PROMISING PRACTICE

Developing Our Teaching Praxis Using a Japanese Lesson Study Model Applied to Corequisite Mathematics

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In 2003, the Texas State Legislature enacted the Texas Success Initiative (TSI). The Texas Higher Education Coordinating Board (THECB) coordinates the implementation of this mandate at both universities and community colleges across the state. Upon entering a postsecondary institution, non-exempt students are tested using the TSI Assessment (TSIA2), a 2021 revision of the initial TSI Assessment. A student's scores are used to assist Texas public institutions of higher education in determining if students are prepared for introductory college coursework in the areas of English Language Arts and Reading (ELAR) and mathematics. Students can be exempted from the TSIA2 if they meet college readiness standards on the SAT, ACT, or end-of-course examinations in math and language arts or successfully complete a Texas high school college preparatory course, which is available to all students enrolled in a public Texas high school.

Since 2017, students who are deemed not college-ready on the TSIA2 in either of the two areas are enrolled in a corequisite sequence (e.g., co-enrolled in a non-credit developmental education class and an entry-level credit-bearing course in the same subject within the same semester). Ideally, the developmental course provides support that is "aligned directly with the learning outcomes, instruction, and assessment of the entry-level credit course, and makes necessary adjustments as needed to advance students' success in the entry-level course" (Texas Higher Education Coordinating Board, n.d., para. 3). This is sometimes referred to as just-in-time support.

At many Texas universities, including Texas State University (TXST), students are placed in either a stand-alone for-credit college mathematics class or in a college corequisite sequence based on their TSIA or exempt status. For example, College Algebra (MATH 1315) is paired with Intermediate Algebra (MATH 1311), or Survey of Contemporary Mathematics (MATH 1316) is paired with Elementary Algebra (MATH 1300). Over the last several semesters, Texas State University has enrolled more and more students in the corequisite mathematics class. This increasing influx of students has led to both new lecturers and additional graduate students being assigned to teach these classes.

Developing a Teaching Praxis

Often, graduate students and new instructors are given their teaching assignments within a

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week or two before a semester begins. This very short preparation time led to the development of this project. As new instructors for the MATH 1316/1300 course at Texas State University, while wading through the available material for the class, the collaborative nature of our department led us to seek out each other during the planning. This article describes the implementation of the Japanese lesson study model by three doctoral teaching assistants at TXST with the dual goals of improving our own teaching practices and creating more engaging and relevant lessons for a non-STEM mathematics co-requisite class.

A Practice with Long Traditions

The century-old Japanese practice of "jugyou kenkyuu," in which jugyou means instruction and kenkyuu means research, was not seen in the English-speaking world until the 1990s (Lewis, 2009). The English translation, lesson study, serves as an umbrella term for the collaborative cycle of teachers researching instructional material, planning classroom teaching and activities, and the discussion, reflections, and revisions that follow implementation. After the revisions, the process continues. Participation in the process is typically voluntary with the goal of continual improvement of both the lesson plan and the teaching practice of the contributing instructor-researchers. The iteration of the lesson study cycle and the sharing of the lessons with others leads to tested lessons that better meet the learning needs of the students while also helping instructors improve their teaching practice.

This article describes the implementation of the Japanese lesson study model by three doctoral teaching assistants at TXST with the dual goals of improving our own teaching practices and creating more engaging and relevant lessons for a non-STEM mathematics co-requisite class.

Moss et al. (2015) recognize the traditional four-stage model of lesson study used by Lewis et al. (2009) and Lewis (2016), which includes goal setting for the study, research and planning of the targeted lesson, implementation of the researched lesson, and finally debriefing and reflection. However, they include four additional stages to the traditional model, which adds engagement with the mathematics, clinical interviews about the targeted lesson, the design and implementation of exploratory lessons, and the creation of resources for other educators. Because our lesson study was designed to be brief, we were unable to incorporate all eight stages described by Moss et al., but we did add two of the four additional stages: (a) as instructors, we engaged with the mathematics, and (b) we created resources for other educators. In fact, the creation of sharable resources was one primary goal at the beginning of the project. Improving our own teaching practice was the other.

Project Birth as Professional Development

After being assigned two sections each of MATH 1316 Survey of Contemporary Mathematics, we decided to collaborate on this lesson study project with two main objectives. First, being new to teaching this course, we each wanted to improve our own practices; second, after looking through the publisher's materials, we wanted to create some lesson materials that were more engaging for the students that could eventually be shared with other graduate students and new instructors of this course.

Our lesson study began with an investigation. We surveyed past and present instructors of the course at TXST to get their help in determining the lessons that would be good targets for the lesson study. We decided to include lessons on combining probabilities, savings plans, and the normal distribution. The consensus was that these lessons were the most difficult for students and needed thoughtful revisions. These lessons were also spaced throughout the semester in a way that allowed us to create a lesson, implement, observe, discuss, and reflect, and then start the process of creating the next lesson while we revised the first one.

We met weekly to collaboratively create each lesson, with each of us taking the lead on one lesson. Our primary objective was to create lessons that foster students' participation with active learning in class in ways that are relevant and interesting. We structured our lessons on a practice often used in mathematics classes that is sometimes called "I do, we do, you do." In this format that supports the gradual release of responsibility and the transition to self-directed learning (Fisher & Frey, 2021), the instructor works an example for the class; next, the instructor works an example with the class, providing answers to prompts that complete the problem; finally, the students are tasked with working an example in pairs or small groups. The combining probabilities lesson was the first to be implemented and observed.

Lesson Implementation and Review

We each implemented the lessons in our classes and observed each other's teaching. When teaching, we committed to teaching the lesson as created, and we tried to limit any extemporaneous additions or improvisations. When observing each other, we focused on answering two primary questions:

- Does the lesson lead to quality student interactions and engagement?
- Do the examples and the problems in the lesson seem to be relevant to the students?

We collected exit tickets from each student at the end of each lesson designed to help us learn where the students still had gaps; we used the exit tickets to make decisions about how to revise and improve lessons and help us know what areas to review further during the current semester. We also tried to gauge how relevant the students considered the lesson's topic.

After teaching and observing the first lesson on probability, we learned two things. First, few of our students had a frame of reference for playing cards. We thought the standard 52-card deck was ideal for illustrating combined probability, so our first lesson was peppered with examples based on cards. The students knew little about the organization of playing cards in terms of ranking, colors, and suits. If we wanted to use cards for examples, we would need to build a frame of reference first or choose more relevant examples. Second, during the "you do" sections of the lesson, many students just stared at their papers, waiting to be told the answer instead of engaging with the mathematics. Many had been exposed to this teaching strategy before and understood they could wait out the example and eventually be shown the answer. We needed a way to address this problem. After reflecting and discussing the lessons and reading through the exit tickets collected from students, we also concluded that we needed to find relevant examples that were more closely tied to the students' lived experiences. We incorporated both of these into the redesign of the first lesson and the initial designs of the second and third lessons. An important goal of the lesson study approach is continual improvement and increased knowledge for the instructor (Dick et al., 2022; Mohammed & Sakyi, 2022), but also improvement of the lesson being studied (Berk & Hiebert, 2009).

Adapting the lessons to include more scaffolding in the group work problems was fairly easy to accomplish. Clearly, there is a tension between not providing enough and providing too much. We planned to be very cognizant of this when observing future lessons so that we could strike a balance in further redesigns. For the second lesson on savings plans, we included scaffolding questions for all the examples worked in the lessons so that when students were completing the "you do" example, they would understand how to answer the scaffolding questions and be better guided to complete the problem (see Appendix A). We modeled answering the scaffolding problems in the "I do" and "we do" examples. After working through the examples with the added questions, students seemed better able to work through "you do" example with the added scaffolding. We also revised the probability lesson to include the creation of a decision tree during the lesson that students could use when working on problems that would help them choose the correct type of probability formula to use and solve the problem correctly. In this instance, we helped the students create their own scaffolding that they would be able to use in probability problems.

The Connection Between Relevance and Engagement

During the revision process, we also began researching strategies for creating relevant and engaging problems. We found a problem-posing framework by Stylianides and Stylianides (2014) that we began using. These researchers proposed design and implementation features for problem solving that dovetailed with our study goals of creating engaging lessons. They suggested that "(1) the problem should have a memorable characteristic (e.g., name, context); (2) the problem should initially seem unsolvable; (3) the problem includes few clearly identifiable mathematical referents (numbers and formulas) that by themselves offer insufficient information for its solution; and (4) the solution to problem should be within the students capability after perseverance (and support from peers or limited instructor scaffolding)" (Stylianides & Stylianides, 2014, p. 11).

This problem-posing framework caused us to rethink the examples we created in the probability section. We jettisoned most of the cards and dice problems that we originally formed the lesson around and instead created a series of examples we called "The Tootsie Pop Problem" (see Appendix B). This example illustrates how we used the problem-posing framework of Stylianides & Stylianides (2014) to create examples. We used the "Tootsie Pop Problem" to work through creating the decision tree that students could use as scaffolding and support while learning to do combined probability problems. When observing during the second cycle of teaching the probability lesson, we noticed that the students were immediately interested in the bag of Tootsie Pops, as compared to when we used examples with cards.

We are in the process of revising another set of combined probability group work problems that revolve around jury selection. The students we teach are over 18 years of age, so the possibility of being selected for a jury is something they are becoming familiar with. We are also tying issues of race and ethnicity in the jury make-up, which can lead to discussion of how a jury may or may not seem to be a jury of peers of the person on trial. One objective of this example is to highlight the connection between what we learn in math and the things they are learning in other classes, such as history, political science, or sociology.

In the savings plan lesson, many of our examples included saving for a house. When teaching and observing this lesson, we realized that homeownership was outside of the experience of many of our students. Additionally, they did not expect to ever buy a house, so these examples felt irrelevant. During our reflection, we noted the need to consider the experiences of our students while creating examples more carefully. For this lesson, we revised the lesson to include examples about saving for the down payment on a car, saving for a vacation, and saving for retirement after getting a job after college. To further increase relevance, we had students look up the possible salaries for jobs they might apply for after graduation and estimate a salary for that to use to budget and save. We also planted seeds about retirement savings by including examples that demonstrated how small amounts of money could grow to large amounts over time with compounded interest and a structured savings plan. The students were much more engaged with problems that asked them to save for something they could see themselves buying, such as a vacation or a car. One student remarked, "It's real-world math that can be applied one day. To me, this is math . . . " and from another, "This . . . has helped me learn to better understand aspects of the real world." For our final lesson on the normal distribution, we focused the examples on things we know students have experience with, such as standardized test scores, grades, and height. At one MATH 1316/1300 teaching forum meeting, someone asked if we could create an example to show what "curving grades" really means. We are still revising this example, but the students seemed to develop better understanding of *z-scores* when the example dealt with grades.

To further increase relevance, we had students look up the possible salaries for jobs they might apply for after graduation and estimate a salary for that to use to budget and save.

A Lesson Study Example Timeline

In late July of 2022 at Texas State University, doctoral teaching assistants in the Department of Mathematics were assigned courses to teach. Several doctoral students were assigned as instructors of record for the co-requisite course MATH 1316/ MATH 1300. One of our authors emailed all of the instructors and asked if any would be interested in working on a lesson study project over the course of the semester. Two authors agreed, and the project was born. We recruited a professor in the math department as a project advisor; then, we began our collaboration. Our first step was to develop a consensus around what lessons to include. We surveyed experienced instructors to obtain input. After reviewing the responses and coordinating our course calendars, we decided on the three lessons for the project. The first of these lessons was to be taught in week 5 of the semester. Prior to this, we met weekly to collaboratively plan the lesson and communicated often outside of our weekly meetings. During weeks 1–4, we engaged with the mathematics (stage 1 of Moss et al., 2015), set goals for our area of investigation (stage 2 of Moss et al., 2015), and planned the research lesson (stage 5 of Moss et al., 2015). In week 5, we each taught the lesson in our own classes. We also each observed at least one teaching session of another team member. Our project advisor also observed lessons. This corresponds to stage 6 of Moss et al. (2015). We completed observation notes about each other's teaching and self-reflections on our teaching. The following week, we met to discuss and debrief the lesson and reflect on what went well and what aspects needed improvement (stage 7 of Moss et al., 2015). Over the next 3 weeks, we worked together to create the second lesson and revise the first lesson. The teach, discuss and reflect, revise cycle was repeated for lessons two and three. Each lesson was spaced approximately four weeks apart so that we had time to reflect on the previous lesson while also creating the second lesson. Over the winter break, we continued to revise the three lessons with the plan to teach the amended lessons in the spring semester. Two of us were assigned to teach the course the following semester. We implemented the revised lessons with one author only serving as an observer. At the end of the spring semester, we had completed the second cycle of the process: teaching, reflecting/ discussing, and revising. At this point, we have three revised lessons available to share with our teaching forum, and we are sharing our process and results with a wider audience, corresponding to stage 8 of the Moss et al. model.

Future Directions

Two of us continue to teach MATH 1316 at TXST, and we continue to revise and improve these lessons. The lessons are available to instructors of MATH 1316/MATH 1300 at TXST. Although we see these lessons as works in progress with the goal of continual improvement, we are happy to share them with anyone who is interested. We have encouraged other instructors who teach MATH 1300/1316 at TXST to collaborate on creating and revamping lessons using the lesson study model and then share with our course forum. Additionally, we agree that lesson study is an interesting and valuable undertaking for graduate teaching assistants. We are continuing to explore how lesson study can be used for professional development. The project made all of us better instructors. In our observations, we each noted how the others had gained confidence with the lesson topics; we all reflected on our increased teaching efficacy and improved content knowledge that we gained from observing each other teach the lesson. We learned from collaboration, observation, and reflection in ways that we would have missed had we worked alone. A second avenue for further study is how to make examples more relevant to students. This can be especially important for non-STEM majors who do not always see a direct connection between mathematics and their future. Every math teacher has heard, “How will I use this in real life?” or “When will I ever use this?” Creating lessons that answer these questions before they are asked or are interesting enough to forestall the question entirely makes both teaching math and learning math better for everyone. We are on a journey to both develop ourselves professionally and create more meaningful lessons for our students through the collaborative lesson study process. We invite you to find a friend or colleague and come along.

References

Berk, D., & Hiebert, J. (2009). Improving the mathematics preparation of elementary teachers, one lesson at a time. *Teachers and Teaching, 15(3), 337–356.* https://doi.org/10.1080/13540600903056692

Dick, L. K., Appelgate, M. H., Gupta, D., & Soto, M. M. (2022). Continuous improvement lesson study: A model of MTE professional development. *Mathematics Teacher Educator, 10(2), 111–128.* https://doi.org/10.5951/mte.2020.0077

Fisher, D., & Frey, N. (2021). *Better learning through structured teaching: A framework for the gradual release of responsibility*. ASCD.

Lewis, C. C., Perry, R. R., & Hurd, J. (2009). Improving mathematics instruction through lesson study: A theoretical model and North American case. *Journal of Mathematics Teacher Education, 12(4), 285–304.* https://doi.org/10.1007/s10857-009-9102-7

Lewis, C. (2016). How does lesson study improve mathematics instruction? *ZDM, 48(4), 571–580.* https://doi.org/10.1007/s11858-016-0792-x

Mohammed, A., & Sakyi, E. (2022). Effect of lesson study continuous professional development on mathematics teachers’ pedagogical competence and perceptions of changes in their classroom practices. *International Journal of Current Science Research and Review*, *5*(4), 987–997. https://doi.org/10.47191/ijcsrr/v5-i4-15

Moss, J., Hawes, Z., Naqvi, S., & Caswell, B. (2015). Adapting Japanese lesson study to enhance the teaching and learning of geometry and spatial reasoning in early years classrooms: a case study. *ZDM*, *47*(3), 377–390. https://doi.org/10.1007/s11858-015-0679-2

Stylianides, A. J., & Stylianides, G. J. (2013). Seeking research-grounded solutions to problems of practice: Classroom-based interventions in mathematics education. *ZDM*, *45*(3), 333–341. https://doi.org/10.1007/s11858-013-0501-y

Texas Education Agency. (n.d.). *The TSIA (Texas Success Initiative Assessment).* https://tea.texas.gov/academics/college-career-and-military-prep/the-tsia-texas-success-initiative-assessment

Texas Higher Education Coordinating Board. (n.d.). *Developmental education.* https://www.highered.texas.gov/our-work/supporting-our-institutions/success-standards-policies/developmental-education/

Appendix A

"I do" Example with Scaffolding Questions

Example: IRA and CD (Individual Retirement Account -Certifies Deposit)
Suppose you want to invest $300 for every month for 5 years.

Different banks offer different rates. Here are three banks that offer different APR:

a. Discover offers 3.50% for 5 years. (I do)
b. Synchrony Bank offers 3.81% for 5 years. (We do)
c. Alliant Credit Union offers 3.65% for 5 years. (You do)

Let's figure out how much we can expect to make after 5 years depositing $300 each month with the different APRs.

a. Discover offers 3.50% for 5 years. (I do).

Step 1: Let's use the question to figure out what we have. Find this in the initial problem.

A = what we are looking for
PMT = $300
APR = 3.5% or .035
n = 12 (each month)
Y = 5

Step 2: What formula do we need?

$$A = PMT\,\frac{\left[\left(1+\frac{APR}{n}\right)^{(nY)}-1\right]}{\left(\frac{APR}{n}\right)}$$

Step 3: Plug in what we know into the formula.

$$\mathrm{A} = 300\ \times \frac{\left[\left(1+\frac{.035}{12}\right)^{(12)(5)}-1\right]}{\left(\frac{.035}{12}\right)}$$

Step 4: Simplify. Use your calculator. Be sure to include all the needed parentheses. (Have students practice this with their calculators).

$$\mathrm{A} = 300\ \times \frac{\left[(1+\ .002916667)^{(60)}-1\right]}{(.002916667)}$$

$$\mathrm{A} = 300\ \times \frac{\left[(1.002916667)^{(60)}-1\right]}{(.002916667)}$$

$$\mathrm{A} = 300\ \times \frac{[(1.190942829-1]}{(.002916667)}$$

$$\mathrm{A} = 300\ \times \frac{(.190942829)}{(.002916667)}$$

$$\mathrm{A} = \$19{,}639.83$$

Interpret what we found. *What is A?*

Accumulated balance or the amount of money in the account after 5 years. This included monthly payments and interest.

How much was deposited over the 5 years?

Amount deposited without interest: $300 a month for 5 years = 300(12)(5) = $18,000.

How much interest was earned?

Interest earned = Accumulated balance – the amount deposited each month over the time period
$19,639.83-18,000 = $1639.83 in interest.

Appendix B

A Relatable Problem

(Based on the Framework of Stylianides & Stylianides, 2014.)

Opening Problem/Exploration-The Tootsie Pop Problem (interesting name)

Review-Connect to Prior Learning (context and mathematical referents)

In this bag of 40 Tootsie Pops there are:

- 13 cherry
- 11 raspberry
- 7 grape
- 5 chocolate
- 4 orange

To find the probability of A, choosing a chocolate tootsie pop, is found by:

$$P(A) = \frac{number\ of\ ways\ A\ can\ occur}{total\ number\ of\ outcomes}$$

$$P(A) = \frac{5}{40} = \frac{1}{8} = .125\ or\ 12.5\%$$

Combined probabilities happens when more than one thing is happening, and we need to find multiple probabilities.

Example

What is the probability of randomly picking a raspberry and a then grape, one after the other (without replacement)?

General discussion about how we might figure this out **(seems unsolvable)**.

Example

Suppose we chose raspberry and orange. How might we figure out the probability of choosing both of these flavors one after the other? Ideas?

Try to elicit the idea of dependence here. This leads into the lesson and we eventually solve the problem.