Preliminary Findings Regarding Student Learning from Lecture and Homework

Hadlee Shields
Oklahoma State University

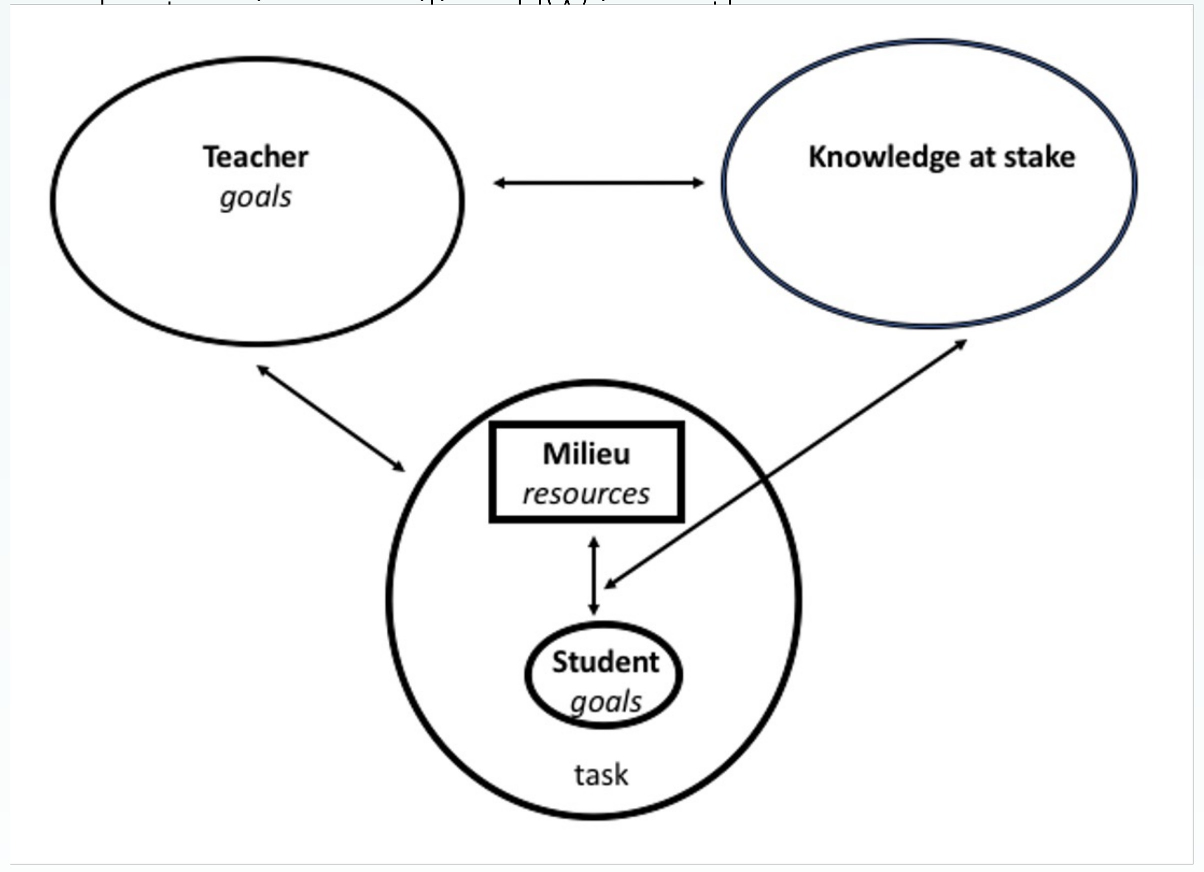
Allison Dorko
Oklahoma State University

Abstract

Lectures and homework both provide opportunities for students to learn mathematics. Researchers have focused on learning from lectures (e.g., Krupnik et al., 2018; Lew et al., 2016; Lew & Zazkis, 2019) and from homework (e.g., Dorko, 2021; 2020a, 2020b; 2019; Ellis et al., 2015; Glass & Sue, 2008; Kanwal, 2020; Krause & Putnam, 2016; Lithner, 2003; Rupnow et al., 2021). However, these studies have focused on each milieu individually. Dorko and Cook (R&R, 2022) propose attending to learning across the two settings is critical for improving student learning in both settings. To that end, our study addresses the questions (1) *What did two developmental mathematics students learn in lecture and what did they learn from homework?* and (2) *How can we explain why they learn particular things in a particular context?*

Theoretical Perspective

- Instructional triangle (Cohen et al., 2005; Dorko, 2021; Herbst & Chazan, 2012): instruction is the interactions among teachers and students around content, in environments
- Milieu: a space in which interactions around mathematical tasks occur



Literature

Though student learning from online homework is a relatively new focus for undergraduate mathematics education researchers, studies have shown:

- Online homework is as effective as paper-and-pencil homework (Dorko, 2020).
- Most successful US college calculus programs have an online homework component (Ellis et al., 2015).
- Students commonly rely on example problems to complete homework.
  - In one study, 84.7% of students reported using worked examples while doing homework.

When completing online homework students used reasoning that included (Dorko 2021, 2020)

- Mathematical thinking
- Guessing
- Copying answers from various sources
- Mimicking the steps of a similar problem
- Reasoning based on expectations from experience

Students learn the procedures from online homework problems, but rarely develop the conceptual insights professors hope some problems might promote (Dorko, 2020, 2021, 2019)

Issues that professors face

- Students worry more about the procedure than the concept itself (Lew et al., 2016; Thompson, 2013; Thompson et al., 1994)
- Students only write what the professor writes (Lew et al., 2016)
- Students may miss verbal-only comments (Lew et al., 2016)

Data Collection Methods

Course context

We collected data from a developmental math class at a large US university. The content was from the class period following the first exam to the class period directly prior to the second exam, and the exam itself. The content included creating graphs on a graphing calculator, using the graphs to solve inequality and optimization problems, solving linear equations by hand, and using slope to find horizontal or vertical changes in right triangle problems.

The data collected include

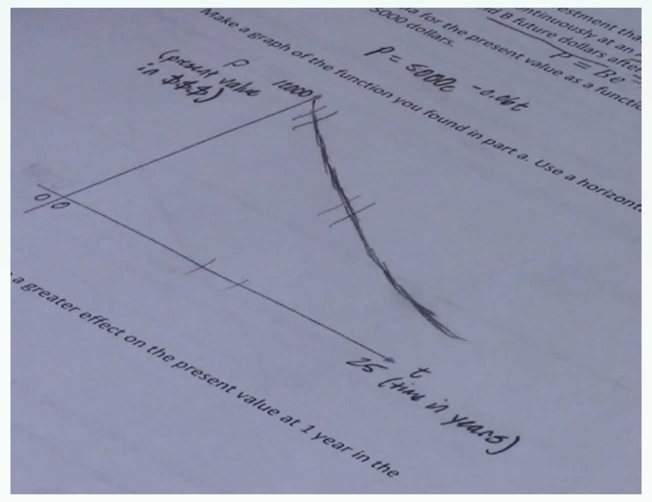
- Videos of eight 75-minute lectures,
- Videos of interviews with students as they completed
  - three written homework assignments
  - six online homework assignments
- The students' exam responses
- An interview with the students about their exams

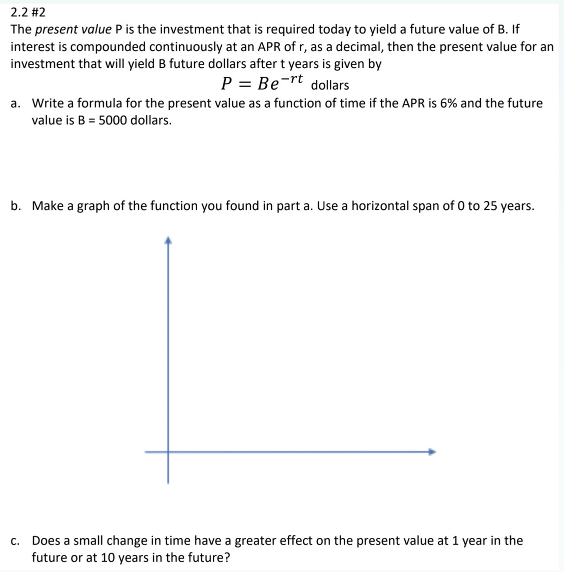
Data Analysis Methods

Data analysis is ongoing, following a thematic analysis method (Braun & Clark, 2020).

1. Read lecture transcript, make list of the knowledge at stake (e.g. when/how/why to use CALC, INTERSECT on graphing calculator)
2. .Read transcript of HW that covered that content
   - Looked for influences of lecture on HW activity (e.g. doing something that was done in lecture, like using the TI-83 to find an intersection on a graph; using a word/phrase the instructor used, like "isolate" the variable)
3. In HW, identified instances student had to attempt problem multiple times, and sought to unpack how they worked their way to a correct answer
4. Repeat 1-3 for all lecture/HW pairs
5. For exam work and interview, looked at HW problems that covered same content as exam problem and what the student's activity looked like on that problem (e.g. multiple attempts, influences from lecture - see (1))

Example: Student 3 learned...





2.2 #2

The *present value* P is the investment that is required today to yield a future value of B. If interest is compounded continuously at an APR of r, as a decimal, then the present value for an investment that will yield B future dollars after t years is given by

$$P = Be^{-rt} \text{ dollars}$$

a. Write a formula for the present value as a function of time if the APR is 6% and the future value is B = 5000 dollars.

b. Make a graph of the function you found in part a. Use a horizontal span of 0 to 25 years.

c. Does a small change in time have a greater effect on the present value at 1 year in the future or at 10 years in the future?

Student 3: "Does a small change have a greater effect on the present value 1 year or 10 years in the future. So what's half of 25, 12.5, that's about here. So 25 would be here. So could definitely say 1. So assuming that the halfway point would be 12.5, since that's what half of 25 is, and moving over to get closer to 10, so it's not obvious on y graph but you can kind of see the change here is a little less steep, like right here compared to right here, this part of the graph is steeper than this part of the graph which means there's a greater effect on the present value here than here."

Influence of lecture on homework activity:

- Attended to steepness of graph, as had been show in class
- Marked areas on graph for lower and higher x values, as had been shown in lecture

Results

Preliminary findings indicate students learned (a) how to identify independent and dependent quantities; how to use the calculator to make graphs, (b) how to interpret graphs, (c) how solving an inequality is different from solving an equation, and how to do both on the calculator; (d) how to optimize functions on the calculator. Students commented that getting answers wrong in the online homework helped them understand how to solve inequalities and optimization problems.

- Influence of lecture on HW activity
  - **Taking time to make sense of given information:** Like the instructor, S1 took time to make sense of and employ given information
    - Identifying independent/dependent variables
    - Units
    - Labeling graph
  - **Using words the instructor used** (e.g. "isolate" a variable, "assign a variable")
  - **Problem contexts**
    - Remembered similar problem contexts from lecture and used this similarity to solve HW problems
    - Connected different problem contexts that both had concave up, decreasing graphs
  - **Use of skills:** table to set graphing window, table to select correct graph, CALC menu features, using graph instead of table to solve problems
  - **Ways of looking at graphs** (steepness for concavity, identifying increasing/decreasing as ways to justify use of procedures)
  - **Applying definitions** (recognized an equation as linear based on class definition)
- Learning from HW activity
  - **"Trial and error", "mastery," "putting stuff into practice":** student's description of what and how she learned from homework
    - She primarily went through CALC menu features via trial and error, taking several problems to sort out what to use when
  - **Solution to one problem influencing solution method to next problem** (e.g., generalizing the practical meaning of an increasing, concave up function)
  - **Quantitative meaning for concavity:** computing AROC over different intervals helped her see the changing rate of change and how it influences the shape of the graph

Discussion & Conclusion

- We think students' learning from mistakes can be explained by Piagetian learning theory: seeing an "incorrect" mark perturbs them
- Lecture appears to give students tools, (e.g. features of the calc menu) but they often go through a trial-and-error process in homework figuring out when to use each tool
- Students notice similar problem contexts, as well as abstracting underlying similarities in mathematical structure (e.g. concavity) .

References

Amman, K., & Mejia Ramos, J.P. (2022). Reframing relearning. In (Eds.) Karunakaran S.S. & Higgins, A., *Proceedings of the 24th Annual Conference on Research in Undergraduate Mathematics Education*, pp. 752-760. Boston, MA.

Braun, V. & Clarke, V. (2020). Can I use TA? Should I use TA? Should I not use TA? Comparing reflexive thematic analysis and other pattern-based qualitative analytic approaches. *Counselling and Psychotherapy Research*, *21*(1), 37-47.

Dorko, A. (2021). How students use the 'see similar example' feature in online mathematics homework. *The Journal of Mathematical Behavior*, *63*. https://doi.org/10.1016/j.jmathb.2021.100894

Dorko, A. (2020a). What do we know about student learning from online mathematics homework? In J.P. Howard and J.F. Rivers (Eds.), *Teaching and Learning Mathematics Online.* (pp.17-24). CRC Press.

Dorko, A. (2020b). Red X's and green checks: A model of how students engage with online homework. *The International Journal of Research in Undergraduate Mathematics Education.* *6*(3), 446-474. doi: 10.1007/s40753-020-00113-w

Dorko, A. (2019). Professors' intentions and student learning in an online homework assignment. In (Eds.) A. Weinberg, D. Moore-Russo, H. Soto, & M. Wawro, *Proceedings of the 22nd Annual Conference on Research in Undergraduate Mathematics Education.* (pp. 172 - 179). Oklahoma City, OK.

Dorko, A., & Cook, J.P. (2022). Why do students rely on homework over lecture? In (Eds.) Karunakaran S.S. & Higgins, A., Proceedings of the 24th Annual Conference on Research in Undergraduate Mathematics Education, pp. 960-966. Boston, MA.

Dorko, A., & Cook, J.P. (under review). A case study of why three students learned from homework instead of lecture.

Ellis, J., Hanson, K., Nuñez, G., & Rasmussen, C. (2015). Beyond plug and chug: An analysis of Calculus I homework. International Journal of Research in Undergraduate Mathematics Education, 1(2), 268-287.

Glass, J., & Sue, V. (2008). Student preferences, satisfaction, and perceived learning in an online mathematics class. MERLOT Journal of Online Learning and Teaching, 4(3), 325-338.

Kanwal, S. (2020). Exploring affordances of an online environment: A case study of electronics engineering undergraduate students' activity in mathematics. The International Journal of Research in Undergraduate Mathematics Education, 6(1), 42-64.

Krause, A., & Putnam, R. (2016). Online calculus homework: The student experience. In (Eds.) T. Fukawa-Connelly, N. Infante, M. Wawro, and S. Brown, Proceedings of the 19th Annual Conference on Research in Undergraduate Mathematics Education, (pp. 266-280). Pittsburgh, PA: West Virginia University.

Krupnik, V., Fukawa-Connelly, T., & Weber, K. (2018). Students' epistemological frames and their interpretation of lectures in advanced mathematics. The Journal of Mathematical Behavior, 49, 174-183.

Lew, K. M., Fukawa-Connelly, T., Mejía-Ramos, J. P., & Weber, K. (2016). Lectures in advanced mathematics: Why students might not understand what the professor is trying to convey. Journal for Research in Mathematics Education, 47(2), 162–198.

Lew, K., & Zazkis, D. (2019). Undergraduate mathematics students' at-home exploration of a prove-or-disprove task. The Journal of Mathematical Behavior, 54, 1-15.

Lithner, J. (2003). Students' mathematical reasoning in university textbook exercises. *Educational Studies in Mathematics, 52*(1), 29-55.

Rupnow, R., Hegg, M., Fukawa-Connelly, T., Tomson, E., & Weber, K. (2021). How mathematicians assign homework problems in abstract algebra courses. *The Journal of Mathematical Behavior, 64,* https://doi.org/10.1016/j.jmathb.2021.100914

Thompson, A.G., Philipp, R.A., Thompson, P.W., & Boyd, B.A. (1994). Calculational and conceptual orientations in teaching mathematics. In A. Coxford (Ed.), *1994 Yearbook of the NTCM* (pp. 79-92). Reston, VA: NCTM.

Thompson, P. W. (2013). In the absence of meaning. In K. Leatham (Ed.), *Vital directions for research in mathematics education*, pp. 57-93. New York: Springer.