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### Project-Based Learning in Social Statistics: Direct and indirect assessment of student learning outcomes

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Project-Based Learning in Social Statistics: Direct and indirect assessment of student learning

outcomes

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Statistics classes are often are often sources of increased anxiety and reduced degrees of self-efficacy for students, which are factors correlated with low levels achievement and engagement in statistics courses (Van Gundy et al. 2006; May 2009). However, research indicates that lower levels of student anxiety and higher levels of student self-efficacy are associated with more better learning outcomes in statistics classrooms (Van Gundy et al. 2006; May 2009). In Spring 2019, as we were completing our second statistics course, we noticed, first-hand, these same patterns among our classmates. Upon being invited to be teaching assistants for a social statistics course in Spring 2020, we both wanted to work with our professor to improve student experiences in the current iteration of her course. We created and implemented a Problem-Based Learning (PBL) to study the effects of our intervention on student learning. Specifically, we collected both direct and indirect evidence of student learning and measured student satisfaction with our intervention. Our work is ongoing, but the full, final analyses from this project will culminate in a scholarship of teaching and learning manuscript that we intend to submit to an academic journal by the end of Summer 2020.

The objectives of our intervention for students were to: reduce statistics-related anxiety, increase statistics efficacy, increase perceived utility of statistics, and by doing so, foster among students the ability to accurately apply and interpret statistical models. In this brief paper, we describe the outcomes related to 1) student anxiety and efficacy (indirect evidence of learning); 2) one assessment of students' ability to apply and interpret statistics (direct evidence of student learning); and 3) student satisfaction with our intervention.

**Problem-Based Learning:** Through making the class more student-centered, we hoped to improve the student experience by increasing engagement and learning through a mini research project that was divided into a predesigned series of assignments. These assignments, termed

“phases”, supported the existing curriculum of the course and built on topics discussed in class. Additionally, to increase student engagement, students chose from three popular areas of social science inquiry for their projects: Gender, Health and Illness and Criminal Justice. Before the phases began and depending on which sociological topic they chose, each student was assigned to one of nine groups and given a research question. We developed the research questions from either the 2016 General Social Survey (GSS) or the 2015 National Crime Victimization Survey: School Crime Supplement (SCS) and created nine distinct combinations of variables, which were distributed after the students were assigned to their respective groups. The phases involved tasks such as finding scholarly articles, analyzing measures of central tendency, writing an abstract and producing and analyzing t-tests, ultimately culminating in a student-designed research poster that was presented in class. Our goal was to assess whether a student-centered method of teaching could improve our indirect measures of anxiety and self-efficacy through creating more engagement with different topics in the course.

**Indirect Measures of Student Learning:** Indirect evidence of student learning (anxiety and self-efficacy related to statistics) was assessed via a self-administered questionnaire at the start of the course and at week eleven. The first questionnaire also contained basic sociodemographic items included primarily for the purposes of sample description and to assess potential bivariate associations between student characteristics and the indirect evidence of student learning. Student anxiety and self-efficacy were measured using four-point and five-point Likert scales, respectively, for which lower scores indicate lower levels of anxiety and higher scores reflected higher levels of self-efficacy regarding statistics.

**Measures of Student Learning and Satisfaction:** We evaluated direct evidence of student learning through student performance on application and interpretation of models used in their

posters. Originally, we had planned to survey students at three points in time, but due to the need to transition to online learning in mid-March, we decided to conduct only one follow-up assessment that took place approximately three weeks after the course moved into its current online format. Additionally, we added nine questions (with four-point Likert scale response choices) to the second assessment to assess student satisfaction with the intervention before the transition to online instruction and students' perceptions related to the effect of COVID-19 on their learning. In the absence of a previously validated measures of student satisfaction with our specific intervention and student experiences during a global pandemic, we created our own measures. We obtained Duquesne University Institutional Review Board approval for this study (and all modifications to our protocol) prior to the conduct of research and all students participating in our research provided written informed consent.

**Results:** All 29 students enrolled in the course elected to participate in our study and all 29 completed the initial questionnaire, but only 21 students completed the follow-up questionnaire. Most of the 29 students identified as female (58.6%), juniors or seniors (79.3%), and indicated plans to attend graduate school (68.9%). The majority (68.9%) identified as middle class with 62% reporting that his/her mother and 41.3% indicating that his/her father had completed at least some college.

Students' mean score on statistics anxiety scale was slightly higher (28.2) and self-efficacy scale was similar (44.5) at baseline to that of other samples in the literature (Van Gundy et al. 2006; May 2009). Additionally, most student groups (66.6%) correctly interpreted and applied their models on their posters presented in class. While the same students (52.3%) reported decreased anxiety and increased self-efficacy scores, findings from our paired samples *t*-tests did not reach statistical significance. However, correlation analyses (Pearson's *r*),

indicated significant, strong negative associations between statistics anxiety and statistics self-efficacy at both baseline ( $r = -.808, p=.000$ ) and the second survey ( $r = -.844, p=.000$ ).

Student responses at follow-up indicated relatively high levels of satisfaction with the PBL intervention in the second survey. We had only 22 responses to this series of questions because we had one respondent for whom we were unable to match with an initial set of responses. More students indicated feeling more engaged with the student-centered research project (57.1%) than with the traditional workbook exercises and 72.7% found the research project to have educational value and only 36.3% categorized it as “not boring”. Additionally, 77.2% of students indicated that working with data concerning a social justice topic of their choice was beneficial to their learning. Interestingly, most students reported that completing the traditional workbook exercises made social statistics to “more understandable” (54.5%) and more educational (81.8%), but “boring” (59.1%). Finally, all respondents responded that COVID-19 has impacted their educational experience at Duquesne University, with 86.3% of students indicating moderate or significant impact.

**Discussion:** This study aimed to assess the effects of a PBL intervention on social statistics students’ anxiety and self-efficacy related to statistics and student learning of statistics. We considered several reasons why our observed decreases in students’ statistics-related anxiety and increases in statistics-related self-efficacy from baseline to follow up, did not reach statistical significance.

The most obvious explanation could be that a PBL intervention of this variety does not significantly affect anxiety or efficacy. Another important consideration in our research, however, is the COVID-19 pandemic. While our plan was to collect follow-up questionnaire data in week nine, we were not able to collect these data until week 11 (due to transition to online

classes, students moving off campus, and obtaining IRB approval to modify our protocol). In the two weeks after the closure of our brick and mortar campus and transition to online learning in our class, we and our professor noted: 1) a temporary (~ two-week period) of decreased levels of engagement (e.g., attendance, in-class participation, response to emails); 2) temporary decline in timely submission and quality of student work; and 3) that two students withdrew from the course, creating temporary, but significant disruption in two of the nine student project groups. In reflecting on our interactions with students during the initial weeks of the transition to online learning, we believe that most of these temporary challenges were due to increased levels of stress and uncertainty brought about by circumstances surrounding the pandemic. We further believe that it is possible that these circumstances may have inflated students' responses to our anxiety scale and potentially, deflated their scores on the self-efficacy scale.

As previously discussed in the results section, the responses to questions about how the students felt the project went were positive, while they found the workbook exercises to be helpful in clarifying the statistical concepts in class. Additionally, most of the class correctly interpreted the statistical tests included on their posters. Regarding our correlations, we found a statistically significant, negative relationship between statistics-related anxiety and self-efficacy, showing a reciprocal relationship. This is consistent with what was reported in our literature, as a lower levels of anxiety lead to higher levels of self-efficacy (Van Gundy et al. 2006; May 2009). While we did not achieve the statistical results that we anticipated, we believe, that given the extreme circumstances (global pandemic) of the semester, that our findings suggest potential for this and similar PBL interventions in social statistics courses, especially when used in tandem with traditional workbook exercises. However, further research (under more ordinary conditions) is needed to confirm the efficacy of our intervention.

### Works cited

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