

# Grant-Writing Bootcamp: An Intervention to Enhance the Research Capacity of Academic Women in STEM

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*Broadening the participation of women in science, technology, engineering, and mathematical (STEM) fields is more than a social-justice issue; diversity is paramount to a thriving national research agenda. However, women face several obstacles to fully actualizing their research potential. Enhancing the research capacity and opportunity of women faculty requires purposeful changes in university practice. Therefore, we designed an intervention, a grant-writing bootcamp informed by self-determination theory (Deci and Ryan 2012), to support the participants' feelings of relatedness, autonomy, and competence. Three grant-writing bootcamps were run over an 18-month period. Using a pre- and post-test design over the span of 1 year (and contrasting results with a comparison sample who were not part of the intervention) showed that the women participating in the grant-writing bootcamp significantly increased the number of external grants submitted, the number of proposals led as principal investigator, the number of external grants awarded, and the amount of external funding dollars awarded.*

*Keywords: women in STEM, self-determination theory, intervention, grant writing, behavioral science*

**T**here is no doubt that women are numerically underrepresented as academic researchers in most science, technology, engineering, and mathematics (STEM) fields (NSF 2014, Corbett and Hill 2015) and that the working environment can feel unwelcoming to those women who do persist in academia (e.g., Holleran et al. 2011, Corbett and Hill 2015, Fox 2015). Broadening the participation of women faculty in STEM fields is more than a social-justice issue; diversity within STEM is paramount to the future of a thriving and innovative national research and economic agenda (Hong and Page 2004, Riley 2008, Intemann 2009, Harding 2015, Thoman et al. 2015). One case in point is that the chief officer for scientific workforce diversity and the director of the National Institutes of Health noted that a lack of diversity in the science research workforce is “limiting the promise of our biomedical enterprise for building knowledge and improving the nation’s health” (Valantine and Collins 2015, p. 12240). If we wish to maximize innovation and discovery and advance equity within academic STEM fields, we must go beyond the hard and important task of adding more women researchers to the academic mix (Etzkowitz et al. 1994, Smith et al. 2015, Mitchneck

et al. 2016) and also focus efforts on supporting diverse talent by growing women faculty members’ research capacity and opportunity for securing external research funding. Within US academic STEM fields, merit evaluations for awards, recognition, promotion, and tenure typically reward research productivity and grant funding (Youtie et al. 2013). Therefore, growing women’s externally funded research portfolio is an essential ingredient to broadening women’s participation at all ranks of academic STEM and potentially breaks down gender inequities within the institution (Fox and Colatrella 2006, Fox 2015).

Women faculty face several obstacles to receiving external research funding. Compared with men, women hold fewer prestigious postdoctoral positions (Sheltzer and Smith 2014), are allocated less in institutional start-up resources (Sege et al. 2015), are given less credit for their contributions in team-science collaborations (Torres 2016), receive fewer invitations to serve as journal peer reviewers (Lerback and Hanson 2017), and are cited less frequently than equally positioned male authors (Larivière et al. 2013, West et al. 2013). Women also face extreme service-workload obligations in higher education (Misra et al. 2011). What is more, women more

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than men contend with gender-related modesty and communal norms that dictate expectations to avoid negotiations that would further their own interests, instead placing others' needs and resources first (West et al. 2013). These issues, combined with factors external to the institution, such as the strong likelihood that women share a disproportionate ratio of domestic and caregiving duties and may not have strong social support for their careers (e.g., Deutsch and Yao 2014), unduly affect women's grant-writing productivity and grant success. Changes in university policy, practice, structure, and culture are required to abet women faculty in writing successful grant proposals (Easterly and Pemberton 2008, Xu 2008).

Setting aside for a moment the hotly debated notion that gender discrimination still exists within grant reviews and panels (Marsh et al. 2009, Mutz et al. 2012, van der Lee and Ellemers 2015; see also Kaatz et al. 2016), what is not debated is that women in STEM submit fewer proposals (e.g., Goldstein et al. 2016) and often receive less funding than men (e.g., Boyle et al. 2015). For example, as was documented in the National Institutes of Health Research Portfolio Online Report Tool, in fiscal year 2014, women submitted fewer grants ( $n = 15,421$  compared with men's 33,472) and constituted approximately 31% of principal investigators (PIs) on research-project grants overall (Rockey 2014). At Montana State University (MSU), the data told a similar story: Since 2010, our university received 2332 grants, with 26.2% awarded to women, but the overall percentage of women faculty ranged from 32.2% (fiscal year 2010) to 37.3% (fiscal year 2014). Only 21% of grants that were funded at MSU in fiscal year 2014 had a woman faculty listed as PI, and the average funding women faculty received was less than a quarter of what their male counterparts received.

What can we do to intervene to increase grant-funded research among women faculty in STEM and in turn bolster future scientific research within the academy and possibly chip away at persistent gender barriers? There is very little published literature testing the efficacy of faculty grant-proposal-writing education on funding success in STEM or other fields. For example, the University of California and California State University Systems' Center for Research, Excellence, and Diversity in Team Science is a retreat-style program that helps women and minorities build networks of collaborators and mentors aimed at improving funding; however, outcome data on the effectiveness of this program are still forthcoming. On a small scale, Frantz (2013) did describe two faculty learning communities (FLCs) focused on grant-proposal development and provided anecdotal evidence showing that three out of five of the participants in one of the FLCs submitted grants, although all grant submissions were to internal funding opportunities (and none were submitted from the other FLC). The goal of this current study was to test the impact of a theory-informed grant-writing bootcamp aimed at improving the submission rate and funding success of women faculty in STEM.

### Self-determination theory

The design of our bootcamp was informed by *self-determination theory* (SDT; Deci and Ryan 2000). SDT states that when a task, event, or job is experienced as "self-determined" (as opposed to controlling), the experience is engaging and fulfilling (Deci and Ryan 2012). To create a self-determined context, the theory posits, people must feel a sense of choice, efficacy, and a meaningful connection with others, which are the three psychological nutrients (*relatedness*, *autonomy*, and *competence*) needed for cultivating a self-determined environment (Deci and Ryan 2000, 2012). *Autonomy* is the experience of control, flexibility, and volition; *competence* is the experience of effectiveness and mastery; *relatedness* is the experience of connection, caring, and involvement with other people (Deci and Ryan 2012). The literature is replete with data supporting the hypothesis that when these three psychological needs are satisfied, positive outcomes ensue (e.g., Levy and Cardinal 2004, Ng et al. 2012). For example, among nurses, the more the workplace satisfied these three needs, the lower were reports of workplace exhaustion, cynicism, and turnover intentions (Trépanier et al. 2015). Indeed, the negative impacts of work pressures are mitigated when employees feel that their workplace supported these needs (Van den Broeck et al. 2008). Parents, teachers, supervisors, and significant others can satisfy (or thwart) people's needs for autonomy, relatedness, and competence (Niemic and Ryan 2009, Deci and Ryan 2012) in a wide variety of domains (Milyavskaya and Koestner 2011).

SDT is useful for designing interventions to cultivate optimal learning (Niemic and Ryan 2009) and change behavioral norms (Williams et al. 2006). For example, the faculty search process at one university was redesigned using SDT to support the search committee's needs for autonomy, competence, and relatedness around conducting a broad and inclusive search for diverse faculty (Smith et al. 2015). Results from the randomized control trial within male-dominated STEM departments showed that searches in the SDT search intervention were significantly more likely to interview and hire a woman faculty member than those in the search-as-usual condition. In short, SDT provides a rich empirical framework for understanding how a given context can foster positive outcomes.

### ADVANCE Project TRACS: Enhancing research capacity and opportunity initiative

Montana State University is a land-grant university serving a rural state that recently moved from *very high research* Carnegie classification to *higher research activity*. MSU houses 17 STEM departments within three STEM colleges—Agriculture, Letters and Science, and Engineering—and employs over 500 tenure-track faculty (27.9% are women in STEM as of fall 2015). In 2012, the university received \$3.5 million in National Science Foundation (NSF) funding to support ADVANCE Project TRACS (Transformation through Relatedness, Autonomy, and Competence Support). Project TRACS has focused on transforming the academic

culture to cultivate the recruitment, retention, and advancement of STEM women faculty and, in the end, to foster excellence in all faculty through three initiatives. The Enhancing Work–Life initiative generates new programs, such as a family advocate and dual-career assistance program, and builds on existing programs, such as providing more flexible solutions for work–life integration through modified duties and stopping the promotion-and-tenure-clock policies. The Enhancing Cultural Attunement initiative promotes respectful communication, sensitivity to the dynamics of relationships within a particular culture, and respect for the values and beliefs of cultures through a Broadening the Faculty Search toolkit, through an equity advocate program, and by engaging the university community in implicit bias education. Finally, the Enhancing Research Capacity and Opportunity initiative institutionalizes systematic research support for women faculty in STEM fields through hiring a grant-submission training coordinator who leads grant-proposal-writing workshops, provides individual proposal assistance, and connects new grant seekers to a mentoring network of successful grantees. It is through this last initiative that the grant-writing bootcamp was created.

### Grant-writing bootcamp

An early version of the grant-writing bootcamp was developed by MSU's College of Education, Health, and Human Development, which set the foundation to build the theoretically informed ADVANCE Project TRACS grant-writing bootcamp. The goal of the 6-week bootcamp was to educate underrepresented faculty about the grant-seeking process from the design phase to the culmination of a full grant submission. A dedicated staff member served as the grant-submission training coordinator. This person facilitated the bootcamp, equipped with a modest budget for refreshments and supplies. Two facilitators with diverse professional backgrounds but both trained in cultural attunement led the bootcamps. Both facilitators were women who held degrees in humanities and social sciences: one with a master of arts in English–writing and the other with a bachelor of arts in comparative culture/anthropology. Both worked professionally as writers and/or editors prior to the bootcamp, and both had previous grant-writing experience in science and technical fields. One facilitator hosted one bootcamp, and the other hosted two bootcamps, for a total of three bootcamps included in this study. Details on the qualifications, duties, and roles of the facilitator are available in the bootcamp facilitator guide, which is freely available on the MSU website (see the supplemental materials).

Drawing from SDT (e.g., Levy and Cardinal 2004, Smith et al. 2015), the bootcamp was designed to enhance the *autonomy* of faculty by encouraging them to take creative approaches with topics, methods, and funding sources; to enhance the *competence* of the faculty by offering tools and templates for writing grant proposals so that they may skillfully navigate the grant narrative, paperwork, and submission process; and to enhance *relatedness* by creating small

groups of similarly situated faculty who could identify with one another and work toward a common grant-proposal goal as well as make connections to established, grant-successful mentors. In the weekly 2-hour sessions, the first hour was devoted to lecture or discussion, and the remaining hour consisted of hands-on writing and workshop activities. The general syllabus of the grant-writing bootcamp is included in the supplemental materials.

In alignment with the objectives of Project TRACS, the bootcamp was intended to engage women researchers in STEM disciplines. To ensure such women were prioritized as attendees, the facilitator identified women faculty using a list of employed faculty. The facilitator sent information detailing the event to women in STEM, inviting them to register early. To avoid backlash or stigma, the invitation did not draw attention to the gender-diversity goals of the program (Latimer et al. 2014). The facilitator then circulated a public announcement to the broader faculty body, including male faculty and faculty in non-STEM disciplines to fill any remaining seats.

### Study overview

Grant-activity data were assessed from women STEM faculty 1 year before and 1 year after the bootcamp. This pre- and post-test design allowed us to examine the grant activity of the participants who engaged in one of the three bootcamps, offered 6 months apart and over an 18-month period, and to compare it with those who did not participate in the bootcamp. The comparison sample was matched to the bootcamp participants by gender, rank, and STEM field category, as have been defined by the NSF ADVANCE indicators toolkit published by Virginia Tech University. The self-report evaluation data were collected after each bootcamp to provide a triangulation of impacts.

### Participants

The bootcamp sample was composed of 20 women faculty in STEM fields (3 were nontenure-track researchers, and 17 were tenure track; 66.7% self-identified as white, 25% as Asian or Asian American, and 8% as Latin American). Of the tenure-track faculty, 16 were at the rank of assistant professor, with 1 at the rank of associate professor. The participants in STEM were distributed as follows among the broad categories of STEM: biological or agricultural sciences (58.3%); engineering (16.7%); earth, atmospheric and ocean science (16.7%); and physical sciences (8.3%). The participants were at MSU an average of 3.7 years (a range of 1 to 10 years) before taking part in the bootcamp, with an average of 8.3 years since receiving their PhDs.

Data were collected from a comparison sample (matched by rank and STEM field category as have been defined by the NSF) of 12 women faculty members (3 nontenure-track researchers and 9 tenure track; 100% were identified as white) who did not complete the bootcamp during the same 1 year before and 1 year after the bootcamp. One year prior to the bootcamp, the comparison sample women had an average of 7.9 years since receiving their PhDs.

## Procedure

Grant-activity data for 1 year prior to and 1 year following the bootcamp were collected from the Office of Sponsored Programs with approval from the university Institutional Review Board. An evaluator external to Project TRACS collected self-report data from the bootcamp participants by circulating a survey at the last session to assess how well the bootcamp supported their feelings of autonomy, competence, and relatedness and to elicit a general evaluation of the bootcamp. The self-report data could not be connected with outcome data because of the anonymity procedures of the survey collection; therefore, the data are included only as a descriptive index to understand the personal sense of psychological-need satisfaction.

**Measure 1: General evaluation of Bootcamp.** The participants rated two items: (1) “I think Bootcamp will have a positive impact on my career advancement” and (2) “I would recommend Bootcamp to my colleagues” using a 1–7 Likert scale (1, *not at all true*; 7, *very true*). These items were combined into an overall evaluation index, with higher scores indicating more positive evaluations.

**Measure 2: Psychological-need satisfaction in Bootcamp.** The faculty rated how true each of three items adopted from the basic-need-satisfaction measure (validated by Deci et al. 2001) were by using a 1–7 Likert scale (1, *not at all true*; 7, *very true*). One item for each psychological need was assessed: “I feel free to express my ideas and opinions in Bootcamp” (autonomy), “The Bootcamp increased my confidence in my ability to do well at grant writing” (competence), and “I really like the people I worked with in Bootcamp” (relatedness).

**Measure 3: Grant activity.** The participants’ names were used to identify institutional data on project variables 12 months before and after the bootcamp, and once collected, the names were removed, and the participants were assigned a numerical code. Data were collected on the number of external grant proposals submitted, the number of proposals led as PI, the number of external grants awarded, and the amount of external funding dollars awarded. We took care to only count external application activity (e.g., from the National Institutes of Health, the NSF, and the US Department of Agriculture), and internal funding (e.g., from the university provost, from the university vice president for research, or college-level grants) was not counted. If an external grant was submitted but still pending (e.g., under review at the sponsoring agency or outcome not yet reported to the institution), it was conservatively coded as *not awarded*.

## Analyses overview

To examine the impact of our grant-writing bootcamp, we first determined the results of the self-report surveys to describe the participants’ experience. Next, we conducted primary analyses of the grant-activity data for the bootcamp

participants 1 year prior to and 1 year following the bootcamp. We then completed our secondary analyses, in which we examined grant activity for our comparison sample, who did not go through the bootcamp, to rule out the possibility that all grant activity improves over a given period of time. Finally, we simultaneously examined the comparison-sample participants with the bootcamp participants to test for possible differences in grant activity prior to self-selecting into the bootcamp and whether and how any of those differences in grant activity between these two samples changed 1 year after the bootcamp. As appropriate, effect-size estimates are provided either as  $r^2$  to estimate a small (.01), medium (.09), or large (.25) effect or as  $\eta^2$  to estimate a small (.01), medium (.06), or large (.14) effect (Murphy and Myers 2004). All analyses were run using the Statistical Package for the Social Sciences (SPSS, version 22).

## Results for bootcamp participants

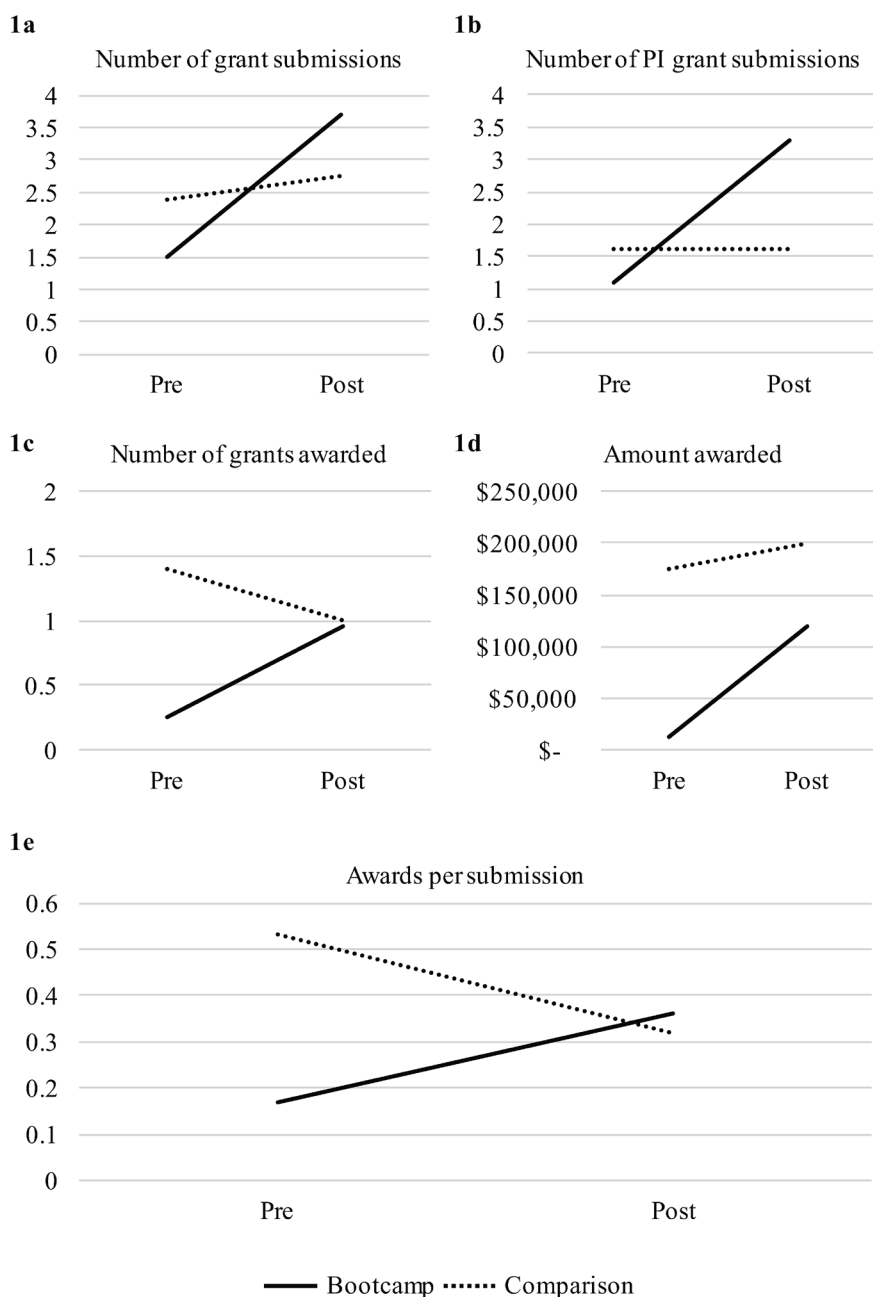
Analyses were first performed on each of the three measures collected from bootcamp participants.

**General evaluation of the bootcamp.** A one-sample  $t$ -test analyzing differences from the neutral point (4 on a 7-point scale) showed that the participants reported agreeing that the bootcamp was a significantly positive experience (mean [ $M$ ] = 6.18, standard deviation [ $SD$ ] = 1.04,  $t(19) = 9.33$ ,  $p < .0005$ ,  $r^2 = .82$ ).

**Psychological-need satisfaction in the bootcamp.** The bootcamp also appeared to foster high levels of psychological-need support. By design, our bootcamp aimed to support feelings of autonomy, competence, and relatedness. The survey data from the participants suggest that the bootcamp accomplished this goal. One-sample  $t$ -tests analyzing differences from the neutral point (4 on a 7-point scale) showed that the participants reported significantly high levels of autonomy ( $M = 6.40$ ,  $SD = .82$ ,  $t(19) = 13.07$ ,  $p < .0005$ ,  $r^2 = .90$ ), competence ( $M = 6.00$ ,  $SD = 1.12$ ,  $t(19) = 7.96$ ,  $p < .0005$ ,  $r^2 = .77$ ), and relatedness ( $M = 6.10$ ,  $SD = 1.12$ ,  $t(19) = 8.39$ ,  $p < .0005$ ,  $r^2 = .79$ ).

**Grant activity.** The mean changes over time are illustrated in figure 1. Because of the lack of normality for the variables, the Wilcoxon signed rank test for comparison of medians was also computed. The results were the same in that the  $t$ -tests that were statistically significant were also significant for the Wilcoxon test—and same for nonsignificant findings. Therefore, the  $t$ -test results are presented for simplicity. This note also holds for the comparison-group analyses. Paired sample  $t$ -test analyses found that compared with 1 year prior to the bootcamp, the women researchers in STEM who participated in our bootcamp showed a significant increase in the overall number of external grants submitted, from  $M = 1.5$  ( $SD = 1.67$ ) grants submitted per person to  $M = 3.7$  ( $SD = 3.01$ ,  $t(19) = 3.69$ ,  $p = .002$ ,  $r^2 = .42$ ; figure 1a. Analyses also showed a significant increase in the





**Figure 1.** The results from an analysis of the bootcamp participants 1 year before and 1 year after the bootcamp as contrasted to a comparison sample of similar faculty during the same time period. (a) The number of grants submitted. (b) The number of grants submitted in which the faculty member was the PI. (c) The number of grants awarded. (d) The amount of money funded in the awarded grants in US dollars. (e) The rate of awards per submission. Abbreviations: PI, principal investigator.

number of proposals led as PI, from  $M = 1.1$  ( $SD = 1.34$ ) to  $M = 3.3$  ( $SD = 2.65$ ,  $t(19) = 5.14$ ,  $p = .000$ ,  $r^2 = .58$ ; figure 1b). Not only did the number of grant submissions increase from 1 year before and after the bootcamp, but analyses also showed a significant increase in the number of external grants awarded before and after the bootcamp, from

$M = 0.25$  ( $SD = 0.55$ ) awarded to  $M = .95$  ( $SD = 1.09$ ,  $t(19) = 2.66$ ,  $p = .15$ ,  $r^2 = .27$ ; figure 1c). Finally, results showed that the bootcamp participants experienced a significant increase in the amount of funding dollars awarded, from  $M = \$12,000$  ( $SD = \$32,198$ ) to  $M = \$119,144$  ( $SD = \$205,987$ ),  $t(19) = 2.27$ ,  $p = .03$ ,  $r^2 = .21$ ; figure 1d), and this result likely underestimated the impact given that any pending applications were scored as “not awarded.”

A rate-of-awards-per-submission variable was computed for both the pre- and post-periods. Analyses showed a statistically significant increase in the rate of awards per proposal submissions for those who submitted at least one proposal, from  $M = 0.10$  ( $SD = 0.18$ ) to  $M = 0.43$  ( $SD = 0.39$ ),  $t(10) = 2.38$ ,  $p = .04$ ,  $r^2 = .36$ ; figure 1e). This positive increase in award rate suggests that increases in external funding dollars were not just due to an increase in the number of submissions.

### Results for comparison sample

Analyses were performed on the grant activity collected from the comparison sample. We then present results on the differences and similarities between bootcamp participants and the comparison sample.

**Grant activity.** A paired sample  $t$ -test found that during the same time period, among women faculty who did not go through the bootcamp, there were no significant improvements or declines in the number of external grants submitted, in the number of proposals led as PI, in the number of external grants awarded, in the amount of external funding dollars awarded, or in the rate of awards per submissions (all  $p > .10$ , with  $r^2$  much smaller than for the bootcamp group, ranging between 0 and .30). These findings are at least suggestive that the improvements in grant activity associated with the bootcamp were not simply the result of the passage of time.

**Differences between bootcamp participants and the comparison sample.** We used one-way analyses of variance (ANOVAs) to make group comparisons and found that the women faculty in STEM who participated in the bootcamp, compared with the comparison sample, had a similar past number of

external submissions 1 year prior to the bootcamp, a similar past number of amount requested in those external submissions 1 year prior to the bootcamp, and a similar past number of submissions as PI 1 year prior to the bootcamp. However, the bootcamp sample had significantly fewer past external grants awarded 1 year prior to the bootcamp ( $M_{\text{Bootcamp}} = 0.25$ ,  $SD = .55$  versus  $M_{\text{comparison}} = 1.4$ ,  $SD = 1.5$  awarded to the comparison sample,  $F(1,30) = 9.38$ ,  $p < .01$ ,  $\eta^2 = .24$ ), as we show in figure 1c. Given that the number of awards differed pre-bootcamp, it is no surprise that the bootcamp participants also had significantly fewer past external grant dollars awarded 1 year prior to the bootcamp ( $M_{\text{Bootcamp}} = \$12,000$ ,  $SD = \$32,198$ ) compared with the comparison group ( $M_{\text{comparison}} = \$187,415.92$ ,  $SD = \$213,181$  for those in the comparison sample,  $F(1,30)=13.32$ ,  $p < .001$ ,  $\eta^2 = .31$ ). As we have illustrated in figures 1c and 1d, the significant difference between the bootcamp participants and nonparticipants prior to the bootcamp in the number of external awards received (and the dollar amount of those awards) disappeared 1 year following the bootcamp, with the bootcamp participants rising to the level of those who did not participate ( $p > .45$ ).

### General discussion

The results demonstrated the positive impact of involving women faculty in a grant-proposal-writing educational intervention designed using SDT. There is much more to securing grants than having a great idea. The bootcamp provided an enriched atmosphere that supported the participants' feelings of relatedness, autonomy, and competence and was associated with a significant increase in the women's number of external grants submitted, number of proposals led as PI, number of external grants awarded, and amount of external funding dollars awarded 1 year after participating in the bootcamp. Our analyses of award rates showed that the impact was not simply due to an increase in number of submissions but instead likely due to the overall quality of proposals. The pattern of results shows that the bootcamp was an educational intervention that enhanced women's research capacity and opportunity over a 1-year time frame. The results of a comparison sample of women in STEM (matched as much as possible on a number of variables) who did not attend the bootcamp offer suggestive evidence that it is not simply the passage of time or other institutional policies or practices that were associated with women's increased grant activity, but rather a positive impact of participating in the bootcamp. Results point to the bootcamp as one way to broaden participation in the national research agenda with the ideas and advances proposed by academic women scholars in STEM fields. Moreover, because academic science is hierarchical and powerful (Fox 2015), changing the gender dimensions with more STEM women as a visible part of the research infrastructure as PIs challenges the status quo and might begin to transform the university into a more inclusive and equitable workplace (e.g., Mitchneck et al. 2016).

### Limitations

There are several limitations to this study, including that this study took place at just one midsized research university serving a rural state. Generalizations to other university settings and types remains to be tested with future adoptions of grant-proposal-writing interventions. Also, we were unable to fully match all 20 women who participated in the bootcamp because of the very nature of the problem: There were too few women faculty in STEM. As such, data comparisons should be interpreted with caution and serve as only one lens by which to examine the impact of the bootcamp.

Future research testing the impact of the bootcamp intervention could include random assignment to the intervention, as well as a larger sample size. A larger sample size would allow tests of intersectionality to unpack the possible impacts on women in general and possibly women of color in particular. Although our sample was majority white, the participants showed greater variation in race and ethnicity compared with the university at large. Although men in STEM were invited to participate in the bootcamp as space allowed, too few participated for any systematic analyses. Future research would do well to examine how similar bootcamps affect men who are underrepresented as PIs of STEM research. Finally, the average participant in this study was a beginning-level faculty member nearing retention review, which suggests that bootcamps might be best suited for new women professors; however, this is an empirical question. A larger sample would allow for a closer examination of who benefits most from the bootcamp.

It is unclear which aspect of the bootcamp was responsible for the positive outcomes. As with many field intervention studies, we examined the impact of the whole intervention versus its various pieces. Although it is not possible to say how feelings of autonomy, competence, and relatedness directly predicted grant-activity outcomes, the self-report survey did confirm that the design of the bootcamp met the SDT criteria, and the participants did report an overall positive experience that satisfied their psychological needs.

### Implications

Limitations notwithstanding, the finding that participation in a six-session grant-writing intervention designed to support autonomy, competence, and relatedness needs is positively associated with grant success is especially meaningful considering the national need to broaden the participation of women in STEM (Valantine and Collins 2015, Mitchneck et al. 2016). Many universities are becoming more progressive in the arena of work-life policies and practices (Tower and Dilks 2015), which are vital to retaining women faculty members. Here, we shine a light on another worthy area of intervention: the grant-getting process, which is a vastly understudied topic (Frantz 2013). We know that dissatisfaction with research support is strongly associated with women faculty's intentions to leave their universities (Xu 2008). One could speculate, then, that grant-writing

bootcamps might have downstream implications on the retention and advancement of academic women in STEM.

To be sure, expanding external funding within academia is a complicated goal in light of the unpredictability of the national funding climate. This grant-writing bootcamp is just one way that university administrators might improve the research capacity for an often-unsupported group: women in STEM. Our results point to the value in committing resources to hire a dedicated person to serve as a facilitator for the bootcamp. At our own university, this position, combined with other duties, is now sustained within the Center for Faculty Excellence in the Provost's Office as part of a larger coordinated effort to provide professional-development opportunities to faculty.

Our bootcamp falls under the recommendations by Porter (2011), who suggested that "home-grown" grant-writing workshops provided by research-office staff and successful faculty members are an inexpensive strategy that may yield positive returns. As universities work to adopt or implement their own bootcamps, it is important to heed the advice of Easterly and Pemberton (2008), who detailed the barriers and supports for writing proposals for external grant funding that have been experienced by women associate professors at three state universities in Idaho. Their recommendations for decreasing barriers and increasing supports included many aspects of our bootcamp, including a proposal-writing mentorship program and internal networking (which would likely improve feelings of relatedness), providing an awareness of services at the university for grant-writing assistance (which could increase competence), and avoiding "cookie-cutter" support that might undermine the autonomy needs of individual faculty.

Research administration should be aware of and attend to implicit biases that affect women faculty members in the area of research (Easterly and Pemberton 2008). University leaders interested in advancing women's research agendas should consider adopting bias-inoculation training for research-administration staff and other key personnel. Indeed, our bootcamp facilitators were hired, in part, for their attunement to gender and diversity issues, participated in ongoing educational trainings around implicit biases aimed at women in STEM, and were required to report their efforts in serving and supporting this underrepresented group of faculty. Indeed, accountability is a key component of a successful sustained effort at broadening the participation of women faculty in higher education (Mitchneck et al. 2016).

### Future directions

Our grant-writing bootcamp focused on developing an original, high-quality research proposal. Once the proposal is submitted, women might also have concerns that their proposal could be met with possible gender discrimination during grant reviews (Ley and Hamilton 2008, Marsh et al. 2009, Mutz et al. 2012, Boyle et al. 2015). For example, Kaatz and colleagues (2016) showed that despite favorable written

summaries of National Institutes of Health proposals, funding rates were lower for women than for men, suggesting a shifting standard depending on the gender of the investigator. This possible source of bias, coupled with the relatively low rates of funding from national agencies, suggests that most proposals will be rejected. At the NSF in fiscal year 2014, for example, the success rate of competitively reviewed proposals ranged from 17% to 27%, with an average of 23% (NSF 2015). Therefore, the next step of our grant-writing bootcamp is the creation of a new bootcamp that extends to revising and resubmitting proposals. The impact of this next level of the bootcamp remains to be tested.

### Conclusions

Universities should consider ways of broadening participation that extend to research infrastructure and support for women in STEM who are already part of the university community. The SDT-informed design of a grant-writing bootcamp resulted in greater research capacity and opportunity for those women in STEM who participated. With a modest but sustained investment, a strategic and carefully designed intervention like this grant-writing bootcamp can add vital diversity and impact to scientific discovery while also adding to the enterprise of a university.

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### Supplemental material

Supplementary data are available at *BIOSCI* online.

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