Work in Progress: Examining the Impact of a Faculty Development Program in Engineering Instructors' Teaching Practices and Perceptions on Active Learning Methodologies

Gianina Morales, University of Pittsburgh and Universidad de Valparaiso, Chile

Gianina Morales is a Faculty at the Universidad de Valparaíso, Chile. She has an M. Ed degree and is currently a Fulbright Ph.D. student at the School of Education at the University of Pittsburgh. Her research focuses on disciplinary literacy in engineering and the improvement of instructional practices to foster persistence and equity in undergraduate engineering education.

Ms. Rene Alejandro Noel, Universidad de Valparaiso, Chile

René Noel is a Faculty at the Universidad de Valparaíso, Chile. René holds a MSc. In Informatics degree. Currently, Rene is a PhD student at Universidad Politecnica de Valencia, Spain, and focuses his research in software production methods, experimental software engineering, and engineering education.

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Abstract

Developing faculty's capabilities for active learning is critical in STEM education. In previous work, we presented the design, execution, and lessons learned of a faculty development program for instructors of introductory engineering courses developed in a Chilean regional university. The program implemented a collaborative coaching model in which methodological experts led teams of instructors in designing and creating coursework materials and accompanied the implementation of the courses through classroom support and weekly reflection sessions. A total of nine instructors started the program, but six continued during the entire year and ended with successful results. Almost five years after the completion of the program, we wonder: How might the faculty development experience have impacted in the long-term the instructional practices and perceptions about active learning and teaching of participant instructors? In this work-in-progress (WIP) article, we describe the design and first outcomes of a qualitative case study prepared to answer this question. The case study includes interviews, classroom observations, and the analysis of coursework materials produced by the focal instructors. We draw on literature about teachers' appropriation of pedagogical tools and the development of instructional practices in higher education as analytic resources. We expect our results will contribute to the current debate on the aspects that promote the sustainability of professional development programs outcomes over time. The authors will present this paper in a Lightning talk to discuss the future possibilities of the study with the audience.

Introduction

In STEM and Engineering in particular, calls for change in faculty's pedagogical practices have been argued and supported by reflections on societal and professional shifts [1], [2], research on students' learning [3], [4], and the imperative of improving the experience and persistence of undergraduate students [5]. Faculty development programs centered on teaching practices are pivotal for the success of transformational initiatives. They promote faculty engagement in student-centered instructional practices [6], i.e., methods and strategies that foster students' active involvement in knowledge construction and problem-solving, broadly known as *active learning*. Teaching practices convey the learning objectives, didactic methods, and assessment strategies that instructors apply in their classes interwoven with their knowledge and conceptions of teaching [7]. Considering all the dimensions of instructional practices and drawing on experiences of active learning faculty development programs (e.g., [8]), we designed and implemented a one-year faculty development program characterized by an active, collaborative, and reflective approach and supported by a coaching system [9].

A total of nine instructors started the program, but six continued during the two semesters. These instructors ended with promissory results in terms of students' learning, management of the techniques and methods worked during the program, and dispositions toward incorporating what they learned into future courses. However, beyond the immediate evaluation, the main challenge is the sustainability of faculty development programs' goals over time [10]–[12]. Considering that our program finished almost five years ago, we have designed a qualitative multiple-case study to follow the instructors that finished the program and trace the long-term influence of the experience

on their practices and beliefs. As our inquiry is in progress, we will address in this paper the conceptual framework, methods, and preliminary findings of the study.

Background

The faculty development program we are following up with this study occurred in the context of an Institutional Improvement Project (IIP) called "Design and implementation of a strategy for evaluation and continuous strengthening of STEM skills." The IIP was implemented between 2015 and 2018 in the college of engineering at a Chilean regional university and had ambitious goals in terms of indicators (e.g., persistence, timely graduation, pass rates, and faculty development rates). The primary strategy was to impact student learning by enhancing instructors' teaching practices. In that context, our faculty development program sought to switch traditionally disengaged and usually gatekeeping introductory courses toward pilot mathematics and physics courses anchored in student-centered and active learning methodologies [9]. The core of the program was a collaborative coaching model in which methodological experts in active learning methodologies (e.g., rich-context problems [13], peer instruction [14], tutorials [15], flipped classroom [16]) led teams of instructors in the planning of the sessions and the design and creation of the coursework materials from before and throughout the courses. The coaches guided weekly collaborative learning and reflection meetings and accompanied the courses' implementation through classroom and virtual support. The program also considered a follow-up structure, which provided timely feedback and continuous evaluation of the program processes.

Conceptual Framework

Attention to professional development in higher education has grown in recent decades. Several reviews have analyzed the factors that influence programs' effectiveness (e.g., [17]–[19]). For instance, based on empirical research, the National Research Council suggests that faculty development programs are more likely to impact practice if they are sustained efforts that last longer than traditional one-time workshops, include coaching and feedback on instructional practice, and deliberatively seek to change instructors' perspectives on teaching and learning [20]. Other authors have also found that programs produce better outcomes if they are extensive [18] and include collaborative and active participation from the instructors [17], [21], [22].

Nevertheless, the complexity of higher education systems makes it difficult to estimate an initiative's effectiveness based solely on its design and immediate evaluation [10]. Changes in departmental leadership and organization, including decisions on which courses are taught by which instructors, influence the long-term effects of faculty development programs. As a result, even compliance by design with the features described in the literature—as in our case—does not guarantee the sustainability of the goals. Moreover, professional learning is also complex [23] and represents a continuous, collective, and social process. Teachers are continually learning, not only inside formal professional development programs but also in their classes and with their peers [24]. The evaluation itself is difficult because of all the elements interwoven [25]. For example, an instructor could be engaged in more than one professional development program at a time, so what change could be attributed to which program and why?

The challenging scenario described makes necessary the design of comprehensive studies aimed at analyzing the long-term effects of professional development programs. Although advanced in K-12 (e.g., [12], [26]), the study of the long-term effects of programs in STEM higher education is incipient. Beyond evaluations of wide programs involving faculty from multiple departments (e.g., [27], [28]), Emery and colleagues' longitudinal study design offers one of the few examples of an integrative proposal for the analysis of the long-term outcomes of a professional development

program in STEM but does not publish results yet [10]. To contribute to the ongoing discussion, we will explore the application of the theory of Grossman and colleagues about teachers' appropriation of pedagogical tools [29] as a primary framework to analyze the sustainability in the long-term of the practices promoted by our faculty development program.

Grossman and colleagues' theory relies on sociocultural theory (c.f. [30], [31]) to understand the mediational power of human interactions, symbols, and materials on teaching development. They distinguish between conceptual (principles, theories, and frameworks) and practical (techniques, methods, resources, and strategies) pedagogical tools. Pedagogical learning entails an active process of appropriation of pedagogical tools. "Appropriation refers to the process through which a person adopts the pedagogical tools available for use in particular social environments (e.g., schools (…)) and through this process internalizes ways of thinking endemic to specific cultural practices" [29, p. 15]. The theory offers a scale of appropriation of five levels: *lack of appropriation*, *appropriating a label* (superficial and vague learning of a tool), *appropriating surface features* (not deep grasping of some elements of a tool), *appropriating conceptual underpinnings* (understanding and application of the theoretical basis for a tool), and *achieving mastery* (beyond grasping, effective implementation of the tool). In our study, we will use this theory as a general guide to make sense of different data associated with the focal instructors: interviews, observations, and classroom materials. We will combine it with the contrastive analysis of the interviews to examine the instructors' conceptions and beliefs of teaching and learning.

Method

To examine the possible long-term impacts of our faculty development program, we design a qualitative multiple-case study. This method allows for the deep examination of a phenomenon through the convergent analysis of different data sources [32], [33]. Our research questions are: 1) How might the faculty development experience have impacted participant instructors' instructional practices in the long term? 2) How might the faculty development experience have impacted participant instructors' perceptions and beliefs about learning and teaching in the long term?

The study participants are six instructors who finished the faculty development program and continue teaching in the institution. Our data collection procedures include semi-structured in-depth interviews, classroom observations, and the analysis of coursework materials produced by the focal instructors for the courses observed. We plan to develop the data collection process within two academic years. The study considers at least three sets of interviews of about one hour at the beginning, middle, and end of the data collection process. We are considering in our interview protocols two sources, Bain's research [7] on participants' beliefs and conceptions about teaching and learning—which we already used during the original program five years ago—and questions about the conceptual and practical pedagogical tools addressed in the program. For the observations and analysis of coursework materials, we will coordinate with the participants which courses will be our focal courses. We plan to observe all the classes in the first and the last content unit from the courses, collect the classroom materials created by the instructors for the classes observed, and perform a content analysis of those materials [34]. In this paper, our preliminary findings come from the first interviews conducted with the instructors in January 2023.

We are following standard procedures of case study research (e.g., [32], [33], [35]), so we are first analyzing the data from each instructor individually, and then we are examining patterns across participants' data. As we mentioned, at the moment of presenting this article, we have conducted

and primarily analyzed the first set of interviews, so our preliminary findings are based on this data. As we move forward in the data collection process, we will compare information across sources in a *triangulating fashion* [32] to converge the different lines of inquiry derived from our research questions. We are employing an eclectic coding method [36] for the data analysis. For the first research question, we started with a provisional or a priori code based on Grossman et al. [29] that have growth and shift by constant data comparisons [34] during the analysis. The second research question starts with inductive codes associated with instructors' declarations regarding learning, teaching, students, themselves, the environment in which they work, and other emergent topics in the interviews. We are following standard coding recommendations (e.g., [37]) to ensure an ethical approach to our data.

Preliminary Findings

In relation to our research questions, we asked instructors in the first interviews about the program's impact on their instructional practices, perceptions, and beliefs about learning and teaching. We describe here the most relevant preliminary patterns that emerged.

Conceptual and pedagogical tools appropriation

In relation to the first research question, we observed some glimpses of tool appropriation. Regarding the **conceptual pedagogical tools**, one of the topics that emerged from more than a single instructor is the concept of *students as builders of their knowledge,* which was emphasized during the program as a guiding principle behind most pedagogical tools. Participants described learning situations in which they give students the possibility to discover the formula or procedure to solve a problem with a practical exercise instead of giving them the method and, after that, the exercise. For instance, one instructor declared:

> "I have tried to do things, mainly about analytical geometry, which was what we saw there [*in the pilot course*], to try to teach it in another way where the kids, more than anything else, discover. Maybe discover where everything comes from, the formulas that you give them. And with applications rather than the reverse way we used to do it, to give them all the content and at the end the practice" (Tess).

Another emerging topic is the *prioritization of knowledge depth instead of breadth*. As commented by two instructors, they prefer to ensure that a course topic is learned in depth before moving to the next one, even if this could affect the course schedule. The idea of ensuring deep student learning in the classroom was worked in the faculty development program through particular attention to practical activities. More than half of the instructors indicated they continue considering practical activities as critical for students learning. A third emerging topic is *the relevance of collaborative work for the construction of sustained learning*. Some instructors have even extended the social understanding of learning beyond the classroom to their teaching preparation practices. Four participants detailed experiences in which they took ownership of the faculty development collaborative method and formed their own teams for designing and implementing courses.

Concerning the **practical pedagogical tools** worked during the program, the interviews show that all the instructors declared the use of at least one of the active learning techniques promoted in the faculty development program. Even when instructors do not remember the names, their descriptions of the use and adaptation of the techniques evidence appropriation of the tools. For example, one instructor described the process of creating *tutorials* in physics—a method based on the development of a written guide that has questions and problems that gradually allow students to conclude a concept and its applications—for a course at another institution, obtaining successful results in students' outcomes. Another instructor indicated that in the context of the coronavirus

pandemic, she created several related *rich contextual problems*, taking advantage of a technique characterized by the inclusion of abundant contextual information in the problems and the prompt for students to infer the questions and not only the answers. Additionally, at least four instructors mentioned using some type of *flipped class activity*. This technique is characterized by the access of students to instructional material (multimedia usually) with the content of a topic before classroom time so that students can come to the class with that knowledge, and the instructor uses time class for practical activities. The instructors indicated the use of the technique with YouTube videos and texts.

Participants also indicate they have continued including *student-centered learning practices leveraged during the program*, such as cooperative problem solving, intensive opportunities for practice in class sessions, continuous formative assessments, and the inclusion of technology used by youth (e.g., mobile phones) with pedagogical purposes. In general, participants' descriptions indicate that they seem to have appropriated the tools promoted in the program. However, we need more data (from observations and coursework materials) to arrive at conclusions about instructors' levels of appropriation.

Perceptions and beliefs

Concerning the second research question, preliminary findings show that all the instructors declare an impact on their conceptions about active learning and teaching elicited by the program. However, there are nuances in their responses, ranging from stating that the program only reaffirmed their perceptions to appraising the experience as a *game changer*. For instance, one instructor indicated that the program only changed his perspectives on technology and its pedagogical use, while another attributed to the program reframing her understanding of the students to see them as *thinkers* and active constructors of their learning.

In relation to their perspectives on students' and instructors' roles, we also noticed some differences in the answers and how the program influenced their visions. For instance, one participant described how the experience changed her perspective of what it means to be a professor because the program disrupted the traditional idea of the professor "imparting" knowledge on top of a platform, far and disconnected from the students. Another instructor indicated that the program helped him to recognize the value of being engaged with the students. He said that he understood that motivation does not mean "to come to classes dressed like a clown to make a show." However, concerning their interpretations of students' results, only half go beyond student accountability and commitment to highlighting the role of instructors. Remarkably, those participants concurred in attributing a relevant role to building personal relationships with students as a powerful tool to support their learning.

Discussion and Future Work

During the program's development, we observed high levels of tool appropriation among the instructors who remain on it—generally above a mere *surface appropriation*. We also observed a change in their perceptions of teaching and learning. However, after almost five years, one question is if instructors still demonstrate tool appropriation and how this potential appropriation is connected with their conceptions and beliefs about teaching and learning. Our preliminary analysis shows promising findings but also some mismatch between the declared knowledge of a tool and its described practice or the instructors' conceptions. The future inclusion of empirical data from observations and artifacts will give us a broader perspective to approach these questions and arrive at conclusions on the long-term impact of our faculty development program.

References

[1] R. M. Felder, "Teaching engineering in the 21st century with a 12th century teaching model: How bright is this?," *Chemical Engineering Education*, vol. 40, no. 2, pp. 110–113, 2006.

[2] R. Graham, *Achieving excellence in engineering education: the ingredients of successful change*. London: The Royal Academy of Engineering & Massachusetts Institute of Technology, 2012.

[3] S. Freeman *et al.*, "Active learning increases student performance in science, engineering, and mathematics," *Proceedings of the National Academy of Sciences*, vol. 111, no. 23, pp. 8410–8415, 2014, doi: 10.1073/pnas.1319030111.

[4] National Research Council, Division of Behavioral and Social Sciences and Education, Board on Science Education, and N. Kober, *Reaching Students: What Research Says about Effective Instruction in Undergraduate Science and Engineering*. Washington, D.C., United States: National Academies Press, 2015.

[5] E. Seymour and A.-B. Hunter, Eds., *Talking about Leaving Revisited: Persistence, Relocation, and Loss in Undergraduate STEM Education*. Cham: Springer International Publishing, 2019. doi: 10.1007/978-3-030-25304-2.

[6] L. R. Lattuca, I. Bergom, and D. B. Knight, "Professional Development, Departmental Contexts, and Use of Instructional Strategies," *Journal of Engineering Education*, vol. 103, no. 4, pp. 549–572, 2014, doi: 10.1002/jee.20055.

[7] K. Bain, *What the best college teachers do*. Cambridge, Mass: Harvard University Press, 2004.

[8] G. Zavala, H. Alarcón, and J. Benegas, "Innovative Training of In-service Teachers for Active Learning: A Short Teacher Development Course Based on Physics Education Research," *Journal of Science Teacher Education*, vol. 18, no. 4, pp. 559–572, 2007, doi: 10.1007/s10972-007-9054-7.

[9] G. Morales, R. Noel, and R. Campos, "Lesson Learned: Active Learning Coaching Program to Promote Faculty Development and Innovation in STEM Courses," presented at the 2022 ASEE Annual Conference & Exposition, 2022. Available: https://peer.asee.org/lesson-learned-active-learning-coaching-program-to-promote-faculty-development-and-innovation-in-stem-courses

[10] N. Emery, J. M. Maher, and D. Ebert-May, "Studying Professional Development as Part of the Complex Ecosystem of STEM Higher Education," *Innov High Educ*, vol. 44, no. 6, pp. 469–479, 2019, doi: 10.1007/s10755-019-09475-9.

[11] J. A. Supovitz, D. P. Mayer, and J. B. Kahle, "Promoting Inquiry-Based Instructional Practice: The Longitudinal Impact of Professional Development in the Context of Systemic Reform," *Educational Policy*, vol. 14, no. 3, pp. 331–356, 2000, doi: 10.1177/0895904800014003001.

[12] Y. Furman Shaharabani and T. Tal, "Teachers' Practice a Decade After an Extensive Professional Development Program in Science Education," *Res Sci Educ*, vol. 47, no. 5, pp. 1031–1053, 2017, doi: 10.1007/s11165-016-9539-5.

[13] P. Heller and K. Heller, *Cooperative Group Problem Solving in Physics*. New York: Cole Publishing Company, 2001.

[14] E. Mazur, *Peer instruction: a user's manual*. In Prentice Hall series in educational innovation. Upper Saddle River, N.J: Prentice Hall, 1997.

[15] L. C. McDermott and P. S. Shaffer, *Tutorials in introductory physics.*, 1 ed. Upper Saddle River, New Jersey: Prentice Hall, 2002.

[16] J. Bergmann and A. Sams, *Flip your classroom: reach every student in every class every day*. International Society for Technology in Education, 2012.
[17] I. Gast, K. Schildkamp, and J. T. van der Veen, "Team-Based Professional Development Interventions in Higher Education: A Systematic Review," *Review of Educational Research*, vol. 87, no. 4, pp. 736–767, 2017, doi: 10.3102/0034654317704306.
[18] A. Stes, M. Min-Leliveld, D. Gijbels, and P. Van Petegem, "The impact of instructional development in higher education: The state-of-the-art of the research," *Educational Research Review*, vol. 5, no. 1, pp. 25–49, 2010, doi: 10.1016/j.edurev.2009.07.001.
[19] C. Henderson, A. Beach, and N. Finkelstein, "Facilitating change in undergraduate STEM instructional practices: An analytic review of the literature," *Journal of Research in Science Teaching*, vol. 48, no. 8, pp. 952–984, 2011, doi: 10.1002/tea.20439.
[20] National Research Council, S. R. Singer, N. Nielsen, and H. A. Schweingruber, Eds., *Discipline-based education research: understanding and improving learning in undergraduate science and engineering*. Washington, D.C: The National Academies Press, 2012.
[21] M. S. Garet, A. C. Porter, L. Desimone, B. F. Birman, and K. S. Yoon, "What Makes Professional Development Effective? Results From a National Sample of Teachers," *American Educational Research Journal*, vol. 38, no. 4, pp. 915–945, 2001, doi: 10.3102/00028312038004915.
[22] C. D. Czajka and D. McConnell, "Situated instructional coaching: a case study of faculty professional development," *IJ STEM Ed*, vol. 3, no. 1, p. 10, 2016, doi: 10.1186/s40594-016-0044-1.
[23] V. D. Opfer and D. Pedder, "Conceptualizing Teacher Professional Learning," *Review of Educational Research*, vol. 81, no. 3, pp. 376–407, 2011, doi: 10.3102/0034654311413609.
[24] L. M. Desimone, "Improving Impact Studies of Teachers' Professional Development: Toward Better Conceptualizations and Measures," *Educational Researcher*, vol. 38, no. 3, pp. 181–199, 2009, doi: 10.3102/0013189X08331140.
[25] D. Chalmers and D. Gardiner, "An evaluation framework for identifying the effectiveness and impact of academic teacher development programmes," *Studies in Educational Evaluation*, vol. 46, pp. 81–91, 2015, doi: 10.1016/j.stueduc.2015.02.002.
[26] J. K. Philippoff, "An Examination of the Long-Term Effects of a Teacher Professional Development in Inquiry Science," Ph.D., University of Hawai'i at Manoa, United States -- Hawaii, 2021. Accessed: Jan. 24, 2023. [Online]. Available: https://www.proquest.com/docview/2597526866/abstract/BB6FF3ECC4714C16PQ/1
[27] M. M. Tennill and M. W. Cohen, "9: Assessing the Long-Term Impact of a Professional Development Program," *To Improve the Academy*, vol. 32, no. 1, pp. 145–159, 2013, doi: 10.1002/j.2334-4822.2013.tb00703.x.
[28] M. Stewart, "Making sense of a teaching programme for university academics: Exploring the longer-term effects," *Teaching and Teacher Education*, vol. 38, pp. 89–98, Feb. 2014, doi: 10.1016/j.tate.2013.11.006.
[29] P. L. Grossman, P. Smagorinsky, and S. Valencia, "Appropriating Tools for Teaching English: A Theoretical Framework for Research on Learning to Teach," *American Journal of Education*, vol. 108, no. 1, pp. 1–29, 1999, doi: 10.1086/444230.
[30] L. S. (Lev S. Vygotsky, *Mind in society : the development of higher psychological processes*. Cambridge: Harvard University Press, 1978.
[31] J. V. Wertsch, *Voices of the Mind: Sociocultural Approach to Mediated Action*. Cambridge, United States: Harvard University Press, 1993.

[32] R. K. Yin, *Case Study Research and Applications: Design and Methods*, Sixth. SAGE Publications, 2018.
[33] S. B. Merriam, *Qualitative Research and Case Study Applications in Education. Revised and Expanded from "Case Study Research in Education."* San Francisco, CA: Jossey-Bass Publishers, 1998.
[34] M. B. Miles, A. M. Huberman, and J. Saldaña, *Qualitative data analysis: a methods sourcebook*, Third edition. Thousand Oaks, California: SAGE Publications, Inc, 2014.
[35] R. E. Stake, *The Art of Case Study Research*. SAGE, 1995.
[36] J. Saldaña, *The coding manual for qualitative researchers*, 3E [Third edition]. Los Angeles ; London: SAGE, 2016.
[37] K. M. MacQueen, E. McLellan, K. Kay, and B. Milstein, "Codebook Development for Team-Based Qualitative Analysis," *CAM Journal*, vol. 10, no. 2, pp. 31–36, May 1998, doi: 10.1177/1525822X980100020301.