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Lesson Learned: Active Learning Coaching Program to Promote Faculty Development and Innovation in STEM Courses

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Abstract:
This lesson learned paper describes the faculty development program conducted to implement active learning methodologies in basic science courses from engineering degrees in a Chilean regional university. Contextualized in an Institutional Improvement Project (IIP) centered on students' STEM skills, the program aimed to impact student learning by enhancing instructors' teaching practices. The faculty development program had a continuous collaborative approach, where methodological experts accompanied a faculty team before and during the execution of the courses. The coaching methodology had three pillars: a collaborative process of design and creation of coursework materials guided by methodological experts, classroom and virtual support, and weekly reflection. In parallel, a follow-up process was applied to evaluate the program's impact. In the article, we present three main lessons learned from our program: the importance of the regular attendance and engagement of the faculty members in the coaching activities, the commitment of the departments to support innovative practices, and organizational conviction to invest in the installation of active learning practices. The authors will present this paper in a Lightning talk to discuss the lessons learned from the experience with the audience.

Introduction

Several scholars have demonstrated that a shift in the traditional model of instruction toward a student-centered active learning perspective in engineering is necessary to foster learning and face the challenges of the XXI century [1]–[3]. In this context, the College of Engineering from the Universidad de Valparaíso (Chile) renewed its curricula towards a "competency-oriented" model, with the participation of professors, students, and industry stakeholders, as well as the collaboration of international experts [4]. The IIP "Design and implementation of a strategy for evaluation and continuous strengthening of STEM skills" accompanied the process of curricular innovation through the development of pilot active learning courses in the areas of physics and mathematics, an important part of the first two years of engineering curricula in Chile [5].

Considering that instructors play a crucial role in students' achievement, addressing faculty teaching practices was a priority in the strategy followed in the IIP. According to Bain [6], college teaching practices involve everything from the learning outcomes, learning methodologies, and assessment strategies that instructors use in their classes to their perception of teaching. Drawing from prior professional development experiences focused on active learning methodologies [7], [8], the IIP team designed a faculty development program that went beyond the traditional training model prior to the start of the academic semester. The program was built on three principles: 1) A robust professional development model requires instructors to construct conceptual, practical, and pedagogical knowledge collaboratively; 2) Pedagogical learning needs time and reflection to be embedded in teaching practice; 3) Supported pedagogical practices are more likely to be sustained and transferred over time.

Following these three principles, the coaching program had two learning objectives: 1) To provide the instructors with the tools to design, implement, and improve the syllabus of engineering subjects based on active learning techniques, and 2) To enhance the instructors' competence of continuous reflection in their teaching practice. Three data collection procedures were also applied to evaluate the program's development and its impacts on students and instructors (follow-up process): semi-structured interviews, classroom observations, and small group analysis—SGA [6]. The follow-up process provided timely feedback to the coaches and assessed factors that enable or hinder future model replications. In what follows, we will describe the structure and activities of the coaching program and the lessons learned from the process.

Coaching Program Structure and Implementation

The coaching program was performed in four basic science courses in the College of Engineering during one academic year before the Covid pandemic. The total number of participants and sections is detailed in Table 1.

Table 1: Summary of program statistics

Subject	Semester	N°Engineering programs[a]	N° Sections	N°Instructors	N° Students
Introduction to Mathematics	1	1	2	1	50
Introduction to Physics	1	2	6	6[b]	210
Algebra	1	3	2	2	52
Mechanical physics	2	2	5	5[b]	180

a: Engineering programs involved: Ocean Engineering, Civil Engineering, Industrial Engineering, Construction Engineering.b: Same instructors.

Each subject had a coach—a methodological expert in engineering education hired specially for this role—who met weekly with the instructors of the course sections. In the weekly workshops, the coach guided the learning of active methodologies, the collaborative production of class materials, and the reflection on the experiences and results of the previous week's classes. An online platform (Google Classroom) supported the in-person meetings. The coach also participated in some classes to assist the instructors and follow up on their learning process. Figure 1 depicts the coaching process that is described below.

Fig. 1. Coaching program structure.

The planning and syllabus design was performed two weeks before the regular classes. First, the coach analyzed the course's program and then selected one or many learning techniques matching the contents of the course with a subsect of engineering learning outcomes. Among the learning techniques applied were Rich-Context Problems [9], the IDEA problem-solving method [10], Peer Instruction [11], Tutorials [12], and Flipped Classroom [13]. After selecting the techniques, the coach gathered the instructors and provided introductory training about each technique's fundamentals and practical implications. Then, the coach guided the group through the joint design of the course syllabus, considering a single or a combination of learning techniques. For instance, a class session could start with a peer instruction activity to assess the group's knowledge of a concept—previously introduced through the flipped classroom technique—and then could continue by grouping the students to apply the concept in a rich-context problem activity collaboratively.

Once the classes started, the coach and the instructors conducted a **weekly workshop**. The coach trained the faculty members in the workshop by showing them the learning technique. The instructors played the role of students, so they could practically understand how the learning technique works and how the coach conducted the activity. By experiencing an active class from a student's point of view, instructors had a better understanding of the different situations students are exposed to when facing this type of class, as well as preconceptions and possible student mistakes that they did not see before. Then the group outlined the class sessions contents and assigned specific tasks in order to create the coursework collaboratively. Also, different assessment instruments, consistent with an active learning approach, were designed. A faculty Google Classroom course was designed to support the coaching activities.

In the **class sessions**, the instructors applied the active learning techniques and assessment instruments. A Google Classroom platform supported the class activities, facilitating timely feedback on students' assignments and doubts. The coach provided classroom support at least once a month for each instructor. It is worth noting that, given the active nature of the learning and assessment tasks, students and faculty had continuous feedback about their performance. In the **weekly workshops**, the last week's results were reviewed from the perspective of the students' performance and the execution of the active learning technique. The group reflected on elements that facilitated or hindered the application of the learning techniques and agreed on improvements and modifications in the classroom activities. The coach followed up on the implementation and results of the modifications.

Lessons Learned and Conclusions

Almost all participants completed the program (two instructors dropped out during their second semester). The pilot courses in which their instructors completed the program increased their pass rates on average by 15.64%. The subject Introduction to Physics had the best results (28% average increase in the pass rate). Another outcome of the program was the coursework materials that participants co-created, used later with adaptations by some College of Engineering departments. In addition, other departments extended the model to other subjects.

We will focus our lessons learned analysis on the factors that enable or hinder the program's success, retrieved from our follow-up process. First, we found that the regular attendance of the instructor was beneficial for the successful application of the active techniques in classes. The sections with the most notable improvements in their pass rates (4) were from faculty whose attendance was almost perfect in the weekly workshops and showed active participation in the Google Classroom platform. In contrast, courses from instructors who missed several weekly workshops had lower improvements in their pass rates. The classroom observations also indicated a higher student engagement and increased application of active learning mediation strategies in the courses from faculty with high participation. The interviews showed that at the end of the experience, these instructors increased their appraisal of active learning methodologies and were enthusiastic about incorporating the techniques learned in future courses.

A second important aspect was the engagement of the engineering departments with active learning. Those departments whose institutional visions favored the transformation of their courses with active methodologies involved more faculty in the program. They were also more supportive in the face of the adjustment challenges, mainly associated with the habit of students and instructors to operate in traditional learning environments. The quantitative results and the qualitative evaluation of the program showed that these same departments had the best results. We conclude that institutional support is key to the commitment and openness to change that instructors need to move forward with this type of innovation.

Finally, attention to organizational factors is also critical to replicating such an experience in other engineering schools. Our program was part of an IIP that had the resources to provide financial incentives to participating faculty, hire the coaches, and fund all the material and follow-up aspects associated with the program. An organizational challenge is to scale the model since we observed of uttermost relevance for students' learning the instructor's engagement in supervision and facilitation practices in the classrooms. In large courses, this could be possible by introducing teaching assistants, trained in the same program. The model is easier to install in advanced engineering courses, given their natural focus on problem-solving. Regardless of their cost, the program installed active teaching practices, motivating several participants to continue using what they learned after completing the training. In the wake of the pandemic, the new educational use of virtual technologies—such as zoom—could allow the program to be affordably replicated with minor adaptations.

References

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

[2] National Research Council (U.S.), 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.

[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, Jun. 2014, doi: 10.1073/pnas.1319030111.

[4] U. R. Cukierman *et al.*, "Triple-Helix and International Collaboration to Design and Implement an Outcomes Based Engineering Curriculum to Better Serve Stakeholders in Valparaíso-Chile," *Paper presented at 2016 ASEE International Forum, New Orleans, Louisiana.* https://peer.asee.org/27270

[5] Colegio de Ingenieros de Chile, "Calificación de Títulos Profesionales de Ingenieros para Admisión de Socios Activos." 2020. [Online]. Available: https://www.ingenieros.cl/reglamentos/

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

[7] 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, Jun. 2007, doi: 10.1007/s10972-007-9054-7.

[8] J. Benegas, H. Alarcón, and G. Zavala, "Formación de profesorado en metodologías de aprendizaje activo de la física," in *Aprendizaje activo de la física básica universitaria*, J. Benegas, M. Landazábal, and J. Otero, Eds. Santiago de Compostela, España: Andavira, 2013, pp. 193–203.

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

[10] V. M. Mercado *et al.*, "IDEA: An Alternative for Learning Problem Solving in the Course of Mechanics for Engineering Students at FICA," *JEHD*, vol. 3, no. 4, 2014, doi: 10.15640/jehd.v3n4a16.

[11] E. Mazur, *Peer instruction: a user's manual*. Upper Saddle River, N.J: Prentice Hall, 1997.

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

[13] J. Bergmann and A. Sams, *Flip your classroom: reach every student in every class every day*. International Society for Technology in Education, 2012.