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A link between a second course in calculus and engineering applications: what the students think about.

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Theoretical background and aims

One of the problems in the early years in an engineering curriculum is that mathematics is taught as a separate subject and, in many cases, the students do not recognize the mathematics they use (Kent & Noss, 2003). Modelling activities are usually recommended to bridge the gap between mathematical content and engineering practices (González-Martín et al., 2021). Problem posing offers opportunities to connect mathematics to students' interests. Moreover, within a classroom community, students could be encouraged to pose problems that others in the class might find interesting or novel. Students' beliefs about the relevance of mathematics are considered as one of the factors that can play an important role in their attitude and motivation (Hannula et al., 2016).

To help student to recognize the relevance of mathematics and make it more interesting, as volunteer supplementary problem posing work, assigning as incentive of 3 over 30 extra bonus points to add to their final grade, to Civil and Environmental Engineering (University of Udine) students were asked to find possible applications of the topics of the course (i.e. differential and integral multivariable calculus and differential equations and systems), to engineering and to present them to the class as completion and support of the standard lessons (see also Lepellere, 2021). At the end of the academic year, we also asked to students who participated to the project to write a report about their impressions of the work done. Thematic analysis technique (Braun & Clarke, 2021) was carried out to identify benefits do students report participating in the project. An anonymous survey on the Moodle platform was also administered. The research questions were: what kinds of application will the students choose? Does participating in the project affect students' belief that knowledge in analysis is relevant to engineering? What benefits do students report participating in the project gave them?

Results

Twenty-five students, out of seventy-five, prepared and presented their project: 46% chose a modelling of real problem; 38% a topic connected to other courses (rational mechanics, construction sciences and hydraulics); 21% presented a simplified extract of a research article. Twelve students wrote a report. From its analysis, three important themes emerged: enjoyment; to challenge understanding; to improve connections of mathematical concepts in other contexts. Eleven students expressed positive enjoyment, as: *It is a good idea to motivate students to go beyond the classic lesson study...* Just one student said: *However, I cannot claim to be satisfied.* Eleven students said that it challenges students' understanding: *This forced us to understand the proposed arguments more fully... from a previous study of the subject I did not understand its essence and its applicability in real contexts...* Just one student said: *it did not help me in the study of the subject.* It helps to make connections of mathematical concepts in other contexts: *It allowed us to broaden our knowledge and get closer to aspects of engineering that perhaps in other cases would not have been of personal*

interest... It has allowed an easier understanding of the same topics seen in other courses allowing a considerable simplification of the learning phase... Seven students spontaneously highlighted their beliefs about mathematics: *abstract topics..., a very theoretical subject in itself..., many concepts are delicate to understand...* There was no lack of critical issues: *It took me a long time to find something... it is not always easy to find precise, certain, and secure information... it is easier for students who have already attended more "technical" courses... I had a hard time developing the idea and find a conclusion...* About the survey, to the multiple-choice question: What do you think of the supplementary work on applications proposed during the course? Only 5% (2 out of 40) wrote the project is not useful, 85% find it useful, but just 7.5% would make it mandatory, 10% would extend the project even at the end of the course given the excessive workload during the semester.

Conclusions

Despite the efforts that teachers do to make calculus more attractive for future engineers, by offering application examples, often related to physics, the students continue to show little interest in the discipline, deeming it “too abstract”. Furthermore, the students are not always able to connect the topics covered in class with those of other courses, sometimes the simple use of a different “language” confuses them. However, it is difficult to propose alternative activities, as evidenced by the fact that while they consider the proposed project useful, they prefer it to remain optional. But if the students are stimulated, they are able to pose and solve problems using mathematical modelling too. From the analysis of the data, we can conclude that the activity had a positive impact on students’ beliefs that mathematics is essential for the continuation of their studies and career as engineer.

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