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NOTES FROM THE FIELD

The Thinking Classroom in a College Setting: A Case Study

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Introduction

Peter Liljedahl describes a Building Thinking Classrooms (BTC) framework that shows teachers how to set up a classroom that promotes thinking. BTC is divided into 4 toolkits. The first toolkit consists of thinking tasks, vertical non-permanent surfaces, and visibly random groups. The second pertains to defronting the classroom, giving thinking tasks verbally and early while standing, voluntary homework, and mobilizing knowledge. The third consists of using hints and extensions to maintain flow, consolidating, and students writing meaningful notes. The fourth toolkit involves assessment.

Though Liljedahl's research pertains to K-12 classrooms, the framework sounded promising for higher education as well. We decided to try it in a college-level calculus I course, taught at a small liberal arts college in the spring semester. There were 15 math and computer science students enrolled. The class met twice a week for 2 hours each day over a 13-week semester. There was one professor and two teaching assistants. We applied most of the aspects of the toolkits to see if the framework was upheld in a higher education setting.

Course Design and Implementation

To plan the course, we listed learning goals divided into limits, differentiation, applications of differentiation, and integration (https://tinyurl.com/calculusLearningObjectives). Next, we produced assessment questions for each learning outcome, including an advanced and beginner category.

Next, we designed the lessons. A thinking task is one that promotes students to think rather than mimic the teacher. In a K-12 classroom it is suggested to use the beginning days to do non-curricular tasks so that students can experience a thinking classroom. Since our class met only twice a week, we used the first day for non-curricular tasks and introduced the culture of the classroom. After the first class meeting, we moved on to learning the curriculum. We primarily used thin slicing, giving a list of problems that get progressively more difficult. To launch these, we followed Liljedahl's suggestion of connecting the new topic to previous knowledge. Here is an example dialogue to launch the derivative of log functions, using previous knowledge of derivatives of exponential functions, implicit differentiation, and inverse functions.

Teacher: If $y = e^x$ what is $\frac{dy}{dx}$?

Student: e^x.

Teacher: How are logarithms and exponentials related?

Student: They are inverses.

Teacher: How can we re-write $y = ln\ (x)$ as an exponential? [if needed remind students that ln is the same as $\log_e$].

Student: $e^y = x$.

Teacher: We ultimately want to find $\frac{dy}{dx}$, the derivative of $ln\ (x)$. Since we already know the derivative of an exponential function, what technique can we use here?

Student: Implicit differentiation.

Then, students worked in visibly random groups on vertical whiteboards. The non-permanence of the boards gives students permission to make mistakes. Since the boards are vertical and placed around the classroom, students stand as they work, keeping them more engaged by discouraging anonymity and keeping them physically active. We gave one marker per group to discourage students from working individually.

After students completed the problems, we consolidated their learning by holding a class discussion on the problems and making connections to the learning goal. This was followed by individual time where students practiced and wrote notes.

For assessment, we utilized check (2 points), check minus (1 point), and X (0 points) symbols on their learning goal sheet correlating to a points system. To receive full credit on a learning goal, students must achieve a check in the basic column and 2 checks in the advanced column for that topic. Our main source of assessment was weekly quizzes. Students could retake each quiz at their own discretion. Oftentimes, learning goals were repeated on later quizzes, giving students multiple opportunities to show understanding. The main benefit is that students can achieve every learning goal at any point in the semester.

We also assessed through a portfolio. We set up a portfolio template in Google Slides (https://tinyurl.com/calculusPortfolio). Each week we gave time in class for students to write a reflection in their portfolio. At the end of each unit there was a reflection with questions pertaining to critical thinking, communication, collaboration, and creativity. The final part of the portfolio was for students to show how they achieved each learning goal.

Framework Modifications

One part of the framework we were not able to utilize was defronting the classroom because we had to share our classroom, making it infeasible to change its configuration. One aspect we changed was giving tasks while standing. While students stood most of the class, we realized that with a two-hour class they did need some seated time. We sometimes launched tasks verbally and sometimes used a set of slides, especially if a visual was needed. The framework suggests homework should not be graded or checked. We modified this by using a courseware system to assign homework. The homework did count towards their grade, but students could make as many attempts as they wanted, getting feedback after each attempt.

Student Interest & Engagement

We gauged students' interest in mathematics before, during, and after the semester. On the first day we used non-curricular BTC tasks. Students expressed they were unfamiliar with BTC tasks and described aspects of mimicking behaviors in previous math classes. One student stated, "Most of my math classes were strictly based on memorization rather than learning math itself." We discussed BTC through an interactive syllabus that outlined the framework and expectations alongside reflective questions. We shared the framework with students to justify why we were running the course this way. Subsequently, students felt that sharing their ideas would be the most difficult part because they get nervous or are not good at communication.

A few weeks into the semester, seven out of 15 students volunteered for an 8-10 minute semi-structured interview to discuss the course so far. Four students seemed to prefer a student-centered classroom, two liked a mix, and one preferred lecture because "that is what I am used to." They all had positive things to say about the class environment and learning techniques. Many preferred groupwork over lectures.

Students appreciated that they could learn from their mistakes. One student said, "In my other math classes, there's a really big difference. With this one, if you make a mistake and realize after, you can go back and fix it."

While students felt nervous about sharing their ideas at the start of the semester, many expressed feeling more comfortable doing so several weeks into the course. One student said, "Everyone respects everyone's opinions here and helps each other out."

In the end of semester portfolio, all students made positive comments about working in groups. "Having the ability to work in groups really strengthened my experience with this course. I enjoyed how I was also able to connect with the other students in the class in a positive way."

We monitored and measured student engagement during 13 consecutive classes in the second half of the semester by observing how often students passed the marker, provided input in their group, and sought assistance through intergroup collaboration. Passing the marker showed more than one student was engaged in the problem. Input in their group showed that students were engaging in discussions rather than independently solving problems. Seeking assistance through intergroup collaboration led to students being more reliant on their peers, thus being more engaged. Based on the high participation in these three categories, it was evident that students were engaged through these actions.

Homework

Each homework assignment had a due date, but students were allowed to continue working on them throughout the semester. Thus, providing homework grades as proof of achievement would not be useful, but it is worth noting the homework completion percentages. In this course, homework completion rates were high. Only one student completed less than 93% of the assignments because they stopped all class activities in the last month of the semester.

Achievement

Figure 1 depicts the grade distribution for learning goal achievement in each unit.

The numeric-to-letter grade distribution is as follows: A = 90-100, B = 80-89, C = 70-79, D = 60-69, F = 0-59. That is, students who scored an A in each unit achieved a minimum of 90% of the learning goals, and so on. Many students earned an A for every unit, making us believe that learning truly was present throughout the course.

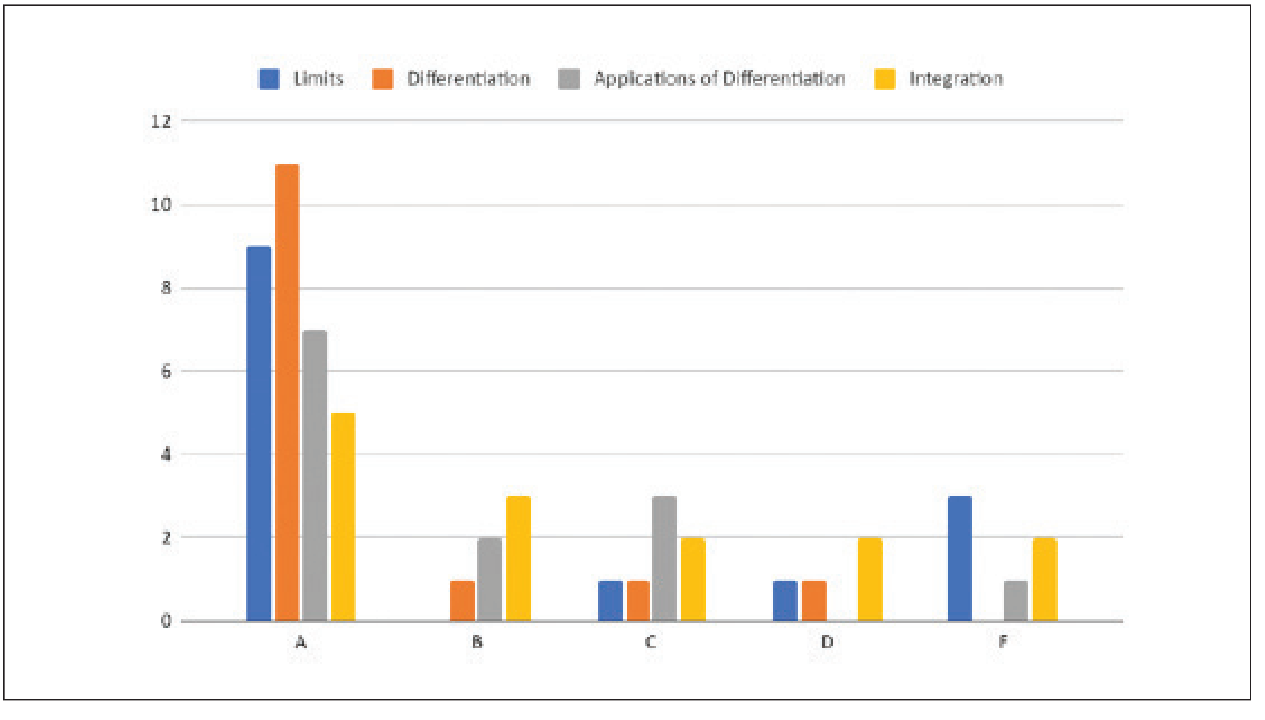
The last unit on differentiation had the fewest A's, as students did not have as many opportunities to demonstrate their learning on this topic. That also provides evidence that students were taking advantage of the opportunity to get more checks in earlier topics when they had more time. This differs from a traditional classroom, where most students are given one opportunity (typically a unit exam), to demonstrate learning prior to moving on to the next unit.

Lessons Learned

There are some areas of BTC that we would like to work on, the first being homework. It would be helpful to clearly state what learning objectives are associated with each homework question and have students keep a log of which learning goals they were able to achieve. Therefore, students take ownership over their learning and become more familiar with the learning goals, making it easier for them to understand our assessment practices.

For the portfolio, we thought the reflections were meaningful. However, it felt as though students were simply complying with this requirement and not thinking of it as a learning tool.

Figure 1
Grade Distributions



We would like to try BTC in additional semesters to get a better understanding of how different students pursuing various majors respond to BTC. We would also like to try this again after the COVID-19 pandemic has subsided.

What Went Well

Instructing a college course with BTC strategies brought forth many positives, including a strong sense of class community, high levels of participation and thinking, and assessment practices that students liked. The classroom community was evidenced by friendships that formed as well as observing interactions between students and comments from the portfolio such as, "everyone respects everyone's opinions here and helps each other out." Additionally, in contrast with other courses offered at our college, students consistently participated in class. This was made apparent through observations and discussions with students as we circulated between the groups. Finally, weekly quizzes were well received in this course, with students citing the opportunity to retake quizzes as particularly helpful.

Conclusion

Utilizing BTC in a college setting made student interest in the course content high, led to a high rate of homework completion, brought forth student engagement, made student learning evident, and developed a strong sense of classroom community. Although some students still preferred direct instruction, many students expressed their enjoyment of a student-centered classroom. Therefore, based on our experiences, we believe that the BTC framework can be successfully implemented in a college mathematics setting with appropriate modifications.

References

Liljedahl, P. (2021). *Building Thinking Classrooms in mathematics: 14 teaching practices for enhancing learning*. Corwin.