Choice and Circumstance: Sources of Faculty Momentum Toward Active Teaching Practices

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To study what shapes instructors' use of student-centered active teaching methods, we examined multiple influences across the faculty career span, using survey data from over 600 mathematics faculty. We present a path model that incorporates factors from graduate teaching experience and job choice to professional development, departmental norms, and involvement in student-oriented scholarly and professional activities. We adapt Adelman's concept of momentum to interpret results and highlight the role of early decision-making and professional environments that reinforce teaching-focused choices in shaping faculty teaching practices.

Keywords: active learning, student-centered teaching, professional development, institutions

Improving instruction has been called the "best bet" for strengthening undergraduate STEM education (Singer, 2013, p. 768). Yet many students do not experience research-based instruction in STEM classes, where 60%-90% of instructors rely on lecturing (Hurtado et al., 2012; Larsen, Glover & Melhuish, 2015; Rasmussen et al., 2016). While minority, first-generation and poor students benefit most from these high-impact practices, these groups least often encounter them (Kuh, 2008). As Fairweather (2008) asserted, "The key… lies in getting the majority of STEM faculty members to use more effective pedagogical techniques than is now the norm" (p. 13).

High-quality, teaching-focused professional development (TPD) can be powerful in shaping instructors' teaching practices (Lattuca, Bergom & Knight, 2014; Laursen et al., 2019). For example, Archie et al. (2022) showed that TPD on inquiry-based learning (IBL) fostered gains in mathematics' instructors knowledge, skills and availing beliefs, that were in turn positively associated with later classroom uptake of IBL. Most future faculty have had little prior learning about teaching (Austin et al., 2009; Golde & Dore, 2001); thus, early career may be an optimal time to offer TPD, when faculty are learning to balance teaching with other duties (Turner & Boice, 1987) and before they settle into habits that serve students less well. Many STEM disciplines have thus offered professional development to early-career faculty (CSSP, 2012), focused on teaching and how to navigate research, service, and collegial relationships. However, the evidence is slim about the impact of this early-career positioning (Connolly & Millar, 2006).

We set out to understand whether and how TPD targeting early-career mathematics instructors influenced their teaching practices. In this paper, we focus on findings about alumni who had previously completed the program. We wanted to learn how alumni are teaching now, and what influenced their teaching—including early-career TPD, other professional learning, and their work environments. As part of a holistic take on the influences on teaching, we also sought to understand alumni careers more fully, considering their other roles such as scholars, leaders and participants in professional societies, and we compared alumni with a matched comparison group to learn whether and how the groups differ. Our research questions and hypotheses are:

RQ1. What are the overall differences in the teaching, scholarly and leadership activities, and institutional environments of alumni and comparison group faculty? *Hypothesis: Alumni program status (vs. Comparison) will predict more active* *teaching when other independent variables in the model are held constant.*

RQ2. What social, professional, and institutional factors predict differences in the use of active learning strategies for teaching? *Hypotheses: Departmental expectations and instructor beliefs that support active teaching are associated with more active teaching in practice. Instructors who engage in career activities related to active teaching, equity and outreach also will teach more actively.*

RQ3. How do early career experiences around teaching influence the role and nature of teaching in instructors' later careers? *Hypothesis: Indicators of early-career interest in and pursuit of teaching-oriented jobs will predict the emphasis on teaching in instructors' careers, as expressed by the number of courses they teach.*

Prior Work and Conceptual Frameworks

Many studies have examined barriers and supports to instructors' uptake of active teaching approaches (e.g., Dancy & Henderson, 2010; Henderson & Dancy, 2007, 2011; Lund & Stains, 2015; Walczyk, Ramsay & Zha, 2007; Yik et al., 2022). Psychological and personal factors, such as beliefs about learning and teaching and prior experience with active teaching, are often highlighted in these studies, as are classroom factors such as the layout of classroom space, class scheduling, and the nature of the course and students. The institutional context where faculty work also has a sizable influence on their ability and motivation to change their teaching, including teaching loads, course coordination, and institutional reward systems (Austin, 2011).

Removing such barriers can therefore serve as leverage to improve teaching. Professional development can increase knowledge and skills and foster facilitating beliefs. Other strategies operate on parts of an institutional system, such as structures that increase accountability for teaching quality, and cultures that support teaching change (Borrego & Henderson, 2014). Manduca (2017) centers the individual learner in an even broader landscape, "as an active agent who learns over time and is responsible for making changes" (p. 416). In addition to formal professional development and institutional context, she highlights "the community of learners that surrounds and supports an individual as they learn and change" (p. 418). Peer communities may support teaching change both during TPD and through disciplinary or departmental groups. Together these ideas cast growth in teaching as a complex, incremental and long-term process, not a simple result of one-off professional development or binary decisions to change.

Moreover, teaching is only one part of a faculty career, so a full picture of faculty teaching must attend to academic careers and how they develop. Calling out insights from the sociology of science, Hermanowicz (2012) noted that the concept of a career is inherently sociological, with its dependence on "advisors, mentors, college origins, doctoral programs, social class backgrounds, colleagues, collaborative networks, postdoctoral appointments, employing departments, employing universities, disciplines, fields, professions, and reward systems… that make careers possible and which differentiate them" (p. 210). This view leads us to attend to educational history and career activities in our study, and to the norms of the overlapping social communities in which faculty careers develop (Ebert-May et al., 2025).

As theoretical framing, we use Adelman's notion of "momentum" (1999), developed in his study of bachelor's degree attainment and racial inequities in this outcome. Dissatisfied with standard accounts of academic achievement, he explored how early elements of students' academic paths, such as the level of their high school mathematics courses, had shaped their college outcomes many years later. This approach highlights that many factors influence individuals' paths and may play out over decades, and draws attention to influences that are not pre-set but can be changed by institutions and individuals themselves. Wang (2017) uses the concept of momentum to clarify antecedents of community college student success, highlighting learning experiences and motivation as well as academic factors that may combine to overcome inevitable friction and help students toward their academic goals. While we focus on a different sphere, our study likewise addresses multiple factors—preparation, motivation, environment, choice—that help to move people toward or away from specific outcomes over long times.

As a metaphor, the term "momentum" highlights forward impetus or motion toward an outcome, what a person needs to build and maintain in order to progress. Momentum may vary in pace or direction over time, depending on diverse individual and environmental factors that may boost momentum or break it by adding friction. It recognizes individuals as "active, responsible participants" in their trajectories, neither laying blame on them for disruptions in momentum nor treating them as "passive creatures whose fate is wholly molded" by institutions (Adelman, 2006, p. xxiv). In this project, we are interested in sources of momentum that impel faculty toward use of active approaches to teaching. The notion entails a developmental perspective on faculty careers (Baldwin & Blackburn, 1981) and is well suited to our retrospective, multi-factor study that considers instructor change as a trajectory, rather than an event, and to our use of path analysis as an approach to modeling a complex data set.

Context for the Study

Particular challenges face studies of TPD that focus on outcomes that are important but take time to develop, such as use of research-based teaching practices. The program must be large, long-lived, and stable over time in design, so that multiple cohorts can be combined to develop a sample with sufficient statistical power. Our study gathered data from MAA Project NExT (PN), which had several features favored by research (e.g., Giersch & McMartin, 2014; Manduca, 2017), related to duration and frequency, mentoring, content, format and facilitation. The year-long TPD program includes three multi-day gatherings and online interactions. Participants interact with peers and seasoned faculty, face-to-face and online, using a variety of mechanisms to foster interaction. Program topics focus on the needs, concerns and interests of new faculty, e.g. teaching methods, curriculum choices, inclusive teaching and advising, outreach, undergraduate research, time management, and balancing multiple faculty duties. The format of the first summer workshop typically includes 1-2 hour interactive blocks for plenary talks, table discussion, mini-workshops, a networking fair, and group meals. Later meetings emphasize participant-planned sessions, plenaries, and social time. Finally, the program is overseen by a committed leadership team with expertise in professional development, bolstered by a diverse set of session leaders, speakers and mentors who model diverse careers, lives, and specialties.

Study Methods

Study Participants

Current analyses of the survey dataset used 634 responses from 492 instructors who participated in Project NExT ("alumni") and 142 from a comparison group constructed by matching alumni survey respondents to non-alumni peers. We surveyed all program participants from 1994-2018. We used the Mathematics Genealogy Project (Jackson, 2007) to match alumni to non-alumni peers by graduate institution, year of Ph.D., and advisor. The peer group is broadly matched in general experience of doctoral education, mathematical subfield, and prestige of doctoral degree, and faced comparable job markets as new PhDs. The final sample reflected a 50% survey response rate. All responses contained complete information about instructors' teaching and described in-person classes. The IRB-approved survey was administered in winter-spring 2022.

Survey Instrument

The survey contained 47 items (some with long lists of choices) asking about topics related to careers as math instructors. These included: 1) the benefits of Project NExT or an alternate professional development project, 2) academic career activities, 3) participation in professional development, 4) participation in professional societies, 5) involvement in research and grants, and 6) their department's expectations in evaluating their work, with a parallel section asking about activities that brought respondents personal career fulfillment. To assess the teaching component, we used items similar to the TAMI-IS survey (Hayward et al., 2018). It asked instructors to choose a course they had taught recently and estimate the amount of class time spent in a range of teaching activities (e.g., Lecture or Group Work). We also probed basic demographics, years of experience teaching at the college level, and institutional characteristics.

Data Analysis

Based on our hypotheses, we tested a three-part model with the outcome variables of Active Teaching, Amount of Teaching and Program Status. We used the statistical software AMOS to examine model fit and regression weights of the independent variables entered into the model using a predetermined set of variables. Of the original set of 28 variables, 16 were significant predictors. To save space, only significant predictors are presented in Table 1 and Figure 1.

We followed best practices in confirmatory path modeling by checking assumptions, reporting multiple model fit statistics and specifying the model *a priori* to analysis. The model was calculated using Maximum Likelihood Estimation and model fit was evaluated using two indices: the Comparative Fit Index (CFI) and the Root Mean Square Error of Approximation (RMSEA). CFI values range from 0 to 1, with values < 0.95, and RMSEA values ≤ 0.09 interpreted as evidence of good fit (Rigdon, 1996).

The path model had three parts, all using items from the alumni survey. Hypothesized relationships between independent variables and *Active Teaching* asked if departmental and personal expectations and career activities for active learning instruction translated to practice. We also wanted to know the predictive association between early career activities and the amount of teaching instructors reported. The third part of the model examined selection into Project NExT, seeking to hold possible confounding variables constant to gauge the relationship between attending PN and later active teaching.

Results

Table 1 describes the variables used in the path analysis, showing where they appear in the path model (denoted by →), and the value of the path coefficient. Figure 1 shows the variables in the model and their path coefficients. We report variables with significant standardized regression coefficients, where * denotes probability $p<0.05$, and ** denotes $p<0.01$. Model fit was "good" with a Chi-Square/Df = 5.8 ($p < 0.001$), CFI = 0.94 and RMSEA = 0.088 (Hu & Bentler, 1999). Correlations (not shown in Figure 1) between independent variables in the model were lower than $r=0.2$, with no collinearity of predictors. While 16 predictors are shown, another 12 were used in the model but were not significant predictors and are not included in Table 1 or Figure 1.

The model describes three interlocking regression analyses. As hypothesized, departmental expectations and personal beliefs were strong predictors of Active Teaching, our primary outcome measure (Outcome Model, Fig. 1 right side). The R-squared value for this model component was 0.27. Departmental expectations to use methods other than lecture had the strongest independent association with Active Teaching (b=0.28), and the personal importance of active teaching also predicted the outcome variable (b=0.19). The factor variable TDO, an aggregate of six items, gauged participation in career activities around teaching, equity and educational outreach. TDO was positively associated with teaching actively (b=0.21). Instructors who taught a greater number of courses in the past two years also incorporated methods of active learning (b=0.14).

Table 1. Variables in Path Analysis, Description, Path Model Association and Path Coefficient

Variable	Description	Path & coefficient
Active Teaching	Factor variable derived from survey questions asking for estimates of class time spent in teaching activities such as Lecture, Group Work, Discussion, Presentation and Short Explanations. (Higher Score is more active, -3 to +3)	Main outcome variable
Expectation_Variety	How does YOUR ACADEMIC DEPARTMENT rate the importance of the following for evaluating your career progress? - Use a variety of teaching methods (1-4)	→ Active Teaching -0.12**
Expectation_Not Lecture	(as above) -Departmental expectation to use methods other than lecture (1-4)	→ Active Teaching 0.28**
TDO	Factor variable asking about teaching, diversity and outreach career activities derived from checklist of survey items.	→ Active Teaching 0.21**
Important_Active	How do YOU rate the importance of the following in terms of what fulfills you personally?- Teaching in more active and engaging ways (1–4)	→ Active Teaching 0.19**
Important_Equity	(as above) - Promoting equity and diversity in your department and institution (1-4)	→ Active Teaching 0.09*
Teach_Freq	How many course sections have you taught in the last two academic years? Integer)	→ Active Teaching 0.14**
Program	Has participated in Project NExT or comparison (0 = Comparison, 1 = NExT)	→ Active Teaching 0.13**
Female	Gender Female (1= Female, 0= Male) (Other was listed as option but no one chose)	→ Program 0.07*
Years_Taught	Number of years taught (Integer)	→ Program -0.11**
PD_Inst	Factor variable of checklist items asking about participation in professional development at institution, higher score indicates more participation (-3 to +3)	→ Program 0.12**
Belongs_AMS	Belongs to American Mathematical Society (0, 1 = belongs)	→ Program -0.08*
Sought_Teaching	Please agree or disagree with the following statements about your early teaching career. - When I started my career I sought out a faculty position that emphasized teaching (1-4)	→ Program 0.20** → Teach_Freq 0.12**
Highest_Degree	Highest mathematics degree offered at institution (1-4, Associates to Ph.D.)	→ Program -0.14** → Teach_Freq -0.23**
Early Teach	Which of the following was (or is) true about yourself during your early career? (1-4 years after you received your Ph.D). - I taught more than one class each semester	→ Teach_Freq 0.10*
Early_Active	Which of the following was (or is) true about yourself during your early career? (1-4 years after you received your Ph.D). - I taught using active or inquiry-based methods	→ Teach_Freq 0.08*
Tenure_Elig	Is your position tenure eligible? (0, 1 = Yes)	→ Teach_Freq 0.14**
EarlyTeachwanted	Which of the following was (or is) true about yourself during your early career? (1-4 years after you received your Ph.D) - I designed my own courses	→Teach_Freq -0.11**

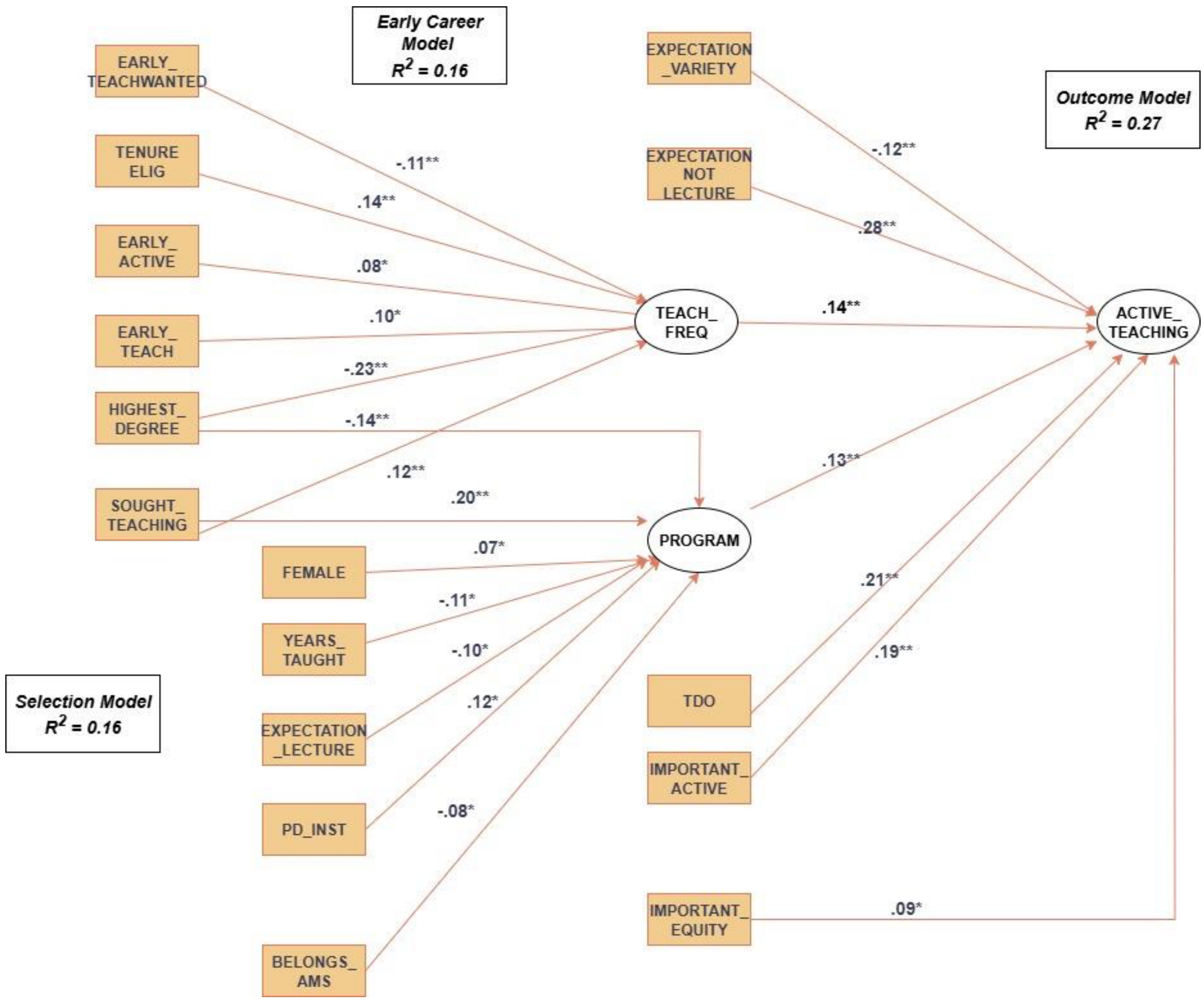

Figure 1. Three-Part Path Model of Relationships between Active Learning, Program Status & Teaching Frequency

Early career practices and decisions were associated with the amount instructors taught (Early Career Model predicting Teach_Freq variable, Fig. 1 upper left). This component of the model had an R-squared value of 0.16. Teaching at institutions offering Masters or Bachelors as the highest degree was highly associated with the amount instructors taught in the past two years (b=-0.23), as was having a tenure-eligible position (b=0.14). Initial career choice, reflected by the statement, "When I started my career I sought out a faculty position that emphasized teaching," was associated with more teaching later in a career (b=0.12). Moreover, those who taught greater numbers of courses in their earlier career were more likely to teach a greater number of classes later (b=0.10), and those who taught actively continued to do so, albeit this effect was relatively weak (b=0.08). Overall, these results showed the impact of early decisions on later career practices.

The third part of the model described and adjusted for differences between Project NExT alumni and the matched comparison group (Selection Model, Fig. 1 lower left predicting Program variable). In general, PN alumni were more likely to be less experienced teachers (b= -0.11) and women (b=0.07) and took part more in professional development at their institutions (b=0.12). They were also more likely to work in departments with less expectation to lecture (b=-0.10). This component of the model is useful at showing differences between groups that persist after matching and holds these differences constant when assessing the Program variable.

Finally, the program effect for Project NExT was statistically significant, indicating that PN alumni were more likely to teach in an active manner. The raw effect size comparing PN to the comparison group was $\delta=0.63$, considered a large effect (Bakker et al., 2019). Using Program in a regression model holds all other variables constant and determines if any remaining variance in active teaching can be explained by group membership. Here, PN group membership persisted in its association with active teaching with a standardized regression coefficient of b=0.13.

Discussion and Conclusions

We highlight a few key findings. First, the results demonstrate that faculty adoption of student-centered active approaches to teaching is not the product of any single influence or decision (Austin, 2011; Henderson & Dancy, 2007). Future faculty make choices that launch them toward a career in an institution that centers teaching (Austin et al., 2009). New faculty may be encouraged to use active teaching methods by social norms and departmental evaluation criteria that value teaching (Ebert-May et al., 2025). They may pursue professional development on teaching, early in their career and later, in the discipline and at their institution. When these activities are rewarding and supported by peer behaviors and norms, people feel fulfilled and more likely to continue to pursue them. Using a momentum lens, these factors are mutually reinforcing and all build faculty momentum toward use of active teaching methods.

Our finding about the association of the TDO construct with active teaching is new to the literature: faculty who take up active teaching are also more likely to take up other scholarly and professional activities that are likewise centered on student experiences and inclusion, such as outreach, diversity and equity work, and engagement with teaching change initiatives. We suggest that active teaching and TDO activities may reinforce one another and may gain further momentum in institutional settings where they are valued and rewarded.

Also salient is the role of early-career experiences and choices in influencing outcomes up to 25 years later in our sample. Pursuing and securing academic work that emphasizes teaching exemplifies the role of choice, while graduate school experiences of teaching may involve a mix of choice, constraint, and chance: all of these are positively associated with active teaching in the model. Moreover, past participation in Project NExT has a measurable and positive association with use of active learning that persists even when other factors are held constant. In text comments that we separately analyzed, PN alumni indicated that both their initial learning experiences and ongoing interaction with a disciplinary peer cohort were influential in shaping their current teaching. Ongoing analyses will elucidate all these associations and link them to additional data sets from this study and to prior research, seeking to build a full picture of how momentum toward use of active teaching practices waxes or wanes among mathematics faculty.

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