Student Interest in Calculus I

Derek A. Williams
North Carolina State University

This reports on a secondary analysis of data collected by the Mathematical Association of America's Characteristics of Successful Programs in College Calculus (2015). Survey data were collected from more than 700 instructors, and roughly 14,000 students making these data ideal for multiple level analysis techniques (Raudenbush & Bryk, 2002). Here, these data are used to analyze students' interest in Calculus I. Results suggest that students with higher frequencies of presenting to their classmates, collaborating with peers, working individually, explaining their work, and taking Calculus I with an experienced instructor tend to be more interested in class.

Key words: Student interest; College calculus; Multiple level modeling

This report presents results from a secondary analysis of the data collected as part of the *Characteristics of Successful Programs in College Calculus* (CSPCC) project[1] headed by the Mathematical Association of America ([MAA], 2015). Here, student interest in Calculus I is investigated and associations with different student-level and instructor-level predictors are analyzed using multiple level modeling techniques with SAS 9.4 (Raudenbush & Bryk, 2002).

The CSPSS project administered surveys to Calculus I students, their instructors, and department heads from a nationwide stratified random sample. Roughly 14,000 students, 700 instructors, and 212 institutions participated. Here, only 5,278 students and 378 instructors are analyzed due to the variables used in this analysis (described below).

Methods

This analysis aims to address two research questions: (1) What are the effects of components of classroom activity (described below) on student interest in Calculus I? (2) Do these effects depend on instructor experience with teaching Calculus I?

Variables and Centering

Participants took two surveys (pre- and post-semester) pertaining to their experiences as a student or instructor of Calculus I at the college level. One item on the student survey was, "My instructor makes class interesting." Students were instructed to rank their beliefs of this item on a 6 point scale, where 0 represents "Strongly disagree" and 5 corresponds to "Strongly agree." Here, *interest* will serve as the dependent variable. Students were also asked to rank how often their instructors allowed them class time to collaborate with their peers, present solutions, explain their work, and work individually. Each of these items was also ranked on a 6 point scale, where 0 represents "Not at all" and 5 represents "Very often." These classroom activities will be used as student-level predictor variables.

Instructors were asked to indicate the number of terms they taught Calculus I during the previous five years. This item was reported with a scale of ranged values (e.g., 3-5 times), so a linearized variable was created using the central value from each range. This is the instructor-level predictor variable used in this analysis. All predictor variables were grand-mean centered

[1] This material is based upon work supported by the National Science Foundation under grant DRL REESE #0910240. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

(Raudenbush & Bryk, 2002) to provide meaningful interpretations of results.

Analysis

To begin an unconditional model was conducted. This model is used to partition variation in interest between instructor-level (level 2) variation and student-level variation (level 1). This model is also used to establish a baseline of the overall variation in interest present in the sample.

The second model conducted contains the four student-level classroom activity predictors, instructor experience, and all cross-level interaction variables. This model is constrained; meaning the variation around slopes was constrained to zero. When compared to similar models with unconstrained slopes, the constrained model was a better fit (Singer, 1998).

Level 1: $interest_{ij} = \beta_{0ij} + \beta_{1ij}(COLLAB) + \beta_{2ij}(PSNT) + \beta_{3ij}(EXPN) + \beta_{4ij}(INDV) + r_{ij}$

Level 2:
$$\beta_{0i} = \gamma_{00} + \gamma_{01}(IEXP) + u_{0i}$$
$$\beta_{1i} = \gamma_{10} + \gamma_{11}(IEXP)$$
$$\beta_{2i} = \gamma_{20} + \gamma_{21}(IEXP)$$
$$\beta_{3i} = \gamma_{30} + \gamma_{31}(IEXP)$$
$$\beta_{4i} = \gamma_{40} + \gamma_{41}(IEXP)$$

Results and Discussion

Results from the unconditional model indicate that 76% of the overall variation in student interest resides at the student-level and the remaining 24% at the instructor-level. Also, on average, students slightly agree that their instructors make class time interesting ($\gamma_{00} = 3.26, t = 74.23, p < .001$). Significant variation at level 2 suggests that further analysis is appropriate.

Peer collaboration ($\gamma_{10} = .06, t = 4.45, p < .001$), opportunities to explain ($\gamma_{30} = .35, t = 28.20, p < .001$), and time for individual work in class ($\gamma_{40} = .08, t = 7.01. p < .001$) are all positively associated with students' interest in Calculus I. Opportunities to present ($\gamma_{20} = .008, t = .52, p = .60$) are not associated with student interest. Recent experience with teaching Calculus I is also associated with an increase in student interest ($\gamma_{01} = .11, t = 5.97, p < .001$).

Additionally, the relationships between frequency of collaboration and interest ($\gamma_{11} = .01, t = 2.46, p = .014$) and frequency of student explanations and interest ($\gamma_{31} = -.01, t = -3.14, p < .001$) both depend on instructor experience, such that the effects are intensified in classes taught by instructors with low experience (more than one standard deviation below the sample mean). The relationship between frequency of presentations and interest depends on instructor experience ($\gamma_{21} = -.01, t = -2.61, p = .009$) such that frequent student presentations are detrimental to student interest in classes taught by instructors with high experiences (more than one standard deviation above the sample mean). However, the opposite occurs with frequent presentations in classes taught by instructors with low experience. The relationship between frequency of individual work and interest does not depend on instructor experience ($\gamma_{41} = -.005, t = -1.25, p = .21$). This model explains 24% of student-level variation and 34% of instructor-level variation (Snijders & Bosker, 2011) in student interest in Calculus I.

Conclusion

Classroom activities such as student presentations, peer collaboration, student explanations, and time for individual work were all identified as factors of *ambitious teaching* (Sonnert & Sadler, 2015). These results suggest that instructors, especially those with low experience, should attempt to implement elements of ambitious teaching, and departments should encourage instructors to teach Calculus I often in order to positively affect student interest.

References

Mathematical Association ofAmerica. (2015). *Insights and recommendations from the MAA national study of college calculus*. (D. Bressoud, V. Mesa, & C. Rasmussen, Eds.).

Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models* (2nd ed.). Thousand Oaks, CA: SAGE Publications.

Singer, J. D. (1998). Using sas proc mixed to fit multilevel models, hierarchical models, and individual growth models. *Journal of Educational and Behavioral Statistics*, *24*(4), 323–355.

Snijders, T. A. B., & Bosker, R. J. (2011). *Multilevel analysis: An introduction to basic and advanced multilevel modeling* (2nd ed.). Los Angeles, CA: Sage.

Sonnert, & Sadler. (2015). The impacts of instructor and institutional factors on students' attitudes. In Broussard, V. Mesa, & C. Rasmussen (Eds.), *Insights and recommendations from the MAA national study of college calculus* (pp. 17–30).