, with time devoted primarily to lecture but supplemented by a variety of in-class activities. After discussing the range of possible options, student preferences were assessed with respect to this first lecture on a scale from "much more lecture-focused: almost all direct instruction, with very few activities" to "much more activity-focused: half of class or more devoted to activities".

(2) *Type and frequency of in-class activities.* We distinguished between eight types of in-class activities, apart from lecture: solo puzzles and challenge problems, group puzzles and challenge problems, individual reflections, "*Kahoot!*[1]-style" quiz games, clicker quizzes, worked example problems, concept-centered review, and freeform discussion. Students were asked to indicate their interest in each activity on a scale ranging from 'not interested' to 'very interested'.

(3) *Degree of adoption of standards-based grading, as opposed to a weighted average over all coursework.* Standards-based grading attempts to link student grades directly to their demonstrated mastery of specific skills, often allowing students multiple attempts to reach a fixed standard [13, 25, 26]. This variable was inspired by the recent successful adoption of standards-based grading in undergraduate algorithms and theory courses [7, 21]. Our approach is also influenced by certain aspects of *specifications grading* [17].

The instructor described two grading models: a traditional points-based approach in which all graded work was combined using a weighted average, and a standards-based approach in which student grades were determined by their best performance on each of a set of key proficiencies represented by a certain problem type. Students were then asked to indicate their preference on a scale ranging from "a mostly traditional grading scheme, in which all classwork contributes significantly to the final grade" to "a mostly standards-based grading scheme, in which the focus is on demonstrating mastery in all skills at or by the end of the course." The details of implementing a grading approach partway between the two extremes were intentionally left open to further discussion (see Section 4).

(4) *Granularity of grading.* In previous iterations of CST, TAs used online grading software to evaluate student work with respect to a common rubric. While this allowed TAs to implement detailed points-based scoring, it deterred TAs from leaving comments specific to individual students.

The instructor described two models that emphasized different aspects of evaluation: one in which student work was evaluated on the basis of a detailed rubric, and one in which TAs allocated their time to providing individualized feedback but graded each question using a more coarse-grained rubric. (As an example of a coarse-grained rubric, we used a scale in which every problem was judged 'excellent', 'satisfactory', 'flawed', or 'blank'.) Students then indicated their preferences on a scale ranging from "scoring with emphasis on a detailed rubric" to "coarse-grained scoring with an emphasis on increased feedback".

The control variables were designed to be narrow enough so that students could plausibly express their opinions on a single, linear scale, but broad enough to allow the final course structure to incorporate open-ended feedback provided by surveys and in subsequent classroom discussions. In this way, we hoped to give students with less-developed preferences clear choices by which to express their opinions, while leaving space for innovative ideas originating from their peers.

In order to mitigate incentives issues, we attempted to remove "easy options" that would prove attractive to students seeking to minimize their workload or maximize their GPA at the expense of their learning. The parameters of student control were limited so that no outcome would lower the standards of evaluation or reduce the overall workload of the course.

After a course structure was adopted at the beginning of the second class period, students were given two further opportunities for detailed feedback via anonymous surveys: once at the course midpoint and once shortly after course completion. The instructor also solicited informal input via weekly "temperature checks" conducted at the end of each class period.

4 STUDENT-DECIDED COURSE STRUCTURE

Context for Survey Results. Our student opinion surveys were used as a starting point for discussion and are not intended as exact summaries of student opinions. Moreover, student opinions may have changed over the course of discussion, which was itself influenced by the presence of the instructor. The surveys may exhibit participation bias: since some students did not respond, their views may not be represented in our data. As a result, our analysis takes the form of an experience report on our specific classroom context.

4.1 Interactivity and In-Class Activities

On the survey given to students after the first class period, a slight majority of the respondents voted for a classroom format in which most class time was devoted to lecture, with up to one third of class time reserved for non-lecture activities. This was the same balance adopted in the first class for a reference point, and this may have anchored student preferences. An additional third of the respondents were evenly split between preferences for a slightly more lecture-focused and slightly more activity-focused class. After a brief discussion, students reached a consensus on a lecture-based

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[1]*Kahoot!* is an online quiz game platform with which most students had previous experience.

format supplemented by significant time (up to one hour) for non-lecture activities, and maintained this consensus for the duration of the course in follow-up surveys.
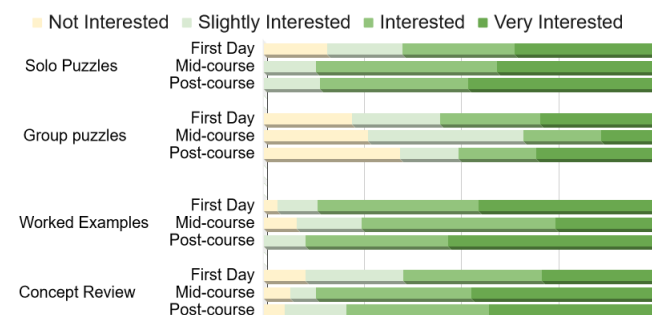

Figure 1: Student interest in solo and group puzzles and challenge problems, worked example problems, and concept-focused review. Responses indicate the fraction of respondents who chose each option on the first day survey (n=31), mid-course survey (n=15), and post-course survey (n=21).

In response to the survey question about in-class activity types, students demonstrated a clear enthusiasm for in-class puzzles and challenge problems. These activities, which took the form of short, concept-focused exercises similar to homework problems, were projected at the front of the class. Students worked independently or in small groups to solve them while the instructor provided context and hints as necessary, eventually working through the solution. Examples of puzzles and challenge problems were incorporated into the first lecture before students took the initial preference survey. For both solo and group puzzles, a plurality of students indicated that they were "very interested" in these activities, with majorities indicating interest. However, solo puzzles were more broadly popular than group puzzles, a relative preference which increased over the course of the short semester (Figure 1).

The reality appeared more complex than a simple preference for solo over group puzzles, however. When given the flexibility to work either alone or in groups, we observed a natural pattern of student behavior: students worked alone to solve the challenge problems offered, and turned to their neighbors when stuck or to check their work when the problems were completed. As a result, we incorporated puzzles and challenge problems suited to this pattern of work at the beginning of each lecture. Puzzles and challenge problems produced steady enthusiasm among students throughout the semester; after completing the class, multiple students volunteered that these were their favorite innovations.

Also popular were the two options for in-class review: worked examples and concept-focused review. The problems used in worked examples were sourced from recent material or recent homeworks, at student request. The instructor then worked through the example in conversation with the students. In contrast, concept-focused reviews began from a certain proof or definition on which a student was unclear. A review of this topic then naturally surfaced other points on which students wanted clarification. We devoted more time to these activities as the course proceeded, as topics grew more

complex and the amount of material to review increased. Student enthusiasm for review activities increased in parallel, although it is unclear whether this reflects a greater anticipated need for review time or increased appreciation for review following exposure.
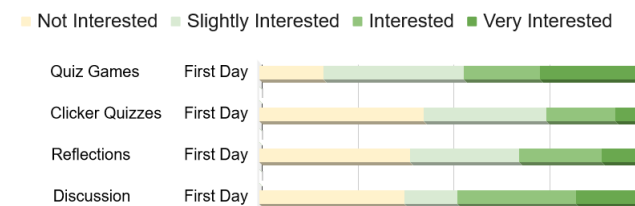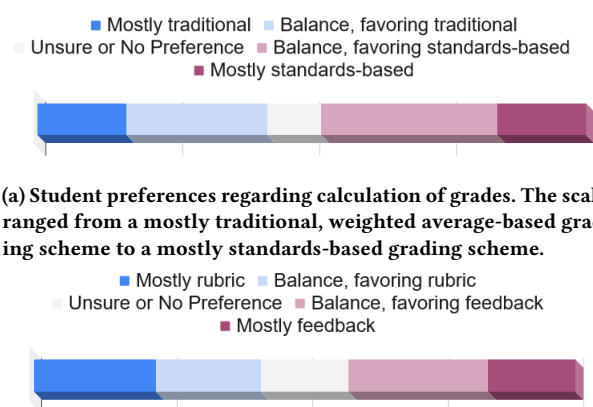

Figure 2: Student interest in the four in-class activities not implemented in the course: "*Kahoot*!-style" quiz games, traditional clicker quizzes, individual reflections, and freeform discussion. Responses are from the first day survey (n=31).

The other in-class activities surveyed, including in-class reflection, clicker quizzes, quiz games, and student-directed exploration of additional topics, were met with less initial enthusiasm (Figure 2). After discussion, the class decided not to implement these activities and expressed similar preferences in subsequent surveys.

4.2 Grading Schema

Students' preferences regarding evaluation were more divided than their preferences regarding the use of class time. Although more students expressed a preference for standards-based grading, almost as many (roughly 40% of respondents) expressed a preference for a weighted average. Two-thirds of respondents voted for some degree of compromise between the two extremes (Figure 3a).

(a) Student preferences regarding calculation of grades. The scale ranged from a mostly traditional, weighted average-based grading scheme to a mostly standards-based grading scheme.

(b) Student preferences regarding grading style. The scale ranged from a detailed, points-based rubric to a system of coarse-grained feedback with longer explanatory comments.

Figure 3: Grading preferences on the first day survey (n=31).

Since there was no clear preference, the instructor presented the survey results and opened the floor for discussion. Some students defended the weighted average, arguing that incorporating

all classwork into the final grade provided a stronger motivation to work hard throughout the class. They contended that if students could easily make up for poor initial work, this would be unfair to students whose efforts were more consistent. In contrast, others argued that average-based grading penalized students who made mistakes at early in the course but ultimately mastered the material.

In order to resolve the discussion, the instructor offered a prepared compromise between standards-based and average-based grading. Under this plan, each homework was organized around problems designed to test certain skills and concepts. The problems on which students struggled the most, as determined by homework performance, were replicated on the final exam with slight modifications. If students did better on a certain problem type on the final exam, this would then overwrite the previous homework grade. This was intended to preserve the motivation to focus on the homework, as students would not know ahead of time which problems would be replicated on the final, while still giving students a second chance to display mastery of more difficult skills.

The class quickly reached consensus on the new grading plan. Although approved by students, this represents our largest compromise of student autonomy to the desire to minimize confusion and contention among students. Since the compromise grading plan was designed and presented by the instructor, it cannot be considered a direct reflection of student preferences.

Students were neatly divided on the issue of grade granularity, with significant groups of students expressing preferences for coarse-grained, narrative feedback and fine-grained, rubric-based feedback (Figure 3b). In discussion, it became clear that most students wanted the benefits of both approaches, and preferred to integrate both types of feedback to the extent possible within the constraints of TA time and energy. The instructor relayed student feedback to the TAs, who developed a strategy of offering narrative feedback only when they detected specific conceptual errors underlying a student's answer. Students who made minor mistakes, or who struggled to make significant progress on a question, were referred to published solutions and to office hours.

## 5 LEARNING OBJECTIVES AND OUTCOMES

Context for Survey Results. Although we believe that our survey results are accurate, we must acknowledge the possibility of response bias. For example, students with generally positive feelings about the course might have attributed those feelings to the participatory governance intervention. The variety of student responses to different questions appears to make this less likely.
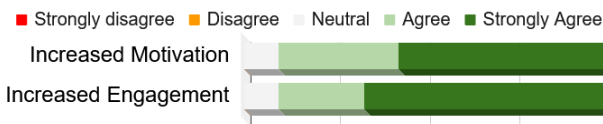
Figure 4: Student agreement with the statements "input into the structure of the course and assessment increased my motivation to do well in the course," and "engagement and interest in the course content," respectively. From the post-course survey (n=21).

Engagement. In a previous offering of CST, students expressed that a willingness on the part of course staff to modify the course structure allowed them to better meet their own needs. Moreover, students who initially struggled in CST renewed their efforts when they believed that the structure of the course would support them in doing so. In this iteration of the course, we observed a similar phenomenon. In the post-course survey, two thirds of student respondents strongly agreed with the statement that "input into the structure of the course and assessment increased my engagement and interest in the course content" (Figure 4).

Empowerment. We anticipated that increasing students' sense of agency would require careful balancing: we wished to give students more ways to exert control over the course without introducing undue confusion or anxiety.
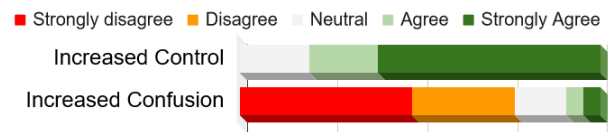
Figure 5: Student agreement with the statement "Input into the structure of the course and assessment increased my sense of control over my performance in the course," and "made course expectations more confusing," respectively. From the post-course survey (n=21).

Although we occasionally compromised both student control and student comfort, students self-reported a successful balance between the two goals. Most respondents to the post-class survey indicated that the chance to participate in course governance increased their sense of control over their performance in the course, while a majority reported *decreased* confusion as a result.
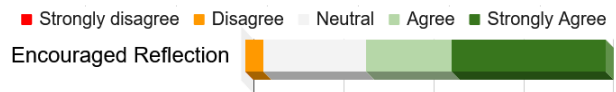
Figure 6: Student agreement with the statement "Input into the structure of the course and assessment made me think about the structure of my other courses." From the post-course survey (n=21).

Critical reflection. Students self-reported that participating in the governance of the course encouraged them to consider the structure of their other courses, although the effect was less pronounced than for engagement and empowerment. A plurality of students strongly agreed with the statement "Input into the structure of the course and assessment made me think about the structure of my other courses," but a substantial minority neither agreed nor disagreed with this statement (Figure 6). A plausible interpretation is that students fell into two categories: certain students were motivated to exert control over the learning environment, while others preferred to take the structure of the class as fixed and work within it. Absent a full understanding of the latter group, we respected their priorities: there are many reasons why a student might not wish to

pursue critical reflection in CST. In this case, we are content if our intervention did not detract from these students' course experience.

Achievement of Learning Objectives. Our changes to the way in which final grades were computed make an apples-to-apples comparison of grades between this and previous semesters impossible. However, we observed other strong indicators of student success. In particular, the opportunity to regain points on some of the most challenging problem types, including undecidability reductions and proofs using the context-free pumping lemma, appeared to motivate students to master these difficult concepts. Based on our limited evidence, our participatory governance intervention appears to have had a moderate positive effect on student performance.

6 LESSONS LEARNED AND OPPORTUNITIES

As summarized in Section 2.1, we anticipated that our students had little experience in analyzing and reconceptualizing their classroom spaces, and might respond with fear to the disruption of a well-understood classroom environment. These expectations were confirmed only in part: many thoughtful and proactive students surprised us with their willingness to contribute opinions and work to make a classroom better adapted to their needs and the needs of their peers. Emphasizing that our intention was not to increase confusion and inviting the class to participate in defining clear standards of success appeared to help. We recommend this tactic.

We were surprised to see students report a significant increase in engagement despite the fact that CST is a major requirement often taken out of obligation. Even if soliciting input from every student is impossible, as might be the case in a larger course offering, we speculate that simply surfacing the issue of student control can be an effective way to bring disengaged and disillusioned students back into conversation about their learning.

Demands on Course Staff. The time and effort required from the course staff was a significant practical concern when designing our participatory governance intervention. In practice, we found that most extra work for the primary instructor took place immediately before and during the first week of the course. The major components of this work included drafting high-level plans for alternative course structures, designing the variables of student control, soliciting and collating student opinions, and creating the modified course plan. Once the use of class time and grading procedures were established, the workload for the remainder of the semester was comparable to that of previous years. Our TAs voluntarily and enthusiastically took up the challenge of providing additional narrative feedback on problem sets. We expect that the maximum effort required from course staff could be scaled back by constraining the degree of student control over the grading process. While this change compromises student agency somewhat, it might be necessary to adapt our approach to larger courses. Such an adaptation would be an interesting extension to our work.

Adaptations for Other Student Populations. As part of our course design, we developed several strategies that can be adjusted depending on the level of autonomy with which students are comfortable. For example, a more conservative implementation of participatory governance might choose to simplify the structure of student control by making all decisions about classroom structure in the manner that we compromised between average-based and standards-based

grading: first, introduce students to the relevant options and their potential drawbacks and benefits. Second, solicit feedback anonymously. Third, incorporate student feedback into a plan designed by the course staff, with additional discussion and iteration on the plan to the degree permitted by the specific classroom environment. This preserves student autonomy in the initial anonymous survey, and in the subsequent discussion, while streamlining the process of finalizing a course structure.

In hindsight, we view this compromise as appropriate for our setting. Although more extensive discussions might have created more organic compromises, they might also have produced antagonism among students who felt strongly about one class structure or grading scheme. Moreover, we observed that some students preferred any grading scheme that was simple and clear over one that was complex or uncertain, regardless of how well the latter was aligned with consensus norms of accuracy or fairness. For these students, understanding the grading system was a prerequisite to optimizing their behavior to achieve their definition of success in the class, which was determined by a grade threshold.

Although we stressed the importance of discussion during the three phases of significant student input at the beginning, middle, and end of the course, the necessity of fully exploring the curriculum limited our time for discussion to around 2 in-person hours in total. In contrast, we can imagine a CS curriculum that prioritizes critical reflection among students to the extent that more classroom time and resources are devoted to this goal. In such a setting, more time could be devoted to introducing alternative course designs, and the course could be more thoroughly student controlled via an iterative process of discussion, consensus and ratification.

We are also optimistic about the scalability of the participatory governance intervention. If implemented at the major or classroom level, the fixed cost of educating students about the pedagogical possibilities of the CS classroom could be amortized over multiple different classes, and potential student anxiety could be mitigated by their acquired experience and confidence in shaping the structure of their own education. Of course, different student populations might opt for different class designs. In a setting with multiple sections of CST, a compromise strategy might be to adopt a single course design for the duration of one semester or academic year, while re-opening discussion in the subsequent semester or year to allow for continued evolution based on student preferences.

To summarize our experience, we observed that the two goals of effectively teaching the fundamentals of CST and empowering students to take control over their education are sometimes in tension: students experience a natural anxiety when asked to interrogate and perform their learning in new ways. However, we found that the risks were justified by clear benefits: increasing student control had a direct and surprisingly powerful impact on student engagement, empowerment and critical reflection.

REFERENCES

[1] Gökçe Akçayır and Murat Akçayır. 2018. The flipped classroom: A review of its advantages and challenges. *Computers & Education* 126 (2018), 334–345.

[2] Jacob Bishop and Matthew A Verleger. 2013. The flipped classroom: A survey of the research. In *2013 ASEE Annual Conference & Exposition*. 23–1200.

[3] Charles C Bonwell and James A Eison. 1991. *Active learning: Creating excitement in the classroom. 1991 ASHE-ERIC higher education reports*. ERIC.

[4] Nathan Brunelle and David Evans. 2022. Comfortable Cohorts and Tractable Teams: Making Large Computing Theory Courses Feel Small. In *Proceedings of the 53rd ACM Technical Symposium on Computer Science Education-Volume 1*. 717–723.

[5] Ricardo Caceffo, Guilherme Gama, and Rodolfo Azevedo. 2018. Exploring active learning approaches to computer science classes. In *Proceedings of the 49th ACM Technical Symposium on Computer Science Education*. 922–927.

[6] Joe D Chase and Edward G Okie. 2000. Combining cooperative learning and peer instruction in introductory computer science. In *Proceedings of the thirty-first SIGCSE technical symposium on Computer science education*. 372–376.

[7] Lijun Chen, Joshua A Grochow, Ryan Layer, and Michael Levet. 2022. Experience report: Standards-based grading at scale in algorithms. In *Proceedings of the 27th ACM Conference on on Innovation and Technology in Computer Science Education Vol. 1*. 221–227.

[8] Catherine H Crouch and Eric Mazur. 2001. Peer instruction: Ten years of experience and results. *American journal of physics* 69, 9 (2001), 970–977.

[9] Paulo Freire. 1996. Pedagogy of the oppressed (revised). *New York: Continuum* 356 (1996), 357–358.

[10] John Hamer, Quintin Cutts, Jana Jackova, Andrew Luxton-Reilly, Robert McCartney, Helen Purchase, Charles Riedesel, Mara Saeli, Kate Sanders, and Judithe Sheard. 2008. Contributing student pedagogy. *ACM SIGCSE Bulletin* 40, 4 (2008), 194–212.

[11] Qiang Hao, Bradley Barnes, Ewan Wright, and Eunjung Kim. 2018. Effects of active learning environments and instructional methods in computer science education. In *Proceedings of the 49th ACM Technical Symposium on Computer Science Education*. 934–939.

[12] Susan Horwitz, Susan H Rodger, Maureen Biggers, David Binkley, C Kolin Frantz, Dawn Gundermann, Susanne Hambrusch, Steven Huss-Lederman, Ethan Munson, Barbara Ryder, et al. 2009. Using peer-led team learning to increase participation and success of under-represented groups in introductory computer science. *ACM SIGCSE Bulletin* 41, 1 (2009), 163–167.

[13] Danielle L Iamarino. 2014. The benefits of standards-based grading: A critical evaluation of modern grading practices. *Current Issues in Education* 17, 2 (2014).

[14] Sebastian Krings. 2022. Experience report on a student-organized ai course. In *Proceedings of the 27th ACM Conference on on Innovation and Technology in Computer Science Education Vol. 1*. 103–109.

[15] Clifton Kussmaul. 2012. Process oriented guided inquiry learning (POGIL) for computer science. In *Proceedings of the 43rd ACM technical symposium on Computer Science Education*. 373–378.

[16] Eric J Mayhew and Elizabeth Patitsas. 2023. Critical Pedagogy in Practice in the Computing Classroom. In *Proceedings of the 54th ACM Technical Symposium on Computer Science Education V. 1*. 1076–1082.

[17] Linda B Nilson and Claudia J Stanny. 2015. *Specifications grading: Restoring rigor, motivating students, and saving faculty time*. Routledge.

[18] Esko Nuutila, Seppo Törmä, and Lauri Malmi. 2005. PBL and computer programming—the seven steps method with adaptations. *Computer science education* 15, 2 (2005), 123–142.

[19] Johanna Pirker, Maria Riffnaller-Schiefer, and Christian Gütl. 2014. Motivational active learning: engaging university students in computer science education. In *Proceedings of the 2014 conference on Innovation & technology in computer science education*. 297–302.

[20] Richard M Ryan and Edward L Deci. 2016. Facilitating and hindering motivation, learning, and well-being in schools: Research and observations from self-determination theory. In *Handbook of motivation at school*. Routledge, 96–119.

[21] Michael Shindler, Matt Ferland, Aaron Cote, and Olivera Grujic. 2020. Experience report: preemptive final exams for computer science theory classes. *Journal of Computing Sciences in Colleges* 35, 10 (2020), 9–14.

[22] Robert E Slavin. 1980. Cooperative learning. *Review of educational research* 50, 2 (1980), 315–342.

[23] Cynthia Taylor, Jaime Spacco, David P Bunde, Andrew Petersen, Soohyun Nam Liao, and Leo Porter. 2018. A multi-institution exploration of peer instruction in practice. In *Proceedings of the 23rd Annual ACM Conference on Innovation and Technology in Computer Science Education*. 308–313.

[24] Elli J Theobald, Mariah J Hill, Elisa Tran, Sweta Agrawal, E Nicole Arroyo, Shawn Behling, Nyasha Chambwe, Dianne Laboy Cintrón, Jacob D Cooper, Gideon Dunster, et al. 2020. Active learning narrows achievement gaps for underrepresented students in undergraduate science, technology, engineering, and math. *Proceedings of the National Academy of Sciences* 117, 12 (2020), 6476–6483.

[25] Carol Ann Tomlinson. 2000. Reconcilable differences: Standards-based teaching and differentiation. *Educational leadership* 58, 1 (2000), 6–13.

[26] Carol Tomlison and Jay McTighe. 2006. Integrating differentiated instruction and understanding by design. *Alexandria, VA., Association for Supervision and Curriculum Development* (2006).

[27] Iman YeckehZaare, Sean Shixuan Chen, and Tirdad Barghi. 2023. Reducing Procrastination Without Sacrificing Students' Autonomy Through Optional Weekly Presentations of Student-Generated Content. In *Proceedings of the 54th ACM Technical Symposium on Computer Science Education V. 1*. 151–157.

[28] Daniel Zingaro. 2014. Peer instruction contributes to self-efficacy in CS1. In *Proceedings of the 45th ACM technical symposium on Computer Science Education*. 373–378.