Designing Games For Approaches To College Mathematics

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With mathematics being a singular obstacle to college retention and degree attainment (Douglas & Salzman, 2019), it becomes especially important that students who struggle to place into first-year mathematics courses are provided a strong foundation. We are developing a new class entitled Approaches to College Mathematics (ACM) for students who failed to place into Precalculus. The course developers recognized that the complex system that contributed to these students' struggles wasn't working. We thus spent the summer developing a student-centered ACM and deliberately hired instructors with philosophies supporting the interwoven nature of conceptual and procedural understanding (NRC, 2001). We hoped that this contrast with widespread, teacher-centered, and strictly procedural approaches (Cohen & Mehta, 2017) would provide the missing connections needed to bolster these students' foundations for Precalculus.

Of the 820 students taking ACM and Precalculus, 333 placed into ACM. This poster focuses on 57 of those students. All these students experienced a pandemic in their freshman year of high school. Preliminary surveys indicate that 42 students are interested in Biology; 16 characterize mathematics in strictly negative terms ("stressful," "hard"), while 10 invoked both positive *and* negative attributes ("difficult, complicated, useful"). In their conceptions of a "math person," 21 students relayed attributes focused on intelligence ("someone who is smart"), while 15 recognized a math person's joy in doing mathematics ("enjoys the problem-solving process"). Survey responses indicate the challenge of connecting hard work (not innate intelligence) with mathematics learning, and the promise of playful experiences in enhancing that learning.

Mathematical play is a crucial part of learning and doing mathematics. Encouraging students to play with mathematical ideas can help them to extend their horizons, make their own conjectures and connections, and build their confidence in an environment where mistakes do not feel so threatening (Holton et al., 2001). As a structured form of play, games can be designed or modified to reflect mathematical structures and then used in undergraduate mathematics classrooms to support students in playing with those ideas (Naik, 2017). For example, Herman (2014) adapted Trivial Pursuit for use in mathematics classes for business majors. Students who played the modified game participated more in class discussions, seemed less afraid of asking questions, reported enjoyment, and showed improvement on test scores. Similarly, Galarza (2017) designed a new card game called Groups as a learning tool for undergraduates studying group theory. After playing Groups, students commented on its accessible and enjoyable format, its ability to offer insight into rich mathematics, its use as a learning tool for novices, and its use as both a learning and a review tool for experts. These examples highlight the potential of two different game design strategies: (1) modifying existing games to map mathematical ideas onto their existing rules and (2) designing entirely new games that reflect mathematical ideas.

In our poster we present two games we designed for ACM, one using each of these two strategies. Functionominoes is a modified dominoes game based on categories and features of functions, while the Order of Operations (OOPS) Game is a new card game about building and evaluating expressions. The poster will feature a synopsis of the value of games to math learning, a description of two ACM classes and students, an overview of our two game designs, examples of our students' work with our games, and links to our game printables and activity guides.

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