Predicting Successful Dissemination of a Project-based Curriculum: Findings from the Passion-Driven Statistics Initiative

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Abstract

The purpose of this study was to inform the dissemination of a project-based statistics curriculum by identifying institutional and instructor characteristics that predict its implementation. Data were drawn from pre- and post-workshop surveys completed by 67 instructors attending a one-and-a-half-day professional development workshop. Nearly half of the instructors who intended to implement Passion-Driven Statistics following the workshop employed the project-based curriculum by the end of the first full academic year. Teaching at a private institution and endorsing a larger number of positive adjectives regarding teachers' likely experiences with the model predicted its actual implementation.

Keywords: Passion-Driven Statistics, project-based learning, statistics education, faculty development

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Science education has been in a state of on-going reform (DeBoer, 2014) with an emphasis on incorporating inquiry-based pedagogies that utilize authentic experiences to model the work of practicing scientists (Bangera & Brownell, 2014; Crawford, 2014). Previous research focused on statistics education has promoted authentic, inquiry-based projects (Bailey & Sinn, 2013) that allow students to "decompose their topic, identify key components; abstract and formulate different strategies for addressing it; connect the original question to the statistical framework; choose and apply methods; reconcile the limitations of the solution; and communicate findings" (Nolan & Lang, 2009, pg. 27). Designed to answer a question or solve a problem, this approach allows students to face challenges that lead to answers, reflect on ideas and make decisions that affect project outcomes (Aditomo et al., 2011; Krajcik & Blumenfeld, 2006). Accumulating research has shown that project-based activities, especially those providing a research experience (Russell et al., 2007), promote positive learning outcomes and may hold promise for better engaging students with varying levels of preparation (Bangera & Brownell, 2014; Dierker et al., 2015; Hatfull, 2010; Jones et al., 1997; Mergendoller et al., 2006).

The statistics education literature is replete with best practices for actively facilitating quantitative reasoning and many have become the focus of professional development programs (e.g. (Lee, 2017; Lovett & Greenhouse, 2000; Rossman & Chance, 2014). In this vein, the Passion-Driven Statistics project has been conducting workshops for instructors to introduce them to a project-based, introductory curriculum that provides students with authentic quantitative research experiences using original data analysis in a statistical package. The curriculum has been implemented as a statistics course, a research methods course, a data science

course, a capstone experience, and a summer research boot camp with students from a wide variety of academic settings. Funded by the National Science Foundation, Passion-Driven Statistics engages students in research with large, real-world data sets.

In previous publications we have described the development of the curriculum (Dierker et al., 2015; Dierker et al., 2012) aimed at increasing access to applied statistics skills both generally and for students traditionally marginalized within many technical fields (e.g., women, underrepresented students, educationally disadvantaged students, etc.). Following the recommendations outlined in the Guidelines for Assessment and Instruction in Statistics Education (GAISE) report (Carver et al., 2016) the project-based curriculum teaches statistical thinking focusing on conceptual understanding and integrating real data with a context and purpose. It fosters active learning and prioritizes technology to allow students explore concepts and analyze data. Designed around projects of students' own choosing, work is organized to focus on the decisions and skills involved in statistical inquiry including the ability to tell accurate and engaging stories with data.

The success of the Passion-Driven Statistics curriculum in attracting and inspiring introductory students is well-documented. Published research has shown that the project-based course attracts higher rates of under-represented minority (URM) students compared to a traditional math statistics course (Dierker et al., 2015). We have also found higher rates of enrollment of both female and URM students in the project-based course compared to a general introductory programming course and an introductory programming course representing a gateway to the computer science major (Cooper & Dierker et al., 2017). Students in Passion-Driven Statistics courses are also more likely to report increased confidence in working with data and increased interest in pursuing advanced statistics course work compared to students from the

traditional statistics course (Dierker et al., 2018a) and the project-based curriculum also promotes further training in statistics. Using causal inference techniques to achieve matched comparisons across three different statistics courses, students originally enrolled in Passion-Driven Statistics were significantly more likely to take at least one additional undergraduate course focused on statistical concepts, applied data analysis, and/or use of statistical software compared to students taking either a psychology statistics course or math statistics course (Nazzaro et al., 2020). Further, liberal arts colleges, large state universities, regional college/universities, community colleges, and high schools have all successfully implemented the model (Dierker et al., 2018b)

Despite these promising outcomes, the dissemination of the model has been slow. The present paper draws on pre-workshop and post-workshop survey data from 67 instructors attending an instructor workshop focused on the Passion-Driven Statistics model. We evaluate institutional and instructor characteristics, and instructor attitudes and experiences that are associated with implementation of the project-based curriculum.

Method

Sample

Pre-workshop and post-workshop survey data from 67 instructors attending a Passion-Driven Statistics faculty development workshop were examined. Forty-one (61.2%) were female and 49 (73.1%) self-reported as White. Twenty-one (31.8%) instructors held a Masters as their highest degree and 45 (68.2%) held a Ph.D. 53 (79.1%) held a full-time appointment. The sample was evenly divided between tenured, tenure-track, or non-tenure track positions, respectively. Teaching load included an average of 5.4 course sections per year (s.d. 2.40, Range: 1 to 12

courses). The average age was 45 (s.d.10.76). Instructors had been teaching for 15.2 years (s.d. 8.92, Range: 2 to 49 years).

Forty-six (71.9%) instructors held a position at a college or university with a Carnegie level of 4-year or above, 14 (21.9%) were from 2-year colleges and four (6.2%) were high school instructors. The instructors represented schools with an average enrollment of 7072 students (s.d. 5029.15, range: 310 to 24717 students). Thirty (46.9%) of the schools were public and 24 (53.1%) were private.

Target Course

Target courses that faculty intended to modify based on the project-based curriculum included such titles as Basic, Elementary, Introductory or Principles of Statistics, Probability, Quantitative Reasoning with Statistics, Statistics for Decision Makers, Storytelling with Data, Research Methods, Introduction to Data Analysis, Independent Study and Research, and Safe and Effective Nursing Care. These courses were largely hosted by a Math or Statistics Department (64.2%), with social science departments accounting for another 11.9% of target courses. A science department (e.g. agriculture, biology and chemistry), a health science department, or a department of information technology hosted the remaining courses. Thirty-six (53.7%) of the target courses did not have any prerequisites.

The average enrollment per class section was 25.3 students (s.d. 12.59, range: 10 - 130 students) and more than half of the instructors reported that they generally devote between 50% and 100% of class sessions to lecture. All were full semester courses meeting on average, 2.4 times (s.d. 0.91, Range: 1 to 5 meetings) for a total of 3.3 hours per week (s.d. 2.08, Range: 1 to 17 hours). While 32 (47.8%) instructors reported already using a statistical software in their target course, only 7 (10.4%) taught software that was code-based (e.g., R, SAS, Stata, or

Python), as opposed to menu-driven (e.g., SPSS). Few (11.9%) reported having any teaching assistants available to them for the target course.

Workshop

Recruitment for the workshops included the following description: "This workshop will support participants in planning authentic data-driven research curriculum for use across a variety of disciplines, and for engaging students at many different levels, including complete beginners. The session will include brief presentations focused on the nuts and bolts of the passion-driven statistics model (passiondrivenstatistics.com) followed by hands on experience with the steps that allow students to engage in independent research. Each participant's experience in the workshop will be individualized to their own interests, background and needs. Early career participants are especially encouraged to attend."

Each workshop lasted 1.5 days, meeting in both the morning and afternoon of the first day and during the morning of the second. Workshops consisted of discussion and one-on-one consulting. During the individualized portions of the workshop, instructor participants were supported in the decisions and skills involved in asking and answering questions with data with the goal of telling accurate and engaging stories. Participants were provided with a large data set and corresponding data dictionary describing survey questions, response categories, frequency of participant responses and the variable names used within the data set. Based on their choice of variables, each was asked to generate testable hypotheses and to prepare data for analysis (i.e. data management). Participants also used descriptive and inferential statistical tools to address their questions and to evaluate and interpret their findings.

Each instructor chose the statistical software platform that they would use during the workshop. The instructors who had limited prior statistical software experience received support

in using SAS OnDemand through the cloud-based SAS Studio platform. A total of 36 (53.7%) participants used SAS, 11 (15.4%) used SPSS, 8 (11.9%) used R and the remaining instructors used either Stata, JMP, Python, Excel, or another statistical software package.

Measures

Data were drawn from surveys completed before (pre) (See Appendix A) and after (post) (See Appendix B) each workshop. Each survey took approximately 10-15 minutes to complete.

Institutional Climate

Support for innovation Instructors characterized support for innovation by answering whether or not their administration is generally supportive of teaching innovation and whether or not faculty at their institution are generally supportive of teaching innovation.

Freedom in planning and implementing curriculum was measured by evaluating whether or not instructors are the final decision makers for the target course's format (lab, lecture, etc.) content, syllabus, assignments, textbook and/or exams. A count ranging from 1 to 6 was creating by summing the number of items endorsed.

Pre-Workshop and Post-Workshop Concerns

In the pre-workshop survey, respondents were asked the question "What are your greatest concerns pertaining to teaching and learning? select 'all that apply" from a list of 8 concerns: keeping students engaged in class, motivating students to prepare before class, covering all the material that I need to cover, how to measure if students are really learning, how to deal with student resistance to non-lecture based teaching, how to deal with colleague resistance to non-lecture based teaching, how to create effective projects/activities that engage students, and being able to support students in the use of technology. A count variable was created to measure total number of teaching and learning concerns.

In the post-workshop survey, participants were asked about their concerns pertaining to using the Passion-Driven Statistics model in their course. The 8 teaching and learning concerns from the pre survey were used along with additional options including “the approach seems too time-consuming for instructors”, “I do not feel that I can deliver the Passion-Driven Statistics approach well”, “I would need to give up too much classroom control”, “Projects seem too time-consuming for students”, “I would not be able to get the support that I would need from my institution”, and “I would not be able to/it would be difficult to get teaching assistants for my class”. Responses ranging from 1=not at all concerned to 5=very concerned were summed to create an aggregate measure of post workshop concerns about the Passion-Driven Statistics model.

Experience and Perceived Gains

Prior experience with features of the Passion-Driven Statistics curriculum were assessed in the pre- workshop survey. We asked respondents to estimate their current level of experience in developing a research question, managing data (e.g., setting aside missing data, creating scales, and/or dichotomizing variables), choosing the correct statistical test, graphing, interpreting statistical results, effectively presenting results, reading primary source scientific literature, conducting a quantitative project entirely of your own design. Response options ranged from 1. Inexperienced to 4. Much experience. Items were summed to create an aggregate measure of prior experience.

Perceived gains following the workshop were assessed in the post-workshop survey by asking respondents to estimate how much they feel they gained as a result of the workshop. Potential areas of gain included developing a research question, managing data, choosing the correct statistical test, writing syntax to run a statistical analysis, graphing, interpreting statistical

results, effectively presenting results. Items were summed to create an aggregate measure of perceived gains.

Involvement in Workshop Training

As a measure of adherence to the workshop, instructors were asked which *steps in the project* they completed during the Passion-Driven Statistics workshop. Steps included selecting variables from a data code book, developing a research question, writing a program to examine frequency tables, data management, interpreting univariate or bivariate graphs, creating and interpreting a graph with three variables, running and interpreting an ANOVA, Chi Square Test of Independence or Pearson Correlation Test, examining moderation, testing multivariate models and sharing research questions or results with others. These selected steps were summed into an aggregate count. Because more experienced instructors may have skipped over early steps, the individual variables measuring use of specific statistical tests were also examined.

Post-Workshop Positive Perceptions of the Curriculum

Additional post workshop questions asked instructors to select from a list of adjectives that describe the Passion-Driven Statistics model for both themselves and their students. Following two open ended statements 1. For *me*, passion-driven statistics will make teaching more _____ and 2. For *students*, passion-driven statistics will make learning more _____, respondents were asked to check 'all that apply. Adjectives included difficult, fun, collaborative, discouraging, empowering, useful, effective, easy, interesting, personal, boring, and engaging. Those adjectives representing positive appraisals (i.e., fun, collaborative, empowering, useful, effective, interesting, personal, and engaging) were summed into a count variable separately for teachers and students.

Outcomes

We examined two main outcomes: a binary measure of intention to implement Passion-Driven Statistics in their course, coded as 1 for "definitely" or "very likely" and 0 otherwise, and a binary measure of whether the instructor actually implemented the model during the first academic year following the workshop.

Data Analysis

Chi-square Tests of Independence and ANOVA were used to evaluate differences between outcome groups (i.e. intention to implement and implementation) for categorical and continuous variables, respectively. We used multivariate logistic regression analyses to predict intention to implement and actual implementation, controlling for pre-workshop variables (e.g., experiences with project-based skills), and we evaluated whether post-workshop concerns about the curriculum accounted for the relationships. Odds ratios (OR) and 95% confidence intervals for the significant effects are reported. An odds ratio is a measure of association between each predictor variable and the outcome (i.e., the odds that the outcome will occur based on the presence or magnitude of the predictor variable), controlling for all other predictors in the model.

Results

Descriptive Statistics

Forty-eight instructors attending the Passion-Driven Statistics workshop (71.0%) felt that their administration is generally supportive of teaching innovation, while 40 (59.7%) believed that the faculty at their institution is supportive of teaching innovation. The majority of instructors reported that they were the final decision maker on the format of their course (74.6%), the course content (53.7%), the syllabus (71.6%), assignments, (80.6%) and exams (77.6%). Ten instructors (14.9%) reported that their course is centralized and that they were not the final decision maker on any aspect.

Prior to the workshop, the most prevalent teaching and learning concern was keeping students engaged in class (77.6%), motivating students to prepare before class (76.1%) and creating effective projects that engage students (88.1%). The least prevalent concern was dealing with colleagues' resistance to non-lecture-based teaching (11.9%). Following the workshop 17 (25.8%) instructors reported being "very" concerned about supporting students in their use of statistical software when using the Passion-Driven Statistics model (25.8%), being able to get teaching assistants to help implement the project-based approach (27.3%), and covering all of the material they needed to cover (27.7%).

Coming into the workshop, instructors reported being more likely to have previous experience developing a research question, graphing, and interpreting statistical results and less likely to have experience managing data or choosing the correct statistical test. The most common perceived gains from the workshop included managing data and writing syntax to run statistical analyses. Forty-one (61.2%) instructors completed five or more steps in the Passion-Driven Statistics project during the workshop. On average, instructors endorsed 4.8 (s.d. 2.41) of eight positive adjectives regarding students' likely experience with the project-based model and 4.5 (s.d. 2.04) positive adjectives regarding teachers' likely experience. Thirty-three (49.3%) instructors reported they would definitely or very likely implement the model, and 17 (25.4%) instructors implemented the model within the first academic year following the workshop.

Differences between those intending vs. not-intending to implement.

Table 1 presents differences among faculty workshop participants intending or not intending to implement the curriculum following the workshop. Instructors intending to implement the Passion-Driven Statistics curriculum were found to be significantly more likely to hold a non-tenure track position compared to those uncertain about implementing the curriculum.

They were also more likely to hold a position at a private institution, teach at the university level, and have fewer years of teaching experience than instructors uncertain about implementing the curriculum. While those intending to implement were no more or less likely to already be using software in their target course, they were more likely to use code-based statistical software (as opposed to menu-driven software). Instructors intending to implement the curriculum vs. those who reported being less certain did not differ by gender, race, degree, or part-time vs full-time status.

Participants intending to implement reported more experience with project-based skills (i.e., developing a research question, managing data, choosing the correct statistical test, graphing, interpreting statistical results, effectively presenting results, etc.). They were also more likely to spend time during the workshop using inferential statistical tools than those less certain about implementing the curriculum. Intending to implement the project-based model was not significantly associated with gains perceived as a result of the workshop

Participants intending to implement the project-based model endorsed a larger number of positive adjectives regarding their perception of the model for both teachers, and students. They also had fewer post-workshop concerns about their likely success with the model. Significant differences were also found when examining whether or not instructors felt that faculty at their institution are generally supportive of teaching innovation. Among those intending to implement the curriculum. 72.7% endorsed a supportive faculty compared to 47.1% of those less certain about implementing. Those intending to implement the curriculum vs. those who reported being less certain did not differ in reports of perceived support from their administration or in freedom for planning and implementing curriculum. Further, intention to implement the project-based

model was not significantly associated with gains perceived by instructors as a result of the workshop.

We used logistic regression models to evaluate which effects remained significant after control for both previous experience with the project-based skills and level of teaching and learning concerns about the model following the workshop. After including both of these variables in each model as covariates, holding a non-tenure track position (O.R. 6.1 CI 1.52-24.11) holding a position at a private institution (O.R. 3.8 CI 1.19-12.49), endorsing a larger number of positive adjectives about teaching with the model (O.R. 1.5 CI 1.10-2.02), and feeling that other faculty at their institution were supportive of innovation (O.R. 3.6 CI 1.10-11.70) remained significantly associated with intention to implement the project-based model.

Table 1. Characteristics and experiences of faculty workshop participants intending or not intending to implement the curriculum following the workshop

	Intend to implement post workshop n=33	Do not intend to implement post workshop n=34	Statistics
Gender (% female)	63.6%	58.8%	n.s.
Race (% white)	69.7%	76.5%	n.s.
Ph.D degree	69.7%	66.7%	n.s.
Full-time position	72.7%	85.3%	n.s.
Non-tenure track position	48.5%	21.2%	X^2=5.4, df 1. p=.0201
Private institution	66.7%	41.2%	X^2=4.4, df 1. p=.0364
University setting	84.9%	61.8%	X^2=5.4, df 1. p=.0331
Faculty colleagues supportive of teaching innovation	72.7%	47.1%	X^2=4.6, df 1. p=.0322

Administration supportive of teaching innovation	33.3%	23.5%	n.s.
Freedom for planning and implementing the curriculum	M=3.67 (s.d. 2.26)	M=4.03 (s.d. 2.12)	n.s.
Year of teaching experience	M=12.1 (s.d. 6.36)	M=18.0 (s.d. 10.06)	F(1, 66)=6.6, p=.0133
Using software in target course	51.5%	44.1%	n.s.
Using code-based software	18.2%	2.9%	X^2=4.2, df 1. p=.0415
Experience with project-based skills	M=29.5 (s.d. 8.37)	M=24.7 (s.d. 7.24)	F(1, 66)=6.3, p=.0143
Perceived gains from workshop	M=18.1 (s.d. 8.01)	M=16.3 (s.d. 8.02)	n.s.
Use of inferential tools during the workshop	24.2%	5.9%	X^2=4.4, df 1. p=.0350.
Positive adjectives endorsed for teachers	M=5.3 (s.d. 2.01)	M=3.7 (s.d. 1.76)	F(1,66)=11.9, p=.0010
Positive adjectives endorsed for students	M=5.5 (s.d. 2.10)	M=4.2 (s.d. 2.52)	F(1, 66)=5.8, p=.0188
Post workshop concerns about the project-based model	M=30.2 (s.d. 9.04)	M=38.5 (s.d. 9.56)	F(1, 65)=13.2, p=.0005

Differences between those implementing or not implementing the project-based curriculum

Nearly half (n=16, 48.5%) of the instructors who reported that they intended to implement Passion-Driven Statistics at the end of the workshop and a quarter (n=17, 25.4%) of the overall sample employed the project-based curriculum within one full academic year. One instructor saying they would “possibly” implement, piloted the curriculum within the first full academic year. This relatively fast uptake was associated with similar predictors as intention to

implement at the end of the workshop. These included greater prior experience with project-based skills, endorsing a larger number of positive adjectives regarding their perception of the model for teachers (but not students), and fewer post workshop concerns about their likely success. Those who implemented the curriculum were more likely to be female than those who had not yet implemented, were more likely to hold a Ph.D. and were more likely to be employed by a private institution. They were also more likely to have been previously using statistical software in their target course.

Table 2 presents differences among faculty workshop participants who implemented to did not implement the project-based curriculum within one academic year. Again, implementation of the project-based model was not significantly associated with gains perceived by instructors as a result of the workshop. Those implementing the curriculum vs. those who did not also did not differ according to race, degree or part-time vs full-time status, tenure status, years of teaching, university setting, perceived support by faculty or their administration or freedom for planning and implementing curriculum. Notably, regardless of whether or not instructors implemented the model in the first year following the workshop, the vast majority (92%) reported that they would recommend the workshop to other instructors

Logistic regression modelling was again employed to evaluate which effects remained significant after control for both previous experience with the project-based skills and level of teaching and learning concerns about the model following the workshop. Endorsing a larger number of positive adjectives regarding teachers' classroom experiences with the model (O.R.1.5 CI 1.03-2.09) and working at a private institution, (O.R.5.7 CI 1.28-25.19) remained significantly associated with implementation.

Table 2. Characteristics and experiences of faculty workshop participants implementing or not implementing the project-based curriculum within one academic year following the workshop

	Implemented the curriculum within one year n=17	Did not implement the curriculum within one year n=50	Statistics
Gender (% female)	82.4%	54.0%),	X^2=4.3, df 1. p=.0382
Race (% white)	64.7%	76.0%	n.s.
Ph.D degree	94.1%	59.2%	X^2=7.1, df 1. p=.0077
Full-time position	88.2%	76.0%	n.s.
Non-tenure track position	64.7%	65.3%	n.s.
Private institution	76.5%	46.0%	X^2=4.7, df 1. p=.0295
University setting	88.2%	68.0%	n.s.
Faculty colleagues supportive of teaching innovation	70.6%	56.0%	n.s.
Administration supportive of teaching innovation	70.6%	72.0%	n.s.
Freedom for planning and implementing the curriculum	M=3.8 (s.d. 2.42)	M=3.9 (s.d. 2.11)	n.s.
Year of teaching experience	11.9%	16.4%	n.s.
Using software in target course	70.6%	40.0%	X^2=4.8, df 1. p=.0292
Using code-based software	11.8%	10.0%	n.s.
Experience with project-based skills	M=32.7 (s.d. 8.99)	. M=25.1 (s.d. 6.91)	F(1, 66)=12.9, p=.0006
Perceived gains from workshop	M=16.1 (s.d. 8.44)	M=17.5 (s.d. 7.91)	n.s.
Use of inferential tools during the workshop	23.5%	12.0%	n.s.

Positive adjectives endorsed for teachers	M=5.6 (s.d. 1.94)	M=4.2 (s.d. 1.97)	F(1, 66)=6.7, p=.0118
Positive adjectives endorsed for students	M=5.4 (s.d. 1.91)	M=4.6 (s.d. 2.54)	n.s.
Post workshop concerns about the project-based model	29.0 (s.d. 8.84)	36.2 (s.d. 9.99),	F(1, 65)=6.9, p=.0110.

Discussion

The benefits of early research experiences for students are well-established (Bangera & Brownell, 2014; Hathaway et al., 2002; Russell et al., 2007; Zydney et al., 2002). Furthermore, course-based experiences, specifically, enroll many more students than traditional research internships and are accessible to students from a wider range of educational and socioeconomic backgrounds (Bangera & Brownell, 2014; Espinosa, 2011). Despite the promise that these early and authentic opportunities hold, efforts to implement research in the classroom have proceeded slowly. In previous publications, we have described the development of a National Science Foundation-funded project-based, applied statistics curriculum (Dierker et al., 2015) and its implementation across diverse educational settings (Dierker et al., 2018b). The present paper extends our previous work by describing recent dissemination efforts through instructor workshops. We found that one quarter of the instructors who attended a workshop implemented Passion-Driven Statistics within the first academic year following workshop attendance, though twice as many reported at the end of the workshop that they intended to implement the project-based model. In addition to prior experience with quantitative research and fewer post workshop concerns about implementation, a non-tenure track position, teaching at a private institution, endorsing a larger number of positive adjectives about teachers' likely experiences with the

model and feeling that their faculty colleagues are supportive of innovation were each found to predict instructors' intention to implement the model. However, beyond prior experience and fewer post workshop concerns, only teaching at a private institution and endorsing a larger number of positive adjectives regarding teachers' likely classroom experiences with the model predicted its actual implementation.

Incorporating authentic inquiry can be a daunting task for instructors, particularly if they do not have the experience themselves. Not surprisingly, those entering the workshop with the kind of research skills needed to conduct quantitative research were more likely to implement the model. Previous research has shown that as many as two-thirds of physics, physical science, and earth science teachers at the high school level do not have majors, minors, or certifications in these areas (Marder et al., 2017). Further, an informal survey of 61 middle and high school teachers suggested that about 40% had no undergraduate research experiences (Stalnaker et al., 2018). Coming into the Passion-Driven Statistics workshop, instructors reported being more likely to have previous experience developing a research question, graphing, and interpreting statistical results and were overall less likely to have experience managing data or choosing the correct statistical test. Though math instructors did not differ from non-math instructors either in intention to implement the project-based model or actual implementation, exploratory analyses showed that math instructors attending the workshop reported less previous experience with research and more post workshop concerns about implementing the model than non-math instructors. They were also less likely to have previously used software in their statistics course (32.6% vs. 75%) and during the workshop, were less likely to use inferential statistics in their own projects (7.0% vs. 29.2%). This confirms a recent report from The International Commission on Mathematical Instruction (ICMI) and the International Association for Statistics

Education (IASE) showing that while most mathematics teachers acknowledge the practical importance of statistics and are willing to give more relevance to the teaching of statistics, many do not consider themselves well prepared (Batanero et al., 2011).

Beyond prior experience, a smaller number of post workshops concerns was also consistently associated with implementation outcomes in both bivariate and multivariate models. Research on precollege teachers has examined the barriers faced in implementing inquiry (Roehrig & Luft, 2004; Trautman, 2004), finding that barriers include logistical constraints, lack of administrative support, teacher knowledge, and teacher perceptions of students (Sunal et al., 2006). In contrast, the present study found that the most common concerns about integrating inquiry into introductory courses at the college level included supporting students in their use of software, being able to get teaching assistants for the project-based approach, and covering all of the material they needed to cover. While the first two concerns speak to teacher knowledge and logistical challenges, additional concern about covering material highlight the continued emphasis on teaching an exhaustive list of topics (Mittag, 1993; Hogg, 1992) at the expense of literacy and communication (Chance & Rossman 2001, Franklin, 2013).

Even after controlling for previous experience and post workshop concerns, those instructors from a private rather than public institution were more likely to intend to implement the model as well as more likely to have implemented within one year of the workshop. Although this may be driven by factors that we did not measure such as the educational background of the students or selectivity of private vs. public institutions, it does not appear to be a function of class size, teaching load or perceived support for innovation by administrators or faculty. That is, we found no differences on these measures between instructors at private and public institutions.

Though not associated with actual implementation after controlling for experience and post workshop concerns, those holding a non-tenure-track position rather than being tenure-track or already tenured were more likely to feel they would definitely or very likely implement the model. Though this was not expected, it might be best explained by the clear emphasis of non-tenure-track positions on teaching with fewer potential expectations surrounding research and administrative duties. Given that 73% of all faculty positions are off the tenure track according to the American Association of University Professors (AAUP, 2016), this is arguably problematic for curricular innovation given that high turnover in these positions as well as the general lack of academic freedom (Flaherty, 2018).

One of the most important findings from the present study is the consistent impact of perceived positive experiences for instructors on both intentions surrounding innovation as well as implementation of the model. Those instructors endorsing a larger number of positive adjectives (i.e., viewing the project-based model as fun, collaborative, empowering, useful, effective, interesting, personal, and/or engaging) were more likely to intend to implement the model at the end of the workshop and also to go on to use the Passion-Driven Statistics approach in their classrooms. This highlights the central importance of innovation not only improving the quality of education for students, but also improving the quality of the teaching experience for instructors. In fact, well-designed curriculum should prioritize everyone.

Though more than 90% of instructors who attended a Passion-Driven Statistics workshop would recommend the workshop to their colleagues, the present findings make clear that for many, the short time period was not adequate to provide the training needed to ensure that many felt able to plan for the sort of change that authentic projects require. Notably, professional development opportunities have been changing in recent years and those focused on a range of

courses have been moving away from the workshop model toward experiences that take place over several months to more than a year (Darling-Hammond et al., 2009). Such formats have been shown to be more effective at enacting teacher change (Yoon et al., 2007). Some faculty partners of the Passion-Driven Statistics initiative have been able to implement the model with only our freely available resources. Others, described here, were able to implement the model within the first year following our brief professional development workshop. For many though, concrete plans for ongoing support will need to be put in place to increase the likelihood of implementation. Though we continued to offer individualized support following the workshop, few faculty without a clear plan at the end of the workshop to implement took advantage of this. Further, in the academic year following the series of workshops, courses were moved on-line in the spring semester due to the Covid-19 pandemic. While this may provide opportunities not previously available, it has also created challenges that will take time to overcome.

Though the sample represents instructors interested in attending a workshop focused on integrating authentic, data-driven projects into their courses, it is unlikely that it is representative of statistics instructors in general. Instead, workshop participants represent are those instructors wanting to improve their teaching methods through new pedagogical approaches. In addition to engaging this group in continued professional development activities, future work should evaluate how to attract a wider population of instructors and to effectively persuade them to integrate empowering curriculum that will prepare students for the modern digital workforce. To do this, reward structures within higher education may need to be adjusted. As was originally described more than 40 years ago by Lincoln and Guba (1978), promotion practices often inhibit adaptation to current reality. Given that most of the top 25 highest paying, in-demand jobs in the 21st century (e.g., data base administrator, project marketing manager, UX designer, business

development manager, solutions architect, etc.) require diverse digital and technological skills (Glassdoor, 2017), rewarding instructors for the integration of these skills with more traditional academic content, and in courses across the curriculum, is warranted.

Passion-Driven Statistics has been used in statistics courses, research methods courses, and data science courses across a wide variety of disciplines. As a course-based research experiences (CURE) it can enroll many more students than traditional research internships. When implemented within introductory as well as more advanced courses, it has the potential to create improved equity and inclusion in the analytics workforce. Making these and other curricular innovations fun, collaborative, empowering, useful, effective, interesting, personal, and engaging for instructors, seems hold the greatest promise for continuing to foster effective change in educational practices.

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Appendix A

PRESURVEY

INTRO In preparation for the Passion-Driven Statistics workshop, we are requesting information to assist us in planning the sessions.

Name of Your Institution _____

What is the target course in which you would like to integrate passion-driven statistics? Please include the hosting department, course number and course name (e.g. MATH132 – Introduction to Statistics). If you are interested in using passion-driven statistics in more than one course, please list the first for which you would like support. If you are planning to develop a new course, please include a tentative title and the department that will host it.

- ○ Hosting department _____
- ○ Course number _____
- ○ Course name _____

How many students are typically in each section of (target course)?

_____

How many days per week does the class meet?

_____

How many total hours does each section of the class meet each week?

_____

What percent of class time (from 0 to 100%) is currently devoted to lectures?

0 10 20 30 40 50 60 70 80 90 100

Percent of Class Time ()	

What are the prerequisites for enrollment in the course?

_____

Do you typically have one or more teaching assistants (TA's for this course)?

- ○ Yes
- ○ No

What if any statistical software do you use in (target course) And what is your level of expertise. Are you a beginner, intermediate or expert?

On which of the following are you the final decision maker for (target course)? (Check all that apply)

- ☐ Format of the course (i.e. lecture, lab, workshop, discussion, etc.)
- ☐ Course content
- ☐ Syllabus
- ☐ Assignments
- ☐ Textbook
- ☐ Development of exams
- ☐ The course is centralized within a department or program and I am not the final decision maker on any aspects of the course.

What is the highest degree that you have earned?

- ○ Associate's Degree
- ○ Bachelor's Degree
- ○ Master's Degree
- ○ Ph.D.
- ○ M.D.
- ○ J.E.D.

How many years of teaching experience do you have (include years in which you may have worked part-time as an instructor)?

_____

How many individual class sections do you currently teach per academic year?

_____

What type of a position do you hold?

- ○ Tenured
- ○ Tenure-track
- ○ Not on the tenure track

What is your gender?

- ○ Male
- ○ Female
- ○ Other

What is your age?

_____

Are you Hispanic or Latino?

- ○ Yes
- ○ No

Regardless of your answer to the previous question, please check one or more of the following groups in which you consider yourself to be a member:

- [ ] White
- [ ] Black
- [ ] Asian Indian or Alaskan Native
- [ ] Native Hawaiian or other Pacific Islander
- [ ] Other

Is your appointment full time?

- ○ Yes
- ○ No

Please give an estimate of your current level of experience in the following.

	No experience or feel inexperienced	Little experience	Some experience	Much experience	Extensive experience	Not applicable / prefer not to answer
Developing a research question	○	○	○	○	○	○
Managing data (e.g., setting aside missing data, creating scales, and/or dichotomizing variables)	○	○	○	○	○	○
Choosing the correct statistical test	○	○	○	○	○	○
Graphing	○	○	○	○	○	○
Interpreting statistical results	○	○	○	○	○	○
Effectively presenting results	○	○	○	○	○	○
Reading primary source scientific literature	○	○	○	○	○	○
Conducting a quantitative project entirely of your design	○	○	○	○	○	○

What are your greatest concerns pertaining to teaching and learning? (Check all that apply)

- ☐ Keeping students engaged in class
- ☐ Motivating students to prepare before class
- ☐ Covering all the material that I need to cover
- ☐ How to measure if students are really learning
- ☐ How to deal with student resistance to non-lecture based teaching
- ☐ How to deal with colleague resistance to non-lecture based teaching
- ☐ How to create effective projects/activities that engage students
- ☐ Being able to support students in the use of technology

How do you perceive your institution's approach to teaching innovation? (Check all that apply.)

- ☐ Administrators are generally supportive of teaching innovation.
- ☐ Faculty are generally supportive of teaching innovation

Appendix B

POST SURVEY

Thank you for attending the Passion-Driven Statistics workshop. Your candid feedback is greatly appreciated.

What statistical software did you use during the workshop? (Check all that apply.)

- ☐ No statistical software
- ☐ SAS
- ☐ R
- ☐ Stata
- ☐ Python
- ☐ SPSS
- ☐ JMP
- ☐ StatCrunch
- ☐ Excel
- ☐ Other _____

What aspects of the project did you complete during the workshop? (Check all that apply.)

- ☐ Selected variables from a data code book
- ☐ Developed a research question
- ☐ Wrote a program that allowed me to examine frequency tables for my selected variables.
- ☐ Performed data management
- ☐ Made and interpreted a univariate graph (one variable at a time)
- ☐ Made and interpreted a bivariate graph (examining the association between two variables)
- ☐ Made and interpreted a graph with three variables
- ☐ Ran and interpreted an Analysis of Variance Test
- ☐ Ran and interpreted a Chi Square Test of Independence
- ☐ Ran and interpreted Pearson Correlation Test
- ☐ Ran and interpreted a statistical test examining moderation (i.e. interaction)
- ☐ Ran and interpreted a multivariate model (e.g. multiple or logistic regression)
- ☐ Shared my research question with others
- ☐ Shared the results of my analyses with others

How much did you GAIN in the following areas as a result of your experiences in this workshop?

	No gain	A little gain	Moderate gain	Good gain	Great gain	Not applicable
Developing a research question	○	○	○	○	○	○
Managing data (e.g., setting aside missing data, creating scales, and/or dichotomizing variables)	○	○	○	○	○	○
Choosing the correct statistical test	○	○	○	○	○	○
Writing syntax to run a statistical analysis	○	○	○	○	○	○
Graphing	○	○	○	○	○	○
Interpreting statistical results	○	○	○	○	○	○
Effectively presenting results	○	○	○	○	○	○

How concerned are you with the following areas pertaining to using the passion-driven statistics model in your course?

	Not at all concerned	Slightly Concerned	Somewhat concerned	Moderately concerned	Very concerned
Keeping students engaged in class	○	○	○	○	○
Motivating students to prepare before class	○	○	○	○	○
Covering all the material that I need to cover	○	○	○	○	○
How to measure if students are really learning	○	○	○	○	○
How to deal with student resistance to non-lecture based teaching	○	○	○	○	○
How to deal with colleague resistance to non-lecture based teaching	○	○	○	○	○
Being able to support students in the use of statistical software.	○	○	○	○	○

	Not at all concerned	Slightly Concerned	Somewhat concerned	Moderately concerned	Very concerned
The approach seems too time-consuming for instructors	○	○	○	○	○
I do not feel that I can deliver the passion-driven statistics approach well	○	○	○	○	○
I would need to give up too much classroom control	○	○	○	○	○
Projects seem too time-consuming for students	○	○	○	○	○
I would not be able to get the support that I would need from my institution	○	○	○	○	○
I would not be able to/it would be difficult to get teaching assistants for my class	○	○	○	○	○

Based on your current knowledge of the passion-driven statistics curriculum, what do you believe would be the results of integrating it into your course? (Check all that apply)
"For me, passion-driven statistics will make teaching more..."

- [ ] Difficult
- [ ] Fun
- [ ] Collaborative
- [ ] Discouraging
- [ ] Empowering
- [ ] Useful
- [ ] Effective
- [ ] Easy
- [ ] Interesting
- [ ] Personal
- [ ] Boring
- [ ] Engaging

For students, passion-driven statistics will make learning more...

- [ ] Difficult
- [ ] Fun
- [ ] Collaborative
- [ ] Discouraging
- [ ] Empowering
- [ ] Useful
- [ ] Effective
- [ ] Easy
- [ ] Interesting
- [ ] Personal
- [ ] Boring
- [ ] Engaging

In the future, how likely are you to integrate passion-driven statistics into your course?

- ○ Definitely Not
- ○ Not Likely
- ○ Possibly
- ○ Very Likely
- ○ Definitely