Student-centred reform of an Applied physics program

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Abstract. We describe reforms in the Applied physics program at the University of Ljubljana. The reforms utilised the Investigative Science Learning Environment (ISLE) approach to a more effective learning and teaching physics. The course was synchronised with recitations and lab work, the classroom was rearranged in a studio setting to support group work, and semi-open investigations were introduced in the lab course to foster authentic experiences. Using active student participation and collaboration, the program aims to produce graduates who are equipped to tackle real-world problems. We report on various changes and attitudes of students and instructors towards the reformed programme.

Introduction

The need for a shift from content-based to skill-based learning is increasingly recognized in new school curriculum guidelines [1, 2]. While different approaches are possible, they all share a focus on student-centred active learning [3, 4]. The recent impact of Covid-19 pandemic and advancements in ICT cause an increased use of digital technology and underscore the importance of developing students' skills to use it [5]. The University of Ljubljana is reforming its Applied Physics study program through The Recovery and Resilience Facility [6] project. The reform is based on the ISLE approach, a student-centred learning methodology that emphasises the development of scientific abilities and habits of mind through inquiry-based activities and focuses on the needs and interests of individual students [7]. The study program under reform suffered from poor inscription numbers, high attrition rates, and poor motivation of the enrolled students. The ISLE approach is ideally fitted to maintain interest in these students by engaging them in the process of developing physical knowledge by themselves and actively shaping their own learning process.

Theoretical framework

The ISLE approach is a student-centred holistic learning environment that emphasises the development of scientific abilities and habits of mind through inquiry-based activities and helps students learn physics by engagement in processes that mirror scientific practice and improve their well-being [7]. It is based on a cycle of logical reasoning, an array of representational tools, and the development of scientific abilities or scientific habits of mind. The cycle of logical reasoning starts with creating the need to know. It is followed by observational experiments that provide students with data that need to be explained. Students generate multiple explanations based on prior knowledge and analogical reasoning. These explanations serve as a base for prediction for the outcome of a testing experiment. The interpretation of results of the testing experiment develops judgement skills. In the process of analysing observations and developing explanation, the students use various graphical representational tools. These tools help students organise and apply knowledge to solve real-world problems. The development of scientific abilities or scientific habits of mind allows students to think like a physicist. The listed aspects of ISLE are well suited for our goals: to increase motivation of students, increase knowledge gain and decrease attrition rate. To describe these reforms and the findings from their analysis we present three investigations as separate contributions. This presentation describes the reforms and provides a summary of the findings from all three investigations. The follow up presentations will focus on students' attitudes towards the reform and specifically towards working in groups, on the development of students' scientific abilities, and on the professional development of instructors.

Methods and Findings

The course was traditionally taught, its enrolment declined in 10 years from 30 down to 15 freshmen, had poor retention rate (less than a third graduating) and non-motivated students (around 5 attended classes). There were 4 hours of lectures/week, 1 hour of seminar, and 3 hours of recitations. The physics lab was 3 hours per week of cookbook recipe-like exercises disconnected from the lecture/recitations topic of the week. We made the following changes: the classroom setup was remodelled to reflect studio-arrangement for student group work on small white boards; the lectures became interactive to reflect the ISLE approach; the labs were fully synchronised with weekly lecture/recitation material and engaged students in the design of their own experiments following the ISLE philosophy. The students were given an opportunity to revise and improve their work for an improved grade. The lecturer and teaching assistants received training in ISLE approach prior to semester and had continuous professional development preparing them to teach weekly course meetings. All the activities were always accompanied and monitored by colleagues experienced in the ISLE approach.

We used multiple sources of data to study the changes in student learning and in the teaching approaches of the instructors that occurred as the reforms were being implemented: student interviews, surveys, students' reports, achievements on tests, teacher evaluation rubrics, and observer notes to investigate the changes occurring throughout the year in students and instructors. In this introductory presentation we combine the findings of the other investigations to assess how well our goals were achieved. We will compare the attrition rate, class attendance and grades with previous years. We will synthesise the findings of the other investigations to provide insight into the effects of the reform. Preliminary results show that our goals were met. We were able to spark interest in the new approach and the results of the test show an increase in students’ knowledge even when it was assessed and tested in a traditional way.

Conclusion

The results of the reform are positive, and we will continue with it in the second year of studies. Hopefully, the word of mouth will reach secondary school students thinking about engineering and/or physics studies to increase the enrolment numbers.

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