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An Unconventional Collaboration at the College Level To Improve STEM Student Success

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The purpose of this article is to illustrate the work that has resulted from a collaboration between a biology professor, a school psychology professor, a researcher in higher education access, and the writing programs director. The essential school psychologist role, as classroom observer and data analyzer, is discussed through an example of work done as part of a larger project focusing on student success and retention for at-risk populations in introductory college biology courses. Best practices for consulting at the college level are discussed and include: collaborate to cultivate the willing, collect and analyze data to sustain instructor involvement, and communicate and advocate. We hope that the model exemplified here might inspire future interdisciplinary collaborations that draw on school psychology expertise to design and conduct research.

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Introduction

In the summer of 2014, the last author observed that the students in his unexpectedly low-enrolled Introductory Biology course received overall higher grades than students in the larger classes that he was used to teaching both in the summer and during the regular academic year. As a scientist, he found this phenomenon interesting and decided to put a team of researchers together to validate whether or not his perceived observations were true. He reached out to the then Dean of the School of Education, and she sent a message out to the faculty. Within the School of Education it was decided that two researchers, one with primarily qualitative expertise and one with quantitative expertise, would best serve to assist with this project. Additionally, this biology professor reached out to the Writing Programs Director to examine if integrating more writing into his class would improve students' critical thinking, and he also reached out to the university Assessment Director for input on ways to evaluate his students' learning. Thus, a seemingly unlikely cross-disciplinary partnership was born between this biology professor, a school psychology professor, a researcher in higher education access, and the writing programs director.

Although the original research question was related to class size, once all the collaborators were gathered, it was clear that this issue was larger than just class size. One question led to another question in a very organic, yet systematic way. In our first semester working together, we tackled the class size issue. In doing so we compared a small class (24 students) and a larger class (80 students) and attempted to ensure that as many factors (e.g., course content, course time of day, same professor) as possible were held constant. We found that that the smaller class both outperformed and was more engaged in class than the larger class, (Scott, McNair, Lucas & Land, 2017). This led us to attempt to understand more deeply factors associated with high attrition and failure rates in introductory biology courses. More importantly, we wanted to explore what kinds of interventions could disrupt those negative trends. Although each of us has our unique role in the on-going project, we are all dedicated to improving retention and graduation rates of underrepresented college students, so more recently we focused exclusively on at-risk students. Therefore, the purpose of this article is to provide a description of this unconventional collaboration, to offer an example of the type of work that has resulted from this collaboration, and to discuss best practices for the school psychologist consulting at the college-level, all learned as a result of this experience.

School psychologists have long been trained in individual and systems consultation and have traditionally consulted with others (i.e., teachers, parents, administrators) in the K-12 school system (Anton-LaHart & Rosenfield, 2004; Barrett, Hazel & Newman, 2017; Reschly & Wilson, 1995). Although trained in consultation, faculty in school psychology programs may fail to consider collaborating with peers at the college or university level. Yet through consultation and collaboration, school psychologists can assist teachers at all levels to use effective instructional processes, including more active learning techniques. School psychologists can build in accountability structures by tracking student and instructor improvement through classroom observation and by providing ongoing feedback based on collected data. School psychologists can also evaluate the effectiveness of programs and make recommendations for change.

Science, Technology, Engineering, and Math (STEM) disciplines have long suffered from high attrition rates and low student success (Chen, 2013; Hannauer & Bauerle, 2012). Given the strong pressure on colleges and universities in the United States to generate more STEM graduates, addressing these concerns over high attrition rates and improving outcomes is imperative and urgent. As noted above, one of the core questions that we tried to address through our collaboration was about the retention rate

of students in introductory biology classes. These classes are often viewed as gatekeepers into medical professions such as pre-med, pre-dental, and other health sciences. They are often lecture-based and designed to "weed students out." Although some might call this a noble function to ensure only the "fittest" enter medical fields, others would observe that there are students who may be quite capable but are simply underprepared. These students (such as first-generation college students or students from historically marginalized populations) may be at-risk for failing these introductory courses but could thrive if pedagogical structures and approaches could be adjusted to optimize student success. These adjustments entail a shift in traditional science-course culture. Therefore, a multidisciplinary approach is likely to yield the most effective solutions because it can operate outside of "the box" (of traditional norms), and to achieve these solutions multiple stakeholders need to collaborate effectively. Such a collaboration allowed us to identify possible factors stifling STEM student success and to help transform introductory biology courses to include more active learning strategies and make lectures more relevant to students' lived experiences.

In addition to encouraging the professor to experiment with teaching methods beyond the traditional lecture-based approach (using more writing to reinforce, extend, and synthesize student learning; techniques of active learning, reflective practice, and transparent teaching), outside observers (assessment director, writing center director, and school psychology graduate student observers) helped him to become more mindful of his assessment of student learning, such as the format of exams and also the activities his students were engaged in during class time, including on-task or off-task behaviors. As mentioned previously, initially we compared the data from a small class and a large class that were held in the same semester. Results suggested that class size had a significant impact on student success and students in the small section out performed students in the large section and were overall more on-task during class time (Scott, et al., 2017); however, we knew securing small sections for all students was unrealistic. Therefore, we decided to focus subsequent collaborative research work on students who most needed help.

Creating the optimal conditions for student success is important for effective teaching. School psychologists often assist in designing conditions where individual students with behavioral or learning challenges can thrive. Higher Education researchers Chickering and Gamson (1987) described seven high-impact educational practices to optimize student engagement which include: student-faculty contact, active learning, prompt feedback, emphasis on time on task, high expectations, respect for diverse learning styles, and cooperation among students. These are perhaps optimized by small class size, and the collaborators often had discussion of these factors. Kuh (2008) adds writing as another high-impact practice for activating student engagement and improving retention. Class size also was a factor here, given that we had to consider instructor workload issues. Each of these practices were incorporated into the fourth author's biology classes. We were able to illustrate the value of these changes because the school psychologists involved in the study were able to collect classroom observation data on active learning/ student engagement. Such is the essential role school psychology practitioners can play in cross-disciplinary research. Although many research questions were asked as part of the larger project, we specifically wanted to know if active engagement in class differed between the small classes (at-risk and traditional) and one large section during the two semesters of data collection and if subsequent academic outcomes differed between the classes. Given that we believed all students benefitted from small classes, we wanted to determine whether, given limited departmental resources, it was worth investing in creating smaller sections for at-risk students. In other words, we hoped to learn whether strategic investment in small sections

for at-risk students, coupled with pedagogical interventions, were powerful enough to ameliorate the disadvantages bourn by the group.

School Psychologist's Role in Collaboration

Method

Participants. Students in two small sections and one large section of one instructor's introductory biology course participated in the study described here. Each small class was capped at 24 students and the large class had 80 students. During the first semesters of the study for which the data for the large class and one of the small classes was collected, students self-enrolled in the introductory biology section of their preference, with some students clearly selecting a smaller class. One student dropped the small section and one student did not complete the course. This small section became the comparison sample for the study described here (comparison small section; CSS). During the same semester, data on the comparison large section (CLS) was also collected. Ten students did not complete the large section. Both large and small sections in this initial sample were heterogeneously mixed based on student demographics. However, during the fourth semester of the study, students were selected to participate in a smaller section based on their at-risk status, e.g., having previously failed the course (at-risk small section; ARSS). There were a total of 20 students enrolled in this small section. No students dropped the course and all students completed the course.

Procedure. Students either enrolled in the biology section of their choosing (first semester of data collection) or were placed in the at-risk section (fourth semester of data collection). During the first semester of data collection multiple sections of the course were offered by a variety of professors, but only the data collected for one professor is analyzed for this study. In order to be as consistent as possible the same professor taught the large and small sections for which the data is analyzed. His classes were offered on a MWF schedule from 11:00-12:15 (CSS) or 12:30-1:45 (CLS). This was done in order to minimize selection bias on the part of the students (i.e., neither section was offered at 8am). The biology curriculum is pre-determined, and all faculty that teach the sections must cover the same material, use the same texts, and maintain roughly the same pace. Students also attend separate lab sections that cover predetermined material. For the instructor for which data was collected, graduate student observers noted the content of the course to verify consistency over time. The observers also noted that the professor was as consistent in other ways, often telling the same jokes, asking the same questions, and using the same activities, etc. The only difference noted by the observers, as would be expected, is that in the smaller classes all students were likely be called on to participate during a class, as compared to in the larger section, because the same amount of time was allowed for each teaching activity in each class. Also, over time, the instructor became more aware of optimal teaching methods and was more likely to be using them more consistently by the fourth semester as compared to the first semester. The instructor also knew that the students in the at-risk group were considered at-risk, and this may have made him even more mindful to call attention to specific study skill techniques or offer colorful anecdotes designed to reduce student anxiety. Still, the course content was still the same in the first and fourth semesters. Data collected both semesters included observational data collected by a graduate student in school psychology and the final course grades.

The graduate student conducted observations throughout the semester (approximately once a week and never on exam days). A modified version of the Behavioral Observations of Students in Schools (BOSS; Shapiro, 2011) was used to observe students in the classroom. The definitions of the observation categories were retained for the observation with the BOSS, including active engagement, passive

engagement, off-task motor, off-task verbal, and off-task passive. Two modifications were made. Rather than observing a single student, all students were observed for successive 15-second intervals, such that each student was observed before starting over with the first student again. Also, only momentary intervals were used such that the student was observed at the end of the 15-second interval and the behavior they were engaged in was recorded. This data was then analyzed using an Analysis of Variance (ANOVA). The final course grade data was analyzed using non-parametric tests, as appropriate.

Results

Observational Data. A series of one-way ANOVAs comparing class means for active and passive engagement, as well as off-task behaviors divided into off-task motor, off-task verbal, and off-task passive behaviors were conducted to determine if such behaviors were significantly related to class-size. Given our focus on active engagement those results will be discussed here, though it should be noted that ANOVA results for all five behavioral categories followed similar patterns. The overall ANOVA for active engagement was significant, $F(2,17) = 7.87$, $p = .004$, indicating that percent of time spent actively engaged in class were different for the small and large classes. Subsequently, Tukey HSD post-hoc analyses revealed that students in the at-risk small section (ARSS) were not significantly more or less actively engaged in class as compared to the comparison small section (CSS), as follow-up tests did not yield significance. However, both small sections (CSS & ARSS) were significantly more engaged than students in the large section (CLS).

Final Grades. We also found that students in the at-risk small section (ARSS) performed similarly compared to the comparison small section (CSS). For both the CSS and the ARSS group, no students failed the course. However, no students earned As in the at-risk group (ARSS). Using Fisher's exact test, the proportion of students who received a C- or better compared to students who received a D+ or lower (neither class had any Fs) was not significant, $p = 1.0$.

Discussion

We found that compared to the initial self-selected group of students in the small section (CSS), students in the small section in the at-risk group (ARSS) were similarly engaged. This is important because one might assume at-risk students would be *less* engaged with the course, especially if they had failed the first time. Interestingly, this level of engagement existed in spite of the fact that the at-risk small group did not achieve at the level of the self-selected small group (CSS). In other words, average grades were lower for the at-risk group, but the small class size and possibly the more adept use of active learning techniques on the part of the professor seemed to mitigate the potential decrease in engagement/motivation that this cohort might otherwise experience. However, they all passed the course the second time while in the smaller group. These research findings reported here combined with other findings (Scott, et. al., 2017) have now led to in-depth discussions within the biology department about how to better improve the experiences of at-risk students. Using data to drive conversations can allow for informed decision making. This unconventional collaboration, and the data collected, opened the door for this conversation.

Limitations and Future Directions. We acknowledge that there are limitations in our study. The data collected for this study is from the students from one instructor for introductory biology classes at a small to mid-size private university. In the future we plan to compare the results of students from this instructor to the results of students from other instructors at this university and also at other universities (another small private and a large public). Therefore, at this time this data may not be generalizable to all introductory biology courses at the university/college level.

Additionally, as time has progressed, the instructor has been transformed into a more self-aware instructor who purposely uses active learning strategies and writing strategies to engage critical thinking in his courses. Therefore, as time has progressed it is likely that the classroom climate and other factors that we did not originally plan to measure have improved the classroom experience for the students. The at-risk section may not have had the same experience as the students in the comparison small section, even though we can confirm that the content and activities were largely the same.

Best Practices for Consulting at the College Level

Collaborate to Cultivate the Willing

School psychologists may not be uniquely positioned to collaborate with other departments at the college or university level, as the observations and data analyses conducted are not unique to school psychology and may be conducted by educational psychologists or other education researchers. However, at a small to mid-size private university, school psychologists may be the best positioned to assist with this type of research, depending on the programs offered by the university or college. School psychologists can impact course design for students in college through these collaborations. The largest reward has been collaborating with a faculty member who found theories about optimizing student success fascinating and who was willing to abandon the traditional lecture for more active engagement in the classroom. Through collaboration, a variety of teaching strategies were discussed, and the biology professor had support to implement changes in the classroom designed to benefit all students in the classroom, including at-risk students. Given that most STEM faculty are not trained on pedagogical best practices during graduate school, collaboration among different disciplines can help to introduce high impact and best practices to faculty members who may teach at-risk students.

There continues to be ongoing consultation with the biology department in order to try to infuse best practices throughout all of the introductory courses, not just the sections delivered by the professor involved in the project. This will take time, as all change does. Right now we have a willing participant, and we are willing to continue our work. Having collected and analyzed data has also helped leverage conversations with the higher administration to help reduce class sizes for students who are at-risk.

Collect and Analyze Data to Sustain Instructor Engagement

The main role of the school psychologist in this project is to analyze the quantitative data collected during the study. Based on results of data collected, we have been able make meaningful changes to the biology course through the help of the instructor. As a scientist, he Land reports that the data has been very helpful in allowing him to see the value of his efforts to make these changes and to support his students. In short, the numbers illustrate precisely the impact of the time and energy he has invested in his course, thus sustaining his motivation for continued efforts. Further, because we analyzed data both during the semester and at the end of each semester, changes could be made in real-time as well as for the subsequent semester based on the results. He has reported that with each change - and then with subsequent data to support the change - he has been energized and invigorated to keep these changes in his classes, despite skepticism from his colleagues that he may not be “weeding out” enough students by using these non-traditional teaching methods.

Being able to use a modified version of the BOSS allowed us to quantify active engagement in the classroom. This was crucial and important, as having trained observers from the school psychology program available to observe in the biology classroom

functioned as independent observers. Without this expertise, we might have been left only with the "feeling" that students seemed more engaged. With the BOSS we could confirm that was exactly what was happening. Additionally, school psychology graduate students were able to see the effects of ongoing program evaluation. Involving graduate students in this collaboration helped model to them the kind of work with which they might be involved in the future.

Communicate and Advocate

Most rewarding has been the fact that our results have helped us engage in the kind of consultations school psychologists are trained to participate in. We advocated for identifying at-risk students and providing additional support to better ensure their success (e.g., small classes, use of active learning techniques, etc.). Given the overall better performance of students in the smaller classes, we were able to advocate for at-risk students to be hand-selected to enroll in the smaller class section during the fourth semester of the study (ARSS). Although the data on this class section is limited (relying only on one semester), and based on a small sample size, the results are encouraging. All students in the smaller section who were retaking the course because they had failed it the first time were able to pass the class the second time. Although students in this group (ARSS) did not get As and had more Cs as compared to students from CSS group, they were able to pass the course likely because they did not receive "more of the same" but truly received "something different" (Abbott, Wills, Greenwood, Kamps, Heitzman-Powell & Selig, 2010). Passing the course allowed these students to continue to progress in their majors, saving time and costs associated with their time-to-degree.

We continue to consider how we might better support and advocate for students, particularly at-risk students. We know that small classes in-and-of themselves are not likely sustainable. However, we are considering how we might better support students early when we notice they are not doing well in courses, practices currently under consideration include the use of on-line learning communities or of teaching assistants for the course who could hold evening office hours in the library where students often study, requiring a stipulated number of visits to office hours (of the TA or professor).

School psychologists should not be afraid to share their knowledge of effective teaching practices at the college level. As we know, the qualifications for teaching at the university level is an advanced, terminal degree, but professors outside of education/ educational psychology departments often do not have much knowledge of effective teaching strategies and they rely on teaching the way they were taught. Although school psychologists may sometimes take their specialized knowledge for granted, it is important that school psychologists share their knowledge at all levels of education.

We also suggest having a plan for communicating findings at all levels: within the department(s), at the university level, within the higher education community and to the wider community. Initially the collaborators brought into this project did not necessarily think about ways to share the results of this project outside of the biology community. However, since this project began, many, including deans and the provost, have become very interested in our work. We have communicated our findings within the campus community, including at the annual Summit on Writing in the Disciplines, which has subsequently helped in terms of internal funding support the project. We have also communicated our findings to the academic community by presenting at a variety of academic conferences and have published aspects of our findings in academic journals.

Conclusion

Although the original study began by examining class size at the university, our recent focus has become effective teaching strategies for at-risk

students. We found ourselves advocating for research-based factors that promote success in learning at the higher education level (e.g., smaller class sizes, active learning strategies, etc.). School psychologists have the knowledge and skills that translate well to the college environment. Examining practices in post-secondary education is very similar to practices used in K-12 schools but is often under-utilized. At all levels, collecting and analyzing observational and other quantitative data are useful to teachers. Strategies for increasing active student engagement, class size issues, and retention of students (or the cost of repeats) are discussions at all levels of education. Our unconventional collaboration may represent a new paradigm in higher education with school psychologists helping to improve student experiences at the college and university level.

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