Research Agenda for Computer Science Education

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Abstract

This study investigates the extent and comprehensiveness of research on computer science education (CSE). Initially, we in order to distinguish CSE research from other forms of educational research, it is imperative to clearly define its objectives and showcase its distinctiveness as a field of study. When evaluating the current state of CSE research, we strive to categorize past discoveries into overarching themes, considering the diverse advancements that have been implemented in the field over time. In addition, we assess each category by taking into account the prospective benefits and drawbacks. On the contrary, we argue that past investigations have overlooked educational theory. Consequently, teachers lack the "pedagogical content knowledge" required to comprehensively grasp the cognitive and instructional challenges that students encounter while learning. Finally, we emphasize the key topics that warrant more investigation in future research on computer science education (CSE).

Keywords: POP-I.B. programmer education POP-V.B. literature review POP-VI.D. Computer Science Education Research

Introduction

An analysis of the existing body of research on computer science education (CSE) reveals that the majority of studies have concentrated on a limited number of broad yet specific topics, including computer-assisted learning, tool development, and course outlines. Conversely, there exists a substantial body of literature concerning the pedagogy of well-established scientific disciplines such as physics and chemistry in educational institutions. A comprehensive scholarly investigation has been carried out on a wide range of difficulties pertaining to the instruction and acquisition of diverse subjects. Furthermore, each issue has a substantial body of pedagogical research that is directly relevant to it. Many computer science teachers lack formal education in the field of education. As a result, computer science education generally prioritizes technology above the study of computer science teaching methods or pedagogy. The objective of this study is to categorize the literature in the field of computer science and identify key subjects that, if enhanced, would facilitate future research and enable

the development of new instructional techniques and resources to enhance computer science education.

What is CSE?

The academic study of computers is a constantly evolving and dynamic field. The scientific studies pertaining to the teaching and learning processes in many fields of study are considerably more varied. Although the objective of this study is not to provide a novel definition of research in computer science education, it is essential to establish certain fundamental principles for future discussions in this field. Acquaintance with the fundamental components of the subject.

Computer science - a diverse and developing discipline

The very phrase "computer science" could be problematic. Furthermore, information science and informatics are both acceptable terms to use. Different languages, nations, universities, research groups, and occupations all have different understandings of these phrases right now. To provide a complete and exhaustive definition of computer science, it may be necessary to combine all scientific fields that focus on digital or electronic data processing and storage. Someone thinks this idea is too broad and wants it broken down into its own field of study. Computer science and informatics, in particular, could be reformulated as scientific disciplines that study the nitty-gritty of building and developing computer systems, with psychology and sociology dealing with the social and organizational aspects of computer use as separate areas of study.

In addition to the aspects already described, our research agenda covers a wide range of connected topics, including media, communication, mathematical modeling, information copyright law, and more. Although this work takes a more accepting approach, the focus will be on what makes computer science a scientific or academic field rather than on any one skill in particular.

The term "computer science" itself may present certain challenges. Moreover, both information science and informatics are deemed suitable terminology to utilize. Currently, there are varying interpretations of these terms among different languages, nations, universities, research organizations, and professions. In order to offer a comprehensive and thorough definition of computer science, it may be essential to integrate all scientific disciplines that concentrate on the processing and storage of digital or electronic data. An individual believes that this concept is excessively general and advocates for its subdivision into a distinct area of academic inquiry. Computer

science and informatics can be defined as scientific fields that focus on the intricate processes involved in constructing and advancing computer systems. Meanwhile, psychology and sociology explore the social and organizational dimensions of computer usage as distinct areas of research. Furthermore, our study agenda encompasses other interconnected subjects, such as media, communication, mathematical modeling, information copyright law, and other related areas. While adopting a more inclusive perspective, this study will primarily examine the characteristics that classify computer science as a scientific or academic discipline, rather than emphasizing any one talent.

What CSE is not

Significant progress is being made in the field of computer-assisted instruction, which is being studied in academic institutions all around the world. By identifying sociology, computer science, and education as subjects that have made substantial contributions to this expansion, Boyd-Barrett and Scanlon (1990) and Oettinger (1969) have recognized the importance of these fields. We intend to differentiate this profession from computer science education (CSE) due to the fact that its principal focus is on using technology as a way of instructing and comprehending courses that are not related to computer science. Technical education and theoretical academic study are the two basic streams that make up the majority of the computer science education system. Within the scope of this investigation, the topic of computer science education and learning is approached from an academic position.

Subject specific educational research

Numerous themes associated to the teaching and learning of scientific knowledge in educational institutions have been the subject of extensive historical research. This research has concentrated on the implementation of pedagogical principles by educational institutions. According to Gundem (1998), this field of research is often referred to as didactics in France, although in Germany and the Nordic countries, it has been connected with the same name because of its similarities. The term "didactic" is commonly used in English to refer to a method of instruction in which the instructor exercises authority over the pupils by means of the delivery of lectures. It is important to notice that this particular definition of didactic is distinct and distinct from the one that came before it. Starting from this point forward, our group has decided to label this vast field of investigation as educational study that is specialized to a certain subject. The academic field known as computer science education (CSE) is primarily

concerned with the investigation of educational strategies that are successful in teaching computer science.

The aim of CSE-research

When it comes to education, the fundamental objective of educational research in computer science education, just like in other fields of study, is to enhance the quality of instruction that is provided in educational institutions of higher learning. In order to determine whether or not this project was successful, it is vital to reach a consensus on the definition of an enhancement. Within the realm of pedagogical approaches, what really constitutes effective methods? When it comes to assisting students in the process of building their own knowledge, what is the most efficient method? Given the vast spectrum of individuals that participated in the research, which included academics, students, and teachers, it is not surprising that the studies that were carried out with the intention of addressing these problems produced a variety of results.

Pedagogical content knowledge

Without a doubt, a competent educator is required to have a substantial amount of information in their area of specialty; yet, this alone is not adequate. The authors Gess-Newsome and Lederman (1999) contend that teachers are required to have understanding of pedagogical content materials. "Educators should possess extensive knowledge and expertise not only in their specific subject area, but also in other relevant fields." People need to empathize with the viewpoints of individuals who are directly involved in order to have a complete understanding of the situation, its potential for misinterpretation, and the aspects that lead to a precise comprehension. A statement was made by Laurillard in the year 1993.The major objective of educational research should not be to endorse effective teaching methods, despite the fact that it can provide helpful guidance for other practitioners. Instead, the objective should be to classify the several approaches that students take in order to either accept or reject the topic. It is absolutely necessary to have a full understanding of epistemology, general pedagogical theory, and one's particular area of competence in order to be able to answer the common questions of who, what, how, and why in an appropriate manner. What are the topics that we believe to be the most important for this class, what are the reasons that justify its inclusion as a required component of the curriculum, and what are some ways that we might make it easier for students to discover the material that is useful to them? When it comes to answering the other three questions, the "who-for" question is extremely important because it gives

background information. Don't forget to take into consideration these questions and the responses that relate to them. Knowledge of this subject is absolutely necessary for all individuals who are involved in the field of education, particularly those who are in positions of authority in the legislative and academic spheres.

The Identity of CSE as a Research Discipline

Ferguson (1971) made a comment on the technological improvements that occurred in the 1970s. He stated that although computer science education appeared to be an academic field, it did not have a distinct discipline or conceptual framework to guide its work (Lewis, 1999a). In light of this, what is the one thing that all of the studies that are conducted in the field of computer science and engineering have everything in common? In this context, we will illustrate that the conventional barriers that exist inside a particular academic subject are of no consequence. This is because there is an abundance of relevant research approaches and various academic links to other domains that have been established for a long time. Putting it another way, the common goal acts as the unifying factor that brings together the several subfields that make up the field. Computer science education (CSE) study is a specialized academic discipline that focuses on giving computer science professors and instructors with the essential material to become highly versed in the subject matter from a pedagogical aspect.

"State of the Art" in CSE

In the subject of computer science education, there is a substantial lack of citations to earlier research, findings, or theoretical frameworks in articles that have been published within the last twenty years, in comparison to those that have been published within the last five years. By highlighting the importance of a shared identity and framework, these findings highlight the necessity of establishing a solid foundation for future study in the field of computer science education. The purpose of this document is to provide a comprehensive list of article categories that are associated with research in the field of computer science education. In addition to this, we evaluate the impact that each region has on the competition. The results of our work have made it possible for us to provide categories that are substantially more thorough, which we believe will significantly improve and improve the field as a whole.

New, untested ideas

Several publications that have been published in recent times have provided unique ideas on education, which is laudable because it stimulates dialog. When it comes to

the usefulness of these principles, however, these publications do not currently possess any empirical proof to support their claims. Program designs, pedagogical methods that are not dependent on implementation, and mathematical abstractions are some examples of teaching programming (Soloway, 1985; Elenbogen & O'Kennon, 1988; Ford, 1984). Other examples include teaching programming using program designs. The basic principles that were proposed are expanded upon by subsequent research, particularly when other academics assess and contrast traditional and contemporary techniques. Several of the articles that go under this category also offer information regarding new educational programs that are either in the preliminary phases of development or serve as a basic model for education. These programs, in particular, promise to have intellect on par with that of humans. Following the resolution of difficult implementation difficulties, these articles provide strategies that can be used to improve the teaching about computer science. It is possible that teachers will not instantly see the results of this work; however, the advice that it provides and the motivation that it inspires can be highly valuable.

Reports from the trenches

The manner in which the course is presented has been altered as a result of their own intuition or the recommendations made by their colleagues. The evaluation of the effects of this modification is conducted in a conference paper by analyzing the comments made by the students, the evaluation made by the lecturer, and occasionally the results of the final examination (Carbone & Kaasbøll, 1998). For the purpose of improving the delivery of a particular course, the information and ideas that are offered in these papers are critically important. When it comes to the development of computer science courses, the sharing of ideas and practices is absolutely necessary. There are a few of these studies that make reference to educational philosophy; nevertheless, the majority of them are primarily founded on robust computer science theory (Allen et al., 1996; Bauer, 1979; Berglund & Daniels, 1997; Dietrich & Urban, 1996; Koffman & Wolz, 1999; Smith & Rickman, 1976). The issues that were brought forward in 1996 were adequately addressed and resolved in 1976. It should come as no surprise that evaluating these kinds of classes by empirical methods is fraught with difficulties. The implementation of these tactics would be unethical, would put students at a disadvantage in one class, and would increase the cost of simultaneously holding two courses for the sole purpose of comparing the results of the two classes. In the process of doing a comparison analysis over a number of years, it becomes

difficult, if not impossible, to determine the influence of specific additions due to the large variety of adjustments that are incorporated into the courses. Furthermore, a number of publications assert that their methodology exemplifies the very best of what students are capable of as individuals. The majority of these efforts have relied on subjective observations and arguments that are effective for initiating discussions but lack substantial impact. Although some attempts have been made to provide evidence for similar assertions in certain instances (Clark, 2000; Koelling & Rosenberg, 1996; Meertens, 1981), the majority of these efforts have relied on these. The authors of articles that are exhibited at the annual conferences of SIGCSE and ITiCSE frequently draw from their own personal teaching experiences. This is especially true for those articles that are written by practitioners in the field of computer science education. A great number of people have experienced difficulties during their first semesters of school, either as a consequence of low performance rates or substantial rates of failure and dropout.

Discussion of theory

In addition, there are publications that contain references to constructivism (Ben-Ari, 1998; Hadjerrouit, 1998) and theories of natural language learning (Murnane, 1993). It is unfortunate that, despite the fact that these references are typically cited in the beginning sections of the publication, the results of the study are rarely analyzed in conjunction with these supplemental or connected theories in the latter sections of the article. Nevertheless, the fascinating aspects of this research are the debates that they start and the conclusions that they arrive to. In addition to laying the groundwork for empirical research that may test and investigate the theories, they also build the framework for the relevance of these theories to the field of computer science education.

Computer Aided Learning & Intelligent systems

Murnane (1993), Ben-Ari (1998), and Hadjerrouit (1998) are three examples of scholarly articles that have documented the theories of constructivism and natural language acquisition, respectively. It is regrettable that the subsequent sections of the article rarely discuss the findings of the study in conjunction with these extra or interconnected theories, despite the fact that it is normal practice to offer these references at the beginning of the publication. Nevertheless, the intellectual discourse that it generates and the significant discoveries that it brings about are the things that truly interest audiences. They lay the groundwork for empirical research to test and

investigate the theories, as well as establish the framework for the application of these theories to computer science education. In addition, they establish the framework for those theories.

Expert/Novice differences

Extensive research (for example, Batra and Antony, 1994; Kahney, 1983; Soloway and Spohrer, 1986; Wiedenbeck, 1985) has been conducted with the purpose of defining the many approaches that professionals and students in the field of computer science employ in order to solve issues and visualise tasks. The purpose of these research is to establish a benchmark for assessing the performance of novices and to provide insightful information regarding the differences between professionals and novices. When it comes to the pedagogy of teachers, this kind of data is really necessary.

Empirical Studies

Furthermore, a considerable compilation of empirical research has been gathered, which includes the investigation of particular programming phenomena, the analysis of student code, and the conduct of interviews with students who have a particular issue. (McIver, 2000) has pointed out that certain groups of students have been the focus of research. Eisenstadt and Lewis (1992), Putnam et al. (1986), and Van Someren (1985) are only a few examples of researchers who have undertaken research on these groups. A further illustration of this is the case of individuals who are in the process of becoming proficient in a new programming language. There are also scholars who focus their attention on certain aspects of programming, such as the errors that students make when programming (Pea, 1986; Soloway & Spohrer, 1986), the constructions that are taught (George, 1996; Good, 1999), and conditional statements (Sime, Green, & Guest, 1973). Additional study has been carried out by a number of scholars, including Booth (1992), Bhuiyan (1992), Brooks (1999), Holmboe (2000), Petre and Blackwell (1999), and others, with the purpose of determining the cognitive frameworks or individual understandings that students possess in relation to programming or systems design. By examining the responses and behaviours of students as they work through actual programming tasks, the purpose of this study is to collect data on the challenges that students face when learning to programme. The findings of this study provide a solid foundation for the development of instructional strategies and educational materials that are more beneficial to students. In order to

make progress in the field of computer science education, it is beneficial to broaden the criteria that are used to classify it.

Educational research

Subject-specific educational research is essentially different from one academic field to another (Gundem, 1998). This is because of the profound importance that subject-specific educational research has to the epistemology and content of each academic discipline. An assessment of a varied body of literature from well-established fields, including scientific education, mathematics education, and language teaching and learning, could potentially offer useful insights on the trajectory of future research in computer science education. We tackle a fascinating subject that will have a significant impact on the direction that education research takes in the future by providing a solution to the first key question about computer science education, which is why students should learn it in school. For a more specific discussion, we go over the steps involved in determining the academic field that will be covered in this particular class. According to Driver et al. (1996) and Sjøberg and Kallerud (1997), the focus of this research is on the academic concept of science and its influence on the everyday lives of the typical individual. This is the primary justification for including a particular subject in the curriculum at a particular grade level. There was a brief discussion in the part that came before this one about the idea that computer science is limited to the use of computers. Research on computer science education (CSE) has primarily focused on examining the intrinsic value of computer science as a field of study within higher education institutions (Jenkins, 1996; Millar & Osborne, 1998). This research is comparable to research that is now being conducted on scientific education. Scholarly investigations in the field of education have traditionally focused on the comprehension or lack thereof of specific subject aspects among students (Ryder et al., 1999; Sierpinska, 1994). This has been the case throughout the course of those investigations. Studies conducted by CSE researchers such as Booth (1992) and Navarro-Prieto and Catmas (1999) are two examples of studies that have investigated this subject. In light of the fact that it is of the utmost importance to provide assistance to educators in the process of obtaining pedagogical content knowledge, I hope that additional study of this kind is carried out. The influence that various epistemic theories have on the teaching and learning of particular subjects is another topic that fascinates academics who study education. When doing research on learning processes that take place outside of the classroom, it is absolutely necessary to establish a solid

theoretical framework upon which to build. Constructivist approaches (Driver et al., 1994; Glasersfeld, 1989) have been partially replaced in this area of research by sociocultural dimensions of learning and contextual learning (Anderson et al., 1996; Hennessy, 1993) (Saljo, 2000). This is because sociocultural learning and contextual learning are more important in this field of study.

Other related research areas

The methods and research issues that are addressed in subject-specific educational research are comparable to those that are addressed in other academic disciplines. Psychological theory, pedagogical theory, and epistemological theory are the three essential foundations that are utilised in the field of French didactics. In spite of this, a framework or theory that is wholly original has been developed. As stated by Gundem (1998), there are at least two significant connections that can be made between the fields of computer science and psychological research. Until now, the emphasis has been placed on the cognitive aspects of developing programming skills or comprehending computer systems, and it is important that this focus be maintained. In light of the fact that the preceding part provided an analysis of a study that is founded on solid principles of knowledge, it is reasonable to anticipate that it will incorporate findings from research that is both more extensive and more complete in the disciplines of psychology and education. There is a clear connection between the fields of computer science and psychology, which has been thoroughly proven by a considerable body of study that is frequently referred to as cognitive science. In trying to duplicate human intelligence in a computer programme, a great deal of research has been done on a variety of facets of human cognition, including the generation of knowledge and approaches to problem-solving. The development of artificial intelligence is the achievement that can be attributed to this method. The development of "intelligent" educational systems is the primary focus of study in the discipline of computer science and engineering (CSE) in this particular region, as was indicated earlier. Based on the current consensus regarding the impact of psychology research on computer science and engineering (CSE), it appears that the primary motivation behind this study is financial objectives, such as increasing productivity and decreasing the percentage of errors caused by human intervention in the computer industry. Computer science educators should participate in a broad examination of the materials available in the domains of psychology and general pedagogical theory in order to strengthen their capacity to mentor future computer scientists. This will have

the effect of enhancing their ability to mentor future computer scientists. Furthermore, improvements in subjects that are connected to computer science might be beneficial to study in the field of computer science. The human computer interface (HCI) and computer supported collaborative learning (CSCL) are two areas that have been the subject of a significant amount of investment in research. The purpose of this study is to investigate the impact that a computer interface has on the cognitive processes of persons while they are interacting with computer systems (Littleton & Light, 1999). In addition, this is a significant contribution to the field of computer science education, considering that the majority of the assignments presented in computer science classes involve the utilisation of computers in a manner that has an impact on the learning process. The current study on computers in education, which focuses on diverse techniques of integrating computer technology into teaching and learning across a variety of topic areas, is unfortunately not well related. This occurs in a substantial amount of the research. The research conducted in these two areas has a significant impact on the discipline of computer science and engineering (CSE), as well as on research conducted in other academic topics. In the event that this occurs, it could be even more prominent.

Thoughts for the future

What are/should be the main areas and methods of research in CSE?

In order for research in computer science education to be recognised as a distinct academic field, it is necessary for it to include all relevant aspects. For the purpose of fostering a collective sense of identity and inclusion within the domain, it is essential to uphold shared principles. This study is centred on the common goal of subject-specific educational research, which is to provide practitioners with assistance in acquiring knowledge regarding pedagogical topics. This study will make use of a variety of research approaches, the specific scope of which will be determined by the project's particular focus. In this study, we have established the links between subject-specific educational research and many research traditions that were previously considered to be separate. In order to make the most of the numerous resources that are available to them, professionals working in this industry need to possess a broad range of knowledge and skills that span a variety of fields. It is of the utmost importance to keep in mind the significance of Feyerabend's (1975) concept of "anything goes" in the realm of scientific inquiry. When a proposition is able to be supported by solid theoretical reasoning or empirical evidence, then it is either possible

or desirable to have that proposition. In order to make progress in the field of computer science education (CSE), it is necessary to have a more harmonious alignment with the theoretical frameworks of education-related fields including pedagogy, psychology, and curriculum studies.

Who do we expect to pursue these issues?

When it comes to learning research, educational psychology departments are typically the ones responsible for doing it, as opposed to departments that are responsible for curriculum and instruction. The researchers who specialise in these two fields do not communicate with one another as much as they should, which is a regrettable situation. Shuell's work, which was published in 1993, is the source of the citation.

Of the biggest significance is the collaboration that takes place between computer scientists and academics in fields such as educational science, psychology, and philosophy. We are able to improve and perfect the findings of earlier educational research by working together in this manner. Furthermore, we are able to adapt this knowledge to the specific challenges that we face in our respective fields. In light of the fact that the existing body of literature is mostly comprised of computer scientists reporting on their own teaching approaches, there is a need for additional researchers that specialise in computer science education (CSE). When it comes to research fields, such as science education, which are considered to be more conventional in the field of education, the majority of the workforce is comprised of scientists. One of the things that sets them apart is the significant knowledge and competence that they possess in the field of education. However, the majority of the research is based on the pedagogical methods of other educators, rather than the researchers' own practices. The area has developed into its own independent academic discipline, which has resulted in the creation of professor positions. Sometimes these posts are located within the department that they were initially assigned to, but more often than not, they are located within a school of education. All things considered, they are the epitome of the greatest degree of contemporary knowledge and experience in the field of educational content.

Conclusion

In order to improve computer science education all across the world, educators have, up until this point, created a positive environment by exchanging ideas, methods, and resources with one another. On the other hand, it seems that the field of computer science education research needs to shift its concentration in order to be successful.

For the purpose of making future research more reliable, it is absolutely necessary to carry out additional empirical research and to engage in comparative analysis. For the purpose of bolstering the statement that computer science education research is significant beyond the scope of simple academic publishing and deserves scholarly recognition, an increase in the prevalence of such studies would be beneficial.

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