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# The Challenges to Introduce Computational Physics as a Course in the Curriculum at the University Level

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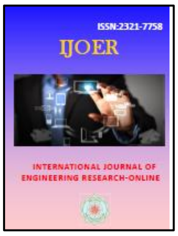


**Abstract**
This paper examines the use of computational tools and programming methods in physics instruction in beginning university courses. The challenges of using computers to solve physics problems in a scientific classroom are examined, along with strategies to help students overcome these obstacles. This essay examines these difficulties from the viewpoints of instructors and students in a physics classroom using a computer-integrated curriculum. Utilizing the two instructors' backgrounds as researchers and their deep programming expertise, the experience was implemented in two classes. The findings are primarily derived from surveys that capture educators' and students' viewpoints.

## 1.Introduction

The use of computers in instructional practices is becoming increasingly popular. According to numerous debates and agreements [1-3], incorporating programming and computing into the classroom gives students a more realistic understanding of what it means to do science and better prepares them for careers in a world where computing is a necessary component across a wide range of applications. The use of virtual platforms during the pandemic has increased interest in incorporating computers into the classroom. This investigation advances the endeavor to broaden instructors' and students' perspectives on the use of computers in university physics instruction [4].

A course's curriculum should be modified to include computational modeling as part of computational integration. Through simulation and computational modeling, students learn to program alongside science in a novel way [5-9].

University first-semester students often experience psychological stress as they learn new problem-solving approaches. From a broader perspective, various studies have identified related obstacles to teaching physics in university basic courses using computational methods. The development of algorithms and code, including syntax, semantics, structure, and stylistic applications, is the primary computational challenge in terms of a skill set [10].

Proficiency in logical-mathematical skills and some expertise in translating concepts into algorithms and code are prerequisites for using computational tools in physics education.

Because the machine offers complex remarks or categorical denials, both are challenging to learn rapidly. A large portion of studies on students' programming experiences concentrate on the difficulties they encounter. A few writers assembled research on learning challenges related to programming languages. Students are worried about understanding code, mastering syntax, variables, and error messages [11].

One crucial aspect is that teachers ensure that certain pupils succeed in their first computer experiences. If you need to understand how to communicate with the compilers and the expected messages when faults are identified in the code, it is easy to get the wrong programming on the computer.

One crucial aspect is that teachers ensure that certain pupils succeed in their first computer experiences. If you need to understand how to communicate with the compilers and the expected messages when faults are identified in the code, it is easy to get the wrong programming on the computer.

According to a recent study, computational tasks could be difficult in the classroom.

It can be difficult to learn a general-purpose programming language and then apply it to scientific modeling. They discovered that some characteristics, such as the way issues are solved and the syntactic complexity of programming languages, can be leveraged. for education[12].

Students were enthusiastic about learning computing, but the integration did not significantly improve learning until they had mastered computational tools and could apply their proficiency with specific lab tools and data analysis techniques, according to an investigation into the effects of a Python-based computational integration at the university level [13,14].

Some studies emphasized several additional advantages that computing offers for the study of physics. They focused on situations where modeling is employed and argued that calculus's computational power enables it to explore intricate real-world physics problems, highlight connections between physics concepts, and produce dynamic visual models. Furthermore, they clarified that kids who use computers are learning to use the tools scientists use, which makes studying physics more engaging.

One issue with computational modeling in physics education is that students often take a long time to become accustomed to the program [15,16].

## 2.Materials and Methods

Given the variety of data sources and the objective of examining college students' computational experiences, this work is a case study. By concentrating on students, teachers, and their viewpoints, an interpretive approach is specifically chosen.

Studies that concentrate on how individuals see and understand a phenomenon rather than the phenomenon itself benefit greatly from the analytical and interpretive approach. The goal is to examine how students anticipate using computational tools in their physics classrooms. This can be thoroughly and qualitatively explored with an interpretive case study.

The case study's reality is restricted when identifying the data sources to the both the instructor and the pupils in the classroom[17].

Student and teacher surveys focused on classroom activities and how the instructor had incorporated computers into the physics lesson. For the educational community and researchers to draw their own conclusions and develop their own ideas about the work, teachers must share their experiences.

The work was completed in the basic physics courses presented in the second semester of 2021, with a focus on the experience of the instructors of the introductory physics courses as researchers and skilled programmers. They were first instructed in the theory of physics, followed by computational exercises and MATLAB programming [18].

The task entailed creating and educating the students on a computer program that applied a random physics topic. For a demonstration to students, the initial explanation is executed accurately and without errors. For practical execution, however, the teacher presents a code with some incorrect or missing lines, which the students must fix according to the guidelines, while taking the intended result into account. The aim is that students with a foundation in the code and familiarity with previously taught physical theories will be able to fix and enhance the program's flaws so that it functions flawlessly and the necessary physical answers can be obtained.

For the two groups chosen for the study, survey protocols were created. The purpose of the questions was to find out how they felt about the physics class and the computational techniques used in it. Additionally, observations of the two groups of students working on the computational task in the classroom were noted.

**3.Results**

Students suffer stress as they learn new physics concepts and use computational techniques to solve problems. When students were proficient in theory and relevant physics concepts, computation prompted them to think about how to translate their physics knowledge into a computer language. In certain instances, this feeling was accompanied by frustration. Some students feel unprepared to take on this new teaching and learning task in physics due to stress and frustration.

It was noted that teachers were unable to give students enough time to become accustomed to a programming language in the physics course, while some students were resistant to adopting new tools for solving physics problems. Many pupils claimed that, because the computational tasks were too difficult, they would typically copy another student's code.

Programming abilities were displayed by a small percentage of students. When applying the algorithms, they demonstrated proficiency and competence in physics problem-solving. There was more to these exercises than merely understanding physics. It was about developing new abilities and showcasing the pupils' inventiveness. Since not all physics concepts are adaptable, computer programs are used to solve problems.

The work was carried out with a group of students in the physics major. Mechanics practical with 13 students as the first group, and another group with an electromagnetism activity with 9 students. The previous results are shown in Tables 1 and 2. The methodological procedure was the same in both groups.

**Table 1.** Results of the survey-interview of the group with the activity of mechanical physics.

| No. of Students | Activity |
|---|---|
| 3 | • They accepted the challenge of programming to find the solutions |
| 3 | • Interested in learning a programming language |
| 2 | • Generated additional stress |
| 1 | • They were not interested in incorporating programming into their physics learning |
| 4 | • They tried, but were frustrated by not achieving results in the expected time |

For the 23 mechanical engineering students evaluated on the use of programming in the simulation of problems in electromagnetism, the assessment tool results are shown in Table 2.

**Table 2**. Results of the survey interview in the electromagnetism activity group.

| No. of Students | Activity |
|---|---|
| 3 | • They accepted the challenge of programming to find the solutions |
| 3 | • Interested in learning a programming language |
| 1 | • Generated additional stress |
| 1 | • They were not interested in incorporating programming into their physics learning |
| 1 | • They tried, but were frustrated by not achieving results in the expected time |

The teacher has research and programming experience in both situations. Gaining proficiency in programming is similar to learning a new language. Students can investigate issues and create code with the right help or computational experience. experience that will surely influence his future career.

The programming's ability to make you forget that the issue was physics was another recurring theme in the polls. To improve their computer skills, some students stopped thinking about physics, which led to feelings of inadequacy in both computing and physics.

Programming is challenging, especially when utilized in the teaching-learning process of physics, according to several students who reported feeling stressed and frustrated. Interpreting codes and faults during program compilation is typically the source of stress. This has been documented previously with kids using Python to learn physics [19].

**Interpretations of Implementation**

Students demonstrated motivation and personally experienced it in surveys. For instance, they claimed that the goal was to improve her understanding of programming concepts, enabling her to recognize the relationship between equations and real-world phenomena. A few students discussed the advantages of computing, highlighting the strengthening and visualization of physics concepts as one of those advantages. Others shared a similar viewpoint: learning physics principles can be achieved by translating thoughts into code. Some talked about the advantages of working with code, while others talked about how writing code helped shape them. Some students proved to themselves that they recognized the importance of carefully translating physical equations into computer code and incorporating software feedback. This made it possible for individuals to engage in the exercises in a way that they believed improved their understanding of physics.

**4.Discussion**

According to student surveys, integrating computing into physics classes raised several additional issues. Some were directly related to the programming language, compilers, program execution, code interpretation, and solution creation.

It is common for obstacles to arise when introducing the computational level of learning to solve physics problems, particularly around the additional skills students must acquire, such as computational knowledge and programming components, including syntax, semantics, and algorithms.

Conceptual knowledge of physics, creating pseudocode, computational thinking, making connections between physics, mathematics, and computers, comprehending the use of computation beyond analytical problem resolution, and learning programming were all relevant abilities. How to annotate your code. Numerous researchers

Self-taught programmers interviewed for this study further support the idea that physics courses should incorporate these abilities.

Additionally, students were anxious when coding solutions and connecting them as parameters and functions, which often led them to view this as an issue.

They also fear that it takes a lot of time and effort to find and fix them.

Understanding the syntax of surveys and how it relates to error messages and solutions is a topic that is frequently discussed. Unless they have taken a programming or simulation course before, students lack these new abilities.

Some pupils can develop an interest in physics through computing. Computational programming provides a chance to develop a more genuine connection with physics, according to classroom professors.

**5.Conclusions**

- This article discusses the difficulties faced by physics students in an introductory physics course taught with computational tools.
- The main feelings before the change in attention to physics problems were stress and frustration, demotivation toward the physical subject, and difficulties in elaborating, implementing, and interpreting numerical solutions.
- Observations were also found between students.
- Descriptions, the teacher's delivery, and student interest.
- It is necessary that physics students understand the need to integrate computing across a significant portion of the curriculum, as industry demands the use of digital tools for the development of automated systems with scientific applications.

**6.Suggestions**

- Although this study is a first step, more research is required to understand the challenges students encounter and to determine how to help them achieve the goals of teaching physics courses in different ways using computational tools.
- There is a need for further exploration, particularly of how the integration of computing into physics unfolds and how the difficulties and frustrations of learning a new programming tool affect students.

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