The Roles and Benefits of Using Undergraduate Student Leaders to Support the Work of SUMMIT-P

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Abstract

The article by Poole, Turner, and Maher-Boulis (2020) describes one way in which undergraduates have been used to support the SUMMIT-P goal of investigating examples of how mathematics and statistics are applied in partner discipline courses. Two other universities in the SUMMIT-P consortium, San Diego State University and Oregon State University, also use undergraduates in different ways to support the work of integrating science applications into math classes. In this article, we compare and contrast these three uses to further highlight this somewhat untapped resource.

Keywords

integrated activities, peer leaders, undergraduate learning assistants

The Synergistic Undergraduate Mathematics via Multi-Institutional Interdisciplinary Teaching Partnerships (SUMMIT-P) consortium is a group of mathematics faculty from ten institutions who work with faculty from partner disciplines to implement curricular updates in lower division mathematics courses. The goal of this article is to argue that undergraduate students can be excellent resources for helping with this task because they bring initiative, knowledge about content being taught in partner disciplines, and a much-needed student perspective into the curriculum development process. In what follows, we support this argument by presenting three cases that describe the different ways in which undergraduates were involved in the creation of integrated activities at three different institutions involved in SUMMIT-P. In all cases, the results created a win-win-win situation for faculty, students in the target math classes, and the undergraduate students serving as leaders.

The first case describes how undergraduate STEM majors at San Diego State University (SDSU) serve as teaching assistants for a precalculus course. Their main responsibility is to teach the integrated lessons during course breakout sessions, but they also have a great deal of input into how the lessons are created and what examples are included. The second case describes a Student Exchange Program (SEP) at Lee University that is designed to pair mathematics majors with non-mathematics majors who are enrolled in an introductory statistics class. The third case describes how undergraduates at Oregon State University (OSU) worked to find biological studies examples to illustrate the central ideas in Calculus I. We conclude by noting that, in all three cases, the undergraduate teaching assistants were involved in the design of integrated activities and brought new perspectives that enhanced the project in ways that faculty alone could not have achieved.

Examples

Example 1: Undergraduate Teaching Assistants at SDSU

At SDSU, Precalculus is taught in a large lecture format that is augmented by weekly recitation sections. The lecture classes, which meet for three 50-minute sessions per week, are held in an auditorium that accommodates roughly 125 students. The material is generally delivered in a straight-forward manner, although some active learning is encouraged through the use of “clicker” questions. On the other hand, the recitation sections, or “labs,” are capped at 25 students and are designed to maximize opportunities for active, collaborative learning. It is important to note that we chose to refer to the recitation sections as “labs” in order to emphasize that the overall goal is not simply to provide rote practice but instead to engage students in active learning lessons that integrate science applications with the particular mathematics topics being studied in the course.

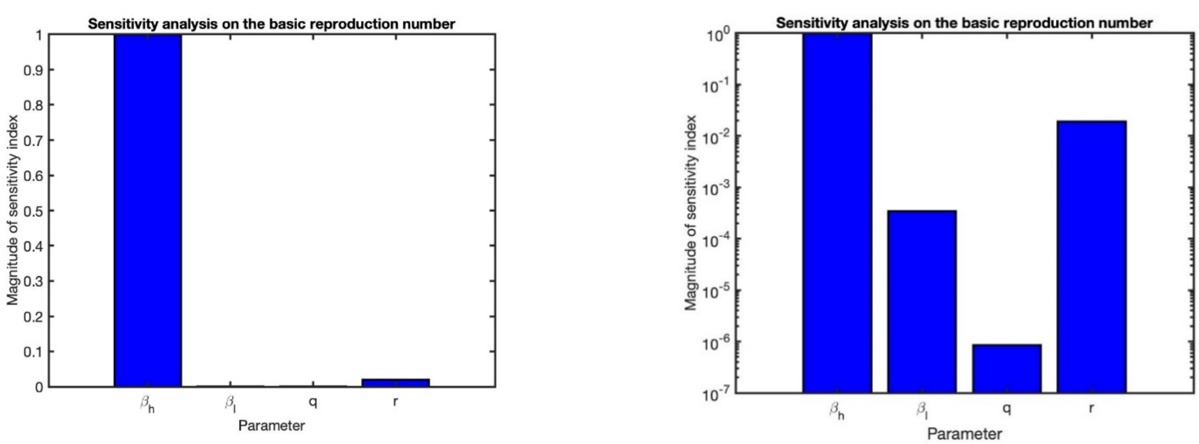
The most unique aspect to the approach taken at SDSU is that these labs are taught by undergraduate students rather than Graduate Teaching Assistants. These undergraduates, often referred to as Undergraduate Learning Assistants (ULAs), are carefully selected to be very strong mathematicians who also have enough self-confidence to talk in front of peers. The group (roughly 7 – 9 ULAs depending on the semester) meet weekly with the coordinator to debrief the prior lesson and discuss the upcoming lesson. During these meetings, the group is introduced to the draft PowerPoint presentation that the director has created for the lesson. The team then debates design, content, and pedagogical ideas to enhance how they will implement the lesson during the following week. Once the lesson has been finalized, the director makes final touches to the shared PowerPoint slides and any handouts. The director also visits the lab sessions on a regular basis to provide content and pedagogical guidance as needed.

Each ULA generally teaches two sections of 25 students during 50-minute lab periods. They are also encouraged to observe other lab sections so that they can gauge time allocation decisions. Although the ULAs are not instructors of record, they are responsible for taking attendance and leading the class in the activity that is described on the PowerPoint slides used to organize the lesson. This span of work enables the ULAs to contribute to just about every aspect of the SUMMIT-P work. Not only do they teach the lab sections, they play a strategic role in transforming the application idea from the client discipline into an active learning lesson with pedagogy that gets students involved in social interaction as well as learning the mathematics and science.

One example that highlights the role that ULAs have played in developing integrated activities for the SUMMIT-P project occurred when the team was discussing the pH lab, which was developed by Bowers (first author of this paper) and a biologist and chemist who are also SUMMIT-P partners. Bowers told the group of ULAs that both the chemist and the biologist emphasized the importance of helping students understand how logarithms are used to transform data containing a lot of very small or very large numbers to one scale so that values can be compared and analyzed. Two of the ULAs (also co-authors on this paper) stated that they used this process while working as interns in a virology lab on campus. The group hypothesized that if the ULAs could create a video explaining their work in their own words, the students in Precalculus could get a better understanding of how logarithms are used *by their peers* in university research. As they describe in the video, the application they explored required comparing the relative impact of various parameters on the progression of AIDs. The work required the use of logarithmic transformations because the data set consisted of extremely small numbers. Thus, nuanced differences between the quantities were difficult to see. The "before" and "after" graphs showing how logarithmic transformation was used to compare the relative contribution of various parameters labeled $\beta_h, \beta_1, q,$ and r in a biological model of AIDS propagation in a virology lab featured in the video are shown in Figure 1.

Figure 1

Two Graphs Created to Demonstrate the Use of Logarithmic Transformation



A second example of how the ULAs have been helpful for implementing the integrated lessons involves their ability to predict how the lessons will be received by the students in Precalculus and also to reflect on what went wrong and could be improved for future semesters. For example, another integrated lab developed through the SUMMIT-P project involves simulating the exponential spread of a virus. This lab has been tweaked many times based on the feedback ULAs provided in discussions after their classes. These tweaks included ideas to accommodate more interaction between students and ways to expedite the process for collecting and modeling the data.

These contributions illustrate how leveraging the ULAs' research experiences, relationships as fellow undergraduates to the students in the class, and perspectives on learning enabled us to create more student-friendly (and hence effective) lessons.

Example 2: Undergraduate SEP Participants at Lee University

Figure 2
A Page of the Resource Website with Information About Terminology Differences

Math-Stats Differences

Statistical Terms	Psychological Definition	Mathematical Definition
Independent variable	A measure that is manipulated or recorded in a study to see how it impacts or influences something else	A value that may be chosen regardless of the value of any other variable.
Dependent variable	A measure that is impacted or influenced by the independent variable, usually interval or ratio data	A variable that depends on the value of one or more other variables.
p-value	This value shows how likely the null hypothesis is in being true. If the *p*-value is less than the alpha value, then you can reject the null	The probability of seeing a result at least as extreme as the actual result for when the null hypothesis is true.
Nominal data	This is categorical data without true numerical value. This is usually seen in groups like male or female; or Republican, Democrat, or Independent	Categorical Data without true numerical value just allocating groups to distinct categories regardless of any measuring value.
Ordinal data	This data has an order to it, but the spacing between each number might not be even (such as first, second, or third in a race)	Has an order to it but a specific type of ordering in that things are ranked.
Interval data	The spacing between each number is even, but has no absolute zero (a good example is Fahrenheit; there is no "real" zero)	Data that is measured in groups where the individuals are equally spaced out inside the group of data, and there is no absolute zero.
Ratio data	The spacing is even between each number and an absolute zero exists (such as weight, age, or height)	There is an absolute data and everything can be measured in relation to other data points because of this.

As Poole, Turner, and Maher-Boulis (2020) describe, the Student Exchange Program (SEP) at Lee University has been designed to provide collaborative learning opportunities about the uses of statistics for pairs of students, one majoring in mathematics and another majoring in a social science discipline (e.g., psychology, political science). Through this collaboration, students extend their knowledge of statistics and the application of statistics in the social science discipline by assuming responsibilities similar to those of the ULAs at SDSU. At Lee this includes (a) attending statistics course lectures and, upon invitation of the instructor, facilitating demonstrations for students enrolled in the class; (b) tutoring students and holding weekly recitation sections; (c) working through problem sets to facilitate discussions about the overlap of statistics and social sciences; (d) conducting interviews with the partnering student on topics related to statistics; and (e) designing instructional supports for student use.

Like the undergraduate participants in SDSU's program, the SEP participants at Lee University were asked to create resources to enhance student learning. For example, SEP participants were tasked with designing and building an instructional website, including finding and posting content to the site (see Figure 2). Importantly, they collaborated in pairs to determine which information would be useful for students accessing the website, including those taking the statistics course and those who sought a review of topics covered in the course. The program directors routinely reviewed the materials before the SEP participants posted them to the website. We provide additional details on these activities in another article in this volume (see Poole, Turner, & Maher-Boulis, 2020).

Example 3: Undergraduate Leaders at OSU

As described by Beisiegel, Kayes, Quick, Nafshun, Lopez, Dobrioglo and Dawkins (2020), the SUMMIT-P team at OSU are working to develop content-rich problems for Calculus I. Undergraduates on this team play a critical role because they are often enrolled in partner discipline courses and, therefore, are more familiar with the content being covered in the partner discipline courses and the relevant and important ways that mathematical topics are used in the different courses. The undergraduates that worked with the OSU faculty were particularly industrious and self-motivated. They worked to find over 20 examples of how local biological scenarios such as local predator-prey concerns and environmental changes impact the region.

One unique innovation that this team implemented is re-introducing a context several times over the course of the semester. For example, in one scenario describing glucose absorption, the exponential function is first introduced early in the term when covering the idea of limits. Later, it is discussed again to explore an application of the first derivative. Finally, the context is brought up a third time in relation to the second derivative. It is critical to note that the applications are authentic. For example, when examining the first derivative, this example required students to explore how the rate of change can be computed as a function of a particular parameter. This small nuance reflects the critical significance of working with client disciplines: mathematicians might not have known that such a shift in focus was needed. These nuances, combined with the intentional repetition, not only solidify the importance of the topic from a biological perspective, they also provide a new way to look at the particular mathematical concepts that transcend the calculation approach used to solve simple practice problems.

Benefits of Involving Undergraduate Students in SUMMIT-P

The goal for describing these three cases has been to call attention to the value of involving undergraduates in projects like SUMMIT-P. The three examples we have presented describe different ways in which students have contributed invaluable insights to the development and teaching of integrated lessons. It is interesting to note that all three participating SUMMIT-P universities, OSU, SDSU, and Lee University, describe the contributions of undergraduate students in similar ways. At each institution, lesson development began by working with partner discipline faculty to find an application that could be used in the mathematics course under study. Then, the SUMMIT-P faculty worked with undergraduates to hone the lessons to work with the instructional constraints. For example, at OSU, the undergraduate students found applications in biology that illustrated the need for exponential and logistic function models in the Calculus I classes. Similarly, undergraduates at SDSU were asked to hone and teach a lesson about pH—a science topic most were not intimately familiar with—in order to create a deeper understanding of how logarithms can be used to compare very small numbers during the lab sessions. Undergraduates at Lee University were asked to find applications of statistics concepts in the field of psychology to be shared among majors and non-majors via a website they created. In each case, the undergraduate teams created a win-win-win situation for faculty, students, and student leaders themselves.

Win for the Mathematics Faculty

These examples have illustrated ways in which the faculty gained critical help from the undergraduate students. At SDSU, the ULAs are actually teaching the labs, and hence the peer leaders are providing instruction which helps faculty communicate important mathematics ideas and concepts. Similarly, the undergraduates in the SEP program at Lee University are extending the teaching efforts of the faculty by mentoring their peers in ways that students may respond to on a more personal level. At OSU, the faculty were rewarded with excellent applications that enlivened their teaching.

Win for the Students Enrolled in the Course

Even though the Common Core Standards for Mathematical Practice (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010) have been in place for almost a decade, we have found that many students still believe that mathematics should be taught in isolation from other subjects. To combat this, all three of these SUMMIT-P programs encourage the students to think about how the mathematics they are learning applies to disciplines outside of pure mathematics and, most notably, to their own future careers. Having undergraduates design examples, teach recitations, and serve as mentors allows the students in courses to interact with peer role models early in their academic careers. By meeting with undergraduate teachers, talking with them, and often struggling with ideas they present, students are able to envision themselves in similar peer leadership roles in the near future. Moreover, they are able to get a sense of what college life can be like when students are excited about what they are learning through their undergraduate majors and are passionate about a field of study.

Win for the Undergraduate Leaders

All three of these cases illustrate what Kuh (2008) calls “High Impact Practices.” The teaching assistant experiences described here are most closely aligned with what Kuh labeled as “Collaborative Assignments and Projects,” which involve “learning to work and solve problems in the company of others, and sharpening one’s own understanding by listening seriously to the insights of others, especially those with different backgrounds and life experiences” (Kuh, 2008). As Kuh notes, such experiences have been correlated with higher graduation rates, more reported satisfaction with college experience, and more successful job placements.

Our findings regarding the benefits to the undergraduate leaders also align with the literature focusing on undergraduate peer leadership roles, which reveals that participants report a number of benefits, including (a) a great deal of applied content knowledge (Fingerson and Culley , 2001), (b) "soft skills" that can translate to the workplace (Lockie & Van Lanen, 2008), and (c) a sense of belonging by participating in this kind of work (Marx, Wolf, and Howard, 2016). These results, in turn, can support the students' efforts to stay connected to the STEM fields (Stout & McDaniel, 2016; Blackwell, Katzen, Patel, Sun, & Emenike, 2017). Based on feedback from our undergraduate peer leaders, it is clear that they have benefitted from these experiences in terms of content and personal as well as professional growth.

Conclusion

This article has presented three cases describing how undergraduate leaders were used to support faculty as they developed integrated activities for lower division mathematics courses. Both SDSU and OSU are large, state universities where change can be difficult to initiate and sustain because of the large-scale tasks involved in developing materials for so many sections of a class. Bringing undergraduate peer leaders onto the team has been a critical component of the integration effort. Undergraduate peer leaders contributed to the development and teaching of the activities without much cost or disruption to the university scheduling system. In contrast, Lee University is a very small institution where change is somewhat easier to implement because faculty and students from all disciplines are interconnected. During a SUMMIT-P site visit, the research team was able to talk with some of the SEP participants. These students described their experiences passionately and remarked that the program has produced deep, interdisciplinary learning and transferrable soft skills for the students learning social sciences and their math major partners as well. Although the roles of the undergraduates differed in the three institutions, the results indicate that these high-impact practices were mutually beneficial to the faculty, students enrolled in the classes, and undergraduate learning assistants.

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