A Literature Review of the Role of Technology in Education

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The role of technology in education is a topic that has been hotly discussed over the course of the past twenty years. The rise of powerful personal computers have introduced the possibility of integrating computer simulations and learning tools into the core of educational planning. One area in particular that has shown a high potential to benefit from the use of computing is the teaching of physics. Many core concepts in the world of physical science are confusing or invisible, making them difficult to explain, and at times impossible to demonstrate. My research question, "What impact does hands-on programming of physics problems have on the comprehension level of college students?" is directly related to this area of research. The following is a brief literature review that focuses on two key sub-areas.

The first of these is how programming can be taught to audiences of varying ages. This is important because a key part of my research question involves using programming to learn physics, and therefore programming environments in an educational context. A similarity found in current and past research [1]–[3] is that there are a few characteristics that researchers found valuable for a programming environment: a low skill floor and a high skill ceiling, "tinkerability" (making it easy to play around with ideas and try new things), and user-friendliness. All three of the aforementioned papers in this area conducted their surveys in school environments with at least 50 students spread across a number of class rooms. The data that was collected came through a mixture of video footage recorded of students using the software [1], and surveys that allowed both students and teachers to report on their feelings about the software and their learning [1][2][3]. The goal of these papers was primarily to examine the efficacy of the tested software to teach programming concepts to new users. Consistently, it was found that through the application of the above three characteristics, alongside careful researcher and teacher supervision, students were able to rapidly learn new programming concepts and apply them in projects.

The second sub-area of research is how simulations and computers impact students' ability to learn physics in school, as well as the general value of hands-on activities (as using a simulation could easily be seen as hands-on). Holstermann et al. [4] and Wang [5] used questionnaires that queried student interest to compare hands-on activities with traditional instructional classes. It was found that students rated their interest in the scientific topics that they were learning considerably higher when they had worked in a hands-on environment. This gives some credibility to the idea that learning through implementing physics into a simulation is superior to a purely academic learning method.

There has also been work done to investigate specifically how physics learning is enhanced through simulation. A common method of data collection is the idea of giving students the same test before and after they engaged in simulation-driven learning [6] [7]. The researchers in these studies argued that this method allowed them to gauge the degree to which students had improved their understanding of core physical concepts after working with them in a simulated environment. The results from these tests provided overwhelming evidence that students' comprehension improved in the post-tests when they used simulations, especially compared to students that learned through traditional methods. An interesting consideration was found in [8]; asking students to evaluate not only their own perceived development and learning, but also the quality of their group collaboration while working with simulations. The researchers found no significant difference between individual and group reporting, however, and so it seems as though group work is not impacted in a significantly different way by the use of computers.

One important concept in this field is Intelligent Tutoring Systems (ITS) [9]. Such systems already exist in teaching, and are used to personally aid students based on their perceived weaknesses through algorithms. In Myneni et al. [9] a variety of methods are presented to enhance the ability of students to learn through digital means, as well as some ways to provide feedback and support that the researchers found valuable. The researchers found that using an ITS allowed them to more effectively remediate misconceptions with physical problems, and that the gains in learning were directly correlated to the number of problems solved within the ITS.

Other papers [10] [11] [12] discuss in detail how a key concept in applying simulations is giving students the freedom and ability to experiment and form hypotheses. The general consensus was that being able to generate, test, and evaluate ideas quickly was extremely beneficial to learning, and was a major advantage over traditional means. Many physical concepts cannot be demonstrated in a classroom (or anywhere), but in a simulation graphics can be used to clearly show students how changes they make to variables in equations affect other parts of the simulation, such as forces or tension.

A notable outstanding question is, “What changes when students create all or part of the simulation themselves?” Every study conducted used pre-existing (or custom-made) software that was taught to the students. The core of my research question is if there are benefits to be gained by having students implement the core physical formulae into the simulation themselves. The papers that I have read unanimously support the idea that using computers is beneficial, and that rapidly teaching programming concepts is feasible (even at a young age). The natural conclusion is to see how these two concepts fit together.

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