Math and Moral Reasoning in the Age of the Internet: Undergraduate Students' Perspectives on the Line Between Acceptable Use of Resources and Cheating

Mariana Levin
Western Michigan University

John P. Smith, III
Michigan State University

Shiv S. Karunakaran
Michigan State University

Valentin A. B. Küchle
Michigan State University

Sarah Castle
Michigan State University

Jihye Hwang
Michigan State University

Robert Elmore
Michigan State University

Younggon Bae
University of Texas, Rio Grande Valley

This study examined how eight students in an introduction to proof (ITP) course viewed a "cheating scandal" where their peers submitted homework containing solutions found on the web. Drawing on their weekly log entries, the analysis focuses on the students' reasoning about the difference between acceptable and unacceptable use of internet resources in learning mathematics. One pattern was that students' view of the relationship between beliefs about mathematics and the work of learning mathematics grounded their views of "cheating." Specifically, some felt that an implicit didactical contract required that model solutions should be available when one learned new material. The case raises the general issue of the relationship between the process of learning mathematics and the appropriate use of external resources. It suggests that instructors may need to re-examine the role of homework, especially its assessment, in their courses, so that productive struggle is valued, not avoided.

Keywords: Proof, Homework, Academic Integrity

There exists a broad literature on cheating at the collegiate level (Kleiner & Lord, 1999; Lathrop & Foss, 2000; McCabe, Butterfield & Treviño, 2012). Cheating is typically defined as an action of fraudulently deceiving or violating rules, including (1) use of paid or unpaid surrogate to complete assignments or assessments (2) unauthorized collaboration on assignments or assessments and (3) unauthorized coaching on assessments (Lathrop & Foss, 2000). This definition is broadly consistent with those typically printed in course syllabi and that are aligned with university academic honesty policies. According to McCabe and colleagues who led the International Center for Academic Integrity (ICAI) student surveys on academic integrity, 68% of undergraduates admit to cheating on tests or written assignments (McCabe, Butterfield, and Treviño, 2012). According to a 1999 U.S. News and World Reports Study, 80 % of students report having engaged in some form of cheating and 90% of those who reported cheating said they had never felt negative consequence for having done so. One of the factors related to the urgency of the issue is the "shifting sociocultural view on the morality of cheating" (Trenholm, 2007). Trenholm reports that a societal shift in focus towards products (degree, GPA, grade on homework) as opposed to processes (grappling with difficult material until one understands it) provides a context in which cheating is seen more as a pragmatic than moral issue (Kleiner & Lord, 1999).

Though there is a wide literature on cheating in collegiate classes generally, the case of upper division mathematics is of interest because both the nature of the work and the student population differs from the case of collegiate work in general (Smith et al., 2017). The character of out-of-class mathematical work required of students in upper division courses has typically involved the experience of exploring novel tasks and formulating arguments, which is a shift from presenting students with opportunities to practice using concepts or algorithms they have learned in class. Under these assumptions, homework is often allocated a substantial part of course grades to encourage students to spend significant time on working on tasks outside of class time. However, the availability of online sources of mathematical work, both open access and for-profit, has exploded in recent years, making the issue of students' access to these sources an issue for mathematics instructors at all levels when they design and assess student work. Understanding what students say about the phenomenon can help instructors of such courses consider how to re-shape their courses so as to respond to both (1) the learning needs of their students around the role of the work of others in learning mathematics and (2) the reality that so much of the traditional canon of problems exists now online, both for free and for purchase.

Setting

This paper considers data of students making sense of the phenomenon of "cheating" by using unauthorized online sources and turning them in as their own within an Introduction to Proof (ITP) course at a large midwestern university. The data was collected as part of a larger NSF-funded grant that involves collecting longitudinal data on a sample of mathematics students as they progress from their ITP course through their upper division mathematics coursework.

The project seeks to understand how ITP students navigate challenges such as completing homework sets that demand a different kind of organization of work and a different character of mathematical work than they have engaged with in the past. In particular, we are interested in the growth and development of students' autonomy and agency in their mathematical work as they navigate upper division coursework in mathematics. Thus, when it became clear to the instructors and the research team how widespread the practice of using unauthorized online sources was in the class (upon scrutiny, every section turned up multiple instances of the use of unauthorized, paid, internet sources on one homework set), we sought to understand students' perspectives regarding the use of online sources for homework.

To give some context for the analysis in this paper, about halfway through the semester (following a particularly long homework assignment), one of the instructors for the course alerted the instructional team that four students had turned in exactly the same solution to a homework task. The solution differed from the previously distributed solutions and the instructor suspected that the online student work subscription service Chegg was the source of the work in question. In response, the course coordinator and instructors opened their own Chegg account in order to monitor activity on the site around the homework questions and to assess the depth of materials available on the site. They confirmed that Chegg was the source of the suspicious student solutions in question and then systematically examined other papers for similar anomalies. Accordingly, the instructional team decided to change the homework grading policy for the remainder of the semester by focusing on homework completion.

The syllabus for the course contained two explicit academic integrity statements. The first statement came from the university code of honor: "I will strive to uphold values of the highest ethical standard. I will practice honesty in my work, foster honesty in my peers, and take pride in knowing that honor in ownership is worth more than grades." The second came from the course Academic Honesty statement: "…unless authorized by your instructor, you are expected to complete all course assignments, including homework, lab work, quizzes, tests, and exams, without any source… Students who violate academic integrity rules may receive a penalty grade, including a failing grade on the assignment or in the course."

In one section of the ITP class, an instructor explicitly talked with students in his section (one of five) about the academic honesty policy in the syllabus, while also encouraging joint work and collaboration outside of class and emphasizing the need for students to come away from a collaborative work experience with a personal understanding. One other section was observed by the project team to have had a similar discussion, if brief, about the intentions and role of out-of-class collaboration in completing class work. By design in this course, students had ample access to external supports: access to a mathematics learning center (MLC), the online platform Piazza, and instructor office hours. In addition, they had access to an extensive "examples document" that provides the tasks worked on in class. Further, the solutions to each assignment were released immediately *following* students turning it in.

Participants

The eight focal participants for this analysis come from two sections (of five) of the ITP course. With respect to the topic at hand, we have the most detailed evidence from these students' homework logs. As part of our broader project goal focusing on students' experience in ITP courses, our participants regularly wrote reflections about their process of navigating challenges in the ITP course. Thus, when the cheating scandal broke, we added a reflection entry prompting them to offer their views of it. The text of our prompt appears in Figure 1. Additionally, we also have corroborative evidence from regular observations conducted during the semester and interviews with the course coordinator.

> In posing these questions (below) to you, I am <u>not</u> asking how you personally choose to use or not use information from the web. I am interested in your views of the issues involved.
>
> - Do you think that looking on the web for solutions to homework problems and submitting them as your own work is "cheating"? Why or why not?
> - What do you think of the reasoning of the instructional team (including your instructor) that including someone else's solution does not help you prepare for the exams?
> - What do you think about the penalty imposed for "cheating": zero for the homework and you can't drop that particular HW grade?

Figure 1. Prompt given to students inquiring about their views on "cheating" and use of external resources.

As suggested by the questions we asked them (above), we were interested in (1) nuance in their perspective around using online sources, (2) the role of homework in learning the course content with some degree of autonomy (indexed by preparedness for exams) and (3) their perspective on the instructional response in the ITP class, including alternative options.

Theoretical Framework

In teaching mathematics, students, teachers, and other stakeholders associate expectations with what mathematics is taught and how it is taught (i.e. obligations that each undertakes and benefits from, and the means by which they envision satisfying the obligations, as well as the consequences for not satisfying them). A *didactical contract* is an interpretation of the set of these expectations and obligations (Brousseau & Warfield, 2014). We view our observations and interviews as providing different and complementary windows into the didactical contract in effect in one particular introduction to proof course. Further, we propose that this theoretical tool is a useful lens for examining students' interpretations of their rights and responsibilities more broadly.

Speaking to the source of these rights and responsibilities, many development researchers have distinguished between heteronomy and autonomy in moral reasoning (Kohlberg, 1976; Piaget & Inhelder, 1969). Heteronomy is the orientation that the source of direction for right behavior comes from dictates or principles from outside (e.g., an adult, parent, or recognized powerful authority). Autonomy, by contrast, is the view that the source of guidance for right behavior is the individual's own principles or sense-making. In the present context, we have external authority that is represented by the university guidelines for academic honesty/dishonesty outlining what is acceptable and unacceptable practice in completing and presenting one's academic work. These guidelines were developed well before the emergence and wide use of "internet resources" like Chegg. On the other hand, students in this course had access to many related sources of "good mathematical reasoning" on specific tasks (e.g., guidance from instructors in the MLC and office hours). These "legitimate" sources of the content and format of "good proofs" raise reasoning challenges for students: What distinguishes acceptable forms of assistance from unacceptable?

Analysis and Findings

For each prompt, participants' responses were grouped into thematic units that captured the essence of each part of their responses to the questions. Following the initial process of thematic grouping, the themes were re-organized to collect common themes across participants together. In this way, the analysis converged on a set of common themes that still preserved the essence of the diversity of themes represented in the data. The first issue our analysis addresses is the range and variability around where participants drew the line around what constitutes acceptable versus unacceptable use of internet resources. A second focus is the source of morality in terms of the role that external directives versus internal convictions played in students' reasoning about what constitutes acceptable/unacceptable behavior. A third focus is how students conceptualized the relationship between learning/understanding and internet resources. Students' logs also prompted them to consider the instructional response in their class, and some went on to discuss their perspective on potential instructional responses that address the issues of fairness and learning. Our analysis of students' perspectives provides a springboard into the discussions and conclusions of this paper, including potential instructor responses to the reality of resources like Chegg being part of the instructional ecology.

Defining Boundary Conditions

To give a sense for the complexity of students' reasoning about what constitutes cheating, consider a vignette that participant G made up to help himself think through the moral issues involved in the use of outside resources in homework completion:

> "Student A and B both go to MLC at the same time, working on the same problem such that the same teaching assistant helps both of them on the problem at the same time on the blackboard. Student A just continues writing on his own, while student B is copying what he saw. Then student C comes in, and without asking anything, but only reading what is on the board, he gets the answer. Then TA teach[es] the same stuff to student D who comes in later. They all have the same way of proof. Suppose that student E saw the work, not on the board but on a website instead, and complete his homework. Who is cheating?"

All eight participants responded with nuance around the issue of using internet-based resources for homework, all citing conditions under which using internet-based resources would and would not be considered cheating. For most, the important distinction was whether a student engaged in original thinking in using the resource, especially after having gotten stuck in working on one's own (participant M) and "not brainlessly copying down answers" (participant F, with a similar sentiment in the logs of participants O, K, G, H, D, M, N). Under the condition that one is not intentionally copying for the purpose of passing off another's work as one's own, participant K went so far as to say that looking [online] for an answer and using it to get one's own can even be better than powering through on one's own. With respect to the use of particular resources, one student explicitly discussed Chegg as a "gray area" (participant N) because it is a paid service as opposed to a public one, where two others found no problem with Chegg because it is a resource that students theoretically have available to them (participants F and D). One participant (M) preferred getting help from resources tied to the course such as Piazza or the Math Learning Center to seeking assistance online. However, M's reasons concerned the lack of information about how one's specific instructor grades proofs. Participant F offered a contrasting view where internet resources were preferable to use when stuck because they were anonymous and didn't bother the professor, teaching assistant, or other students.

Internal Versus External Orientation Concerning Impact of Copying

Participants were divided in their focus on whether copying could help/hurt with *external performance* (participants H: "problems on exam could be different so copying can hurt", O: "getting closure on HW problems could help solve future problems", G: "looking at others' solutions can help you prepare"). Instead, other participants focused on the negative impact of copying on personal understanding (e.g., N and F). The preparation issue extends beyond the academic context. Some students appeared to be skeptical about whether finding other solutions undermines preparation, for the class, but also more generally in the world of work. For example, consider the following segment from a classroom observation completed just after the use of Chegg was discovered:

> At the beginning of class, a male student is discussing differences between working in industry in academia with his peers. He claims that 90% of students in the class will be going into industry. Another student argues that it is ridiculous that everyone in industry uses calculators and googles things – why are calculators not permitted in classes? A third student then claims that the professors in this class keep saying that they need to go through rigorous and technical proofs, but in industry people just google things. The student recognizes that in academia people need to come up with new stuff that can't just be googled. However, why can't we use google since 90% of us are going into industry [referring back to the first student's claim]. People use computers and "cheat" all the time. He closes by agreeing that the situation [of not being allowed to use internet resources] is kind of annoying.

Connections between views on internet resource usage and views of mathematics learning

Explicit in two students' logs (O and D) were references to using online sources in order to obtain models for the purpose of understanding assigned problems. Participant O went so far as to say that if one had not been taught specific techniques to solve assigned problems then one "had" to google the problem in order to find out what techniques they should use. Such an assertion belies a commitment to the view that mathematics learning involves merely learning to apply a suite of algorithms or techniques appropriately. That is, assigning tasks for which one needs to develop a chain of reasoning or a technique that has not been explicitly taught is seen as a violation in expectations about the nature of mathematics learning (and thus, what mathematics teaching should entail). The purpose of homework in this model of teaching and learning is to practice known techniques. While O's log was notable for its explicit invocation of this view, this perspective on mathematics learning has been a common theme in our prior interviews of ITP students reflecting on the differences between their lower division mathematics experience and proof-intensive upper-division courses (Author, 20xx). In contrast to O's perspective, participants H, M, and K invoked the perspective that mathematics learning is about engaging in reasoning and thus copying solutions from the internet undercuts the purpose of the course (reasoning). Two other students (F and N) thought copying solutions was detrimental to learning (participant N: Chegg is bad for learning because you are not truly synthesizing the material; participant F: Writing new solutions is helpful because you recognize how to solve new problems in the future). However, the nature of "understanding" was never unpacked further in these students' logs. Thus, it is possible they believed that copying using Chegg doesn't help one learn the material, but that "learning the material" still could focus on known algorithm application.

Views on Instructional Response

With respect to our third question, participants were split on their level of sympathy to those who engaged in using unauthorized internet resources. Some (D and F) offered reasons why students may engage in this behavior (participant D: "necessary" if one can't make it to office hours; participant F: helpful to get closure if one is struggling, especially when the grade is based on correctness). Participant G remarked that students cheat because they want their grades, and they already don't have enough time for their work and sleep. When the homework seems too hard and there is no help through sanctioned methods on the weekend, then students naturally turn to the internet. In contrast, participant K was strongly unsympathetic to those who had been caught with copied solutions because of inequity in grading relative to students who had been playing by the rules. One theme that repeatedly emerged was students' worry over whether it could be possible for a student to be falsely identified as cheating when, because there is a canonical proof approach, their work could look like someone else's or an online source (H, O, and K). With respect to the move to completion as opposed to correctness grades, K remarked that he still planned to give his best effort on subsequent homework, and the move to completion made him feel like he didn't have to get everything exactly right. (However, we note that in a later interview with K, he mentioned that in practice, he had been less motivated to put in as much effort on the homework following the shift to grading for completion).

Discussion and Conclusions

Instructors may assume that students and instructors have a shared understanding of how to appropriately use sources, cite sources, and collaborate. Our modest analysis shows that these issues are more nebulous and complex for students than they may appear on the surface, especially as pertains to their work in upper-division mathematics, which has a different character than their lower division coursework and also other courses that require academic writing. A discussion of student reflections on cheating is important for course instructors because without it, instructors might try, as one TA did, to admonish their students to "Stop cheating!" However, this approach is unlikely to be successful because students may (1) honestly not know how to think about the role of the work of others in their learning activity in upper division courses and (2) it leaves completely open what exactly the students are supposed to stop. In fact, without further elaboration, instructors could be admonishing students to stop forms of activity that may actually be instrumental in their learning. Indeed, our participants did by and large seem to agree that a boundary around acceptable usage is that some understanding of the proof had to be generated by the student through sense-making. Backwards engineering or processing a proof that they found was different in their view than "brainless copying."

Since students have access to written academic integrity policies and many other forms of external guidance and yet copying solutions persists, we do not believe the most effective response is to make sure students understand the ground rules about what is and is not sanctioned. Instead, our perspective is that platforms such as Chegg are a part of the ecology of resources available to students that we need to be aware of and be more proactive in engaging with and designing experiences for students that still achieve our goals and maintain a level playing field. In a similar vein, Lang (2013) urges professors to move away from considering the dispositional factors that may make cheating more likely and instead focus on contextual factors that influence cheating. In his synthesis of cheating at the collegiate level, he identified four classroom-level conditions that can induce cheating: (1) Emphasis on performance, (2) High stakes on the outcomes of the performance, (3) Extrinsic motivation for success and (4) Low expectation of success.

The work of Mejía-Ramos et al. (2012) in delineating a framework for assessing proof comprehension provides some ideas in the direction of other forms of questions instructors can ask that tap into a deeper synthesis of the material than the commonly employed approach of asking students to reproduce complete arguments (that may be more possible to search and copy wholesale from the web). Asking students more open-ended questions or to generate their own questions can both quell cheating and also communicate a different image of the discipline to them—that they *should* be asking questions. With references to the findings of the analysis, it is worth considering whether extensive access to “model” tasks (as was the case in this particular ITP course) has the effect of reifying a view of mathematics learning as being primarily about learning to recognize and adapt model solutions. This is particularly salient in a course like Introduction to Proof where one of the meta goals for the course is to prepare students to engage in productive struggle (Hiebert & Grouws, 2007) and to become more comfortable grappling with tasks for which they will *not* have a model solution to base their work on.

In the context of collegiate mathematics, and calculus in particular, Reinholz and colleagues have been experimenting with a technique called Peer-Assisted Reflection (PAR) (Reinholz, 2015; 2016). Empowering students with the responsibility as a class to generate their own criteria for what makes a good proof and then engaging students in judging the quality of their own proofs or proofs of their peers may help shift disciplinary authority to the students. While turning in assignments and receiving a score can communicate that the teacher decides what is and is not good mathematical work, the PAR approach can help students self-assess their own work, understand flaws in work they might encounter on the internet, and also send the strong and disciplinarily authentic message that grading and proof quality is not a judgment up to the mercurial whims of one professor.

While this study is modest in its scope, it is hoped that it will spark a discussion about the ways in which upper-level mathematics instructors can respond to the fact of the widespread availability of solutions on the internet in ways that promote the learning goals of these courses.

Acknowledgements

This paper reports research supported by the National Science Foundation’s IUSE program under grant #1835946. All opinions, findings, and conclusions or recommendations expressed here are those of the authors and do not necessarily reflect the views of the Foundation

References

Brousseau G., Warfield V. (2014) Didactical contract and the teaching and learning of science. In R. Gunstone (Ed.) *Encyclopedia of Science Education*. Springer, Dordrecht. (pp. 163-170).
Hiebert, J., & Grouws, D. A. (2007). The effects of classroom mathematics teaching on students’ learning. *Second handbook of research on mathematics teaching and learning, 1*, 371-404.
Inhelder, B., & Piaget, J. (1969). *The psychology of the child*. New York: Basic Books.
Kleiner, C., & Lord, M. (1999). The cheating game. *US News & World Report, 127*(20), 54-63.

Kohlberg, L. (1976). Moral stages and moralization: The cognitive-development approach. *Moral development and behavior: Theory research and social issues*, 31-53.

Lathrop, A., & Foss, K. (2000). *Student cheating and plagiarism in the internet era: A wake-up call*. Englewood. Colorado: Libraries Unlimited.

Lang, J. (2013*). Cheating lessons: Learning from academic dishonesty*. Harvard University Press.

McCabe, Butterfield, and Treviño (2012). *Cheating in college: Why students do it and what educators can do about it*. Johns Hopkins University Press.

Mejia-Ramos, J. P., Fuller, E., Weber, K., Rhoads, K., & Samkoff, A. (2012). An assessment model for proof comprehension in undergraduate mathematics. *Educational Studies in Mathematics, 79*(1), 3-18.

Palazzo, D. J., Lee, Y. J., Warnakulasooriya, R., & Pritchard, D. E. (2010). Patterns, correlates, and reduction of homework copying. *Physical Review Special Topics-Physics Education Research, 6*(1), 100–104.

Reinholz, D. L. (2015). Peer-assisted reflection: A design-based intervention for improving success in calculus. *International Journal of Research in Undergraduate Mathematics Education, 1*(2), 234-267.

Reinholz, D. (2016). The assessment cycle: a model for learning through peer assessment. *Assessment & Evaluation in Higher Education, 41*(2), 301-315.

Roediger III, H. L., & Karpicke, J. D. (2006). Test-enhanced learning: Taking memory tests improves long-term retention. *Psychological science, 17*(3), 249-255.

Smith, J., Levin, M., Bae, Y., Satyam, V., Voogt, K. (2017, February) *Exploring Undergraduates' Experience of the Transition to Proof.* In (Eds.) A. Weinberg, C. Rasmussen, J. Rabin, M. Wawro, and S. Brown, Proceedings of the 21st Annual Conference on Research in Undergraduate Mathematics Education, San Diego, California.

Trenholm, S. (2007). A review of cheating in fully asynchronous online courses: A math or fact-based course perspective. *Journal of Educational Technology Systems, 35*(3), 281-300.