Integrating Human-Centered Artificial Intelligence in Programming Practices to Reduce Teachers' Workload

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Abstract

Artificial intelligence (AI) has impacted every industry, including the education sector. In this position paper, we explore how human-centered AI (HCAI) can be integrated in programming activities in school rather than discussing the design of user interfaces of HCAI systems. Our main proposal is to integrate HCAI in educational practices to reduce teachers' workload by providing meaningful scaffolds to the learners, connecting technology and domain knowledge.

Keywords

Human-centered AI, education, programming, school, scaffolding

1. Introduction

Human-centered artificial intelligence (HCAI) has received increasing attention in recent years, including the national educational systems worldwide. The United Nations Educational, Scientific and Cultural Organization (UNESCO)'s (2022) mandate is to focus on human-centered approaches to AI– "AI for all," where everyone can take advantage of the technological revolution underway and access it. UNESCO states that the connection between AI and education involves three main areas: 1) learning with AI (e.g., the use of AI-empowered tools in classrooms), learning about AI (AI technologies and techniques), and preparing for AI (e.g., enabling citizens to better understand the potential impact of AI on human lives [14]. Here, we focus on the first approach, "learning with AI."

Although HCAI in education is an emerging field, there remains limited research. Nonetheless, Yang et al. [17] state that the research trends have brought new applications of AI in education, e.g., adoption of machine learning and new deep learning algorithms. Furthermore, AI research can potentially improve intelligent tutoring with more precise adaptation and personalization. When focusing on HCAI, the emphasis is on "learning with AI," e.g., Replika [7], a virtual friend or a chatbot companion powered by AI; Thinkster [12], a virtual math tutor built with AI to create personalized learning programs; and Cognii [2], a virtual learning assistant that engages students using conversational AI. This position paper adds to the debate along this line of research. The research questions addressed in this paper are as follows: 1) How is programming integrated in learning school subjects? and 2) How can programming take advantage of HCAI to improve learning? This paper focuses on exploring how HCAI can be integrated into programming activities in schools, not on the design of user interfaces for AI systems. We ground our position and discussion of HCAI in research as activities that stem from educational research on programming in schools.

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2. Related work

2.1. Human-centered artificial intelligence

HCAI empowers developers to build and design AI systems that support human self-efficacy, promote creativity, clarify, and distribute responsibility, and facilitate social participation [11], thus putting humans at the center of design thinking. Shneiderman [11] underscores that the goal in HCAI is to put human users at the center, emphasizing user experience design, measuring human performance, and celebrating the new powers that people have. However, this contradicts the traditional AI view where developers and researchers focus on building AI algorithms and systems for machine autonomy, measuring algorithmic performance, and celebrating what AI can do on its own. Therefore, Shneiderman [10] argues that HCAI presents three ideas that go beyond automatization: 1) the possibility of high levels of human control and high levels of automation, 2) shift from emulating humans to empowering people, and 3) governance structures for HCAI (reliable, safe, and trustworthy systems).

It is important to highlight that at the heart of HCAI is to recognize that the way intelligent systems solve problems, especially machine learning, is fundamentally alien to humans without computer science knowledge [8]. This underscores the need for future generations of pupils to learn about programming, computational thinking, and computer science to enable them to understand the algorithms underlying advanced AI systems such as deep learning and be able to interpret them effectively. Riedl [8] emphasizes that HCAI can be divided into two main aspects: 1) AI systems that understand humans from a sociocultural perspective and 2) AI systems that help humans understand themselves. In this paper, we focus on the first aspect, which is useful when discussing HCAI in the context of an educational institution. Shneiderman [10]. presents an HCAI framework using three main ideas: 1) design for high levels of human control and high levels of automation, 2) understand the situations in which full human control or full computer control are necessary, and 3) avoid the dangers of excessive human control or excessive computer control.

2.2. A sociocultural perspective on learning

In a sociocultural perspective on learning, learning is seen as context-bound, situated in socialpractices, and mediated by symbolic and cultural artifacts. Hence, this approach emphasizes participation in different social practices [9]. This paper takes on the view that learning can best be understood as social interactions mediated by artifacts; more precisely, in our case, the learning processes during programming are mediated by technological tools, resulting in social interactions between the teachers, learners, and AI chatbot. A central concept within the sociocultural perspective on learning is pedagogical scaffolding [16]. Hammond and Gibbons [3] define scaffolding as how teachers and other seniors help and support peers by providing feedback in the learning process. Maybin and colleagues [4] define scaffolding as different kinds of support the learners receive in their interaction with parents, teachers, and other mentors as they move towards new skills or concepts. A current direction in this area is automated text analysis, such as EssayCritic [6]. Another central concept in a sociocultural perspective on learning is the zone of proximal development, which is a key concept derived by Vygotsky [15] as ways in which individuals move between different stages of development and their potential learning levels.

3. Methods

The empirical data presented in this article is derived from a design-based research project [5], in which we were participant observers in a classroom that used block-based programming (MakeCode in micro:bit) as an exploratory design space for solving physics tasks assigned by the teacher. The project consists of four interventions over a 2-year period including a total of 130 pupils aged 12–16 years. The pupils met 3 hours/week for 16 weeks over 2 semesters. Data were collected using video recordings of classroom interventions. The data presented below is derived from the last intervention, fourth, where we were in a physics lab and recorded a video of a group of pupils using programming for solving physics tasks.

Thematic analysis was used to analyze the entire dataset and screen for emerging common topics. Thematic analysis is a qualitative method for identifying and organizing patterns of meanings across a dataset to enable the researcher to make sense of collective or shared meaning and experiences [1]. Examples of thematic codes that emerge when screening data are knowledge sharing, programming, computational concepts, and collaboration.

4. Findings and design scenario to include human-centered AI

In this section, we will address the research questions: 1) How is programming integrated into learning school subjects? and 2) How can programming take advantage of HCAI to improve learning? We address the research questions by presenting two different data excerpts that show how pupils work when using programming for solving physics tasks assigned by the teacher. Presenting the empirical data extract address the first part of the research question exemplifying how programming is integrated into school subjects. This is useful to provide a realistic context of how these data can be extended to integrate HCAI as a scaffold to help the learner. However, in the table where the data is presented, we have added a column named "AI chatbot," which is our design scenario, being an example of how HCAI can be integrated and connected to programming practices when using micro:bit in an educational context.

When sketching out a design scenario for how a micro:bit can be extended to include HCAI, we uncovered that there are at least two different yet relevant directions: 1) focusing on scaffolding the domain-specific knowledge learning process (in our example, physics) or 2) scaffolding learning programming and how to use the micro:bit (a third approach emphasizing collaboration is presented as direction for further work). We will present one design scenario from each to cover both directions, reflecting data extract 1 and data extract 2. Data extract 1 and 2 below derive from one physics class where the students use micro:bit for solving physics related tasks. The AI chatbot presented in the fourth column in the tables is not included per se in the study, as it is created as an add-on for suggesting a future design scenario for reflecting on how an AI chatbot can be integrated in an already existing technology used in school, the micro:bit. These data extracts derive from a research project where we developed and implemented technology rich interventions in several K-12 classrooms, consisting of pupils ranging 12-16 years old. We followed three classes (20 students in each class) over two years and videorecorded our observations in the classroom of the students when they were working in groups on using micro:bit for solving subject-specific tasks. The scenarios are based on the lessons we learned.

Table 1 below presents data extract 1 derived from a lesson in physics where four pupils are working together on a task given by the teacher on how to program and use a micro:bit to measure conductivity. The pupils are experiencing problems with the micro:bit and the code as the assembly is not working properly in connection with measuring conductivity. Two of the four pupils are discussing the problem that starts by one of them asking a question.

Table 1. Data extract 1. Pupils using micro:bit to measure conductivity.

Line	Participant	Verbal utterance (comments in parenthesis)	AI chatbot
1	Student 1	"Shall we see on the micro:bit. It looks like that." (Looks at the code on the screen)	*What are you working on now?*
2	Student 2	"Yes. Because the number is there." (pointing to the micro:bit) "I think that's correct."	
3	Student 1	"Okay."	
4	Student 2	"We can try it here again." (Connects the wires and measures conductivity)	*Are you having trouble with how to connect pin1 and pin2 to the micro:bit? Type yes, if you need help.*
5	Student 1	"Ok. Fine now! (Does it work?)"	
6	Student 2	"But it shows that the air conducts electricity?"	*Are you still having a problem with connecting pin1 and pin2 to the micro:bit?*

			I can see you have also connected a resistor, is the resistance correct?
7	Student 1	"Okay, then we'll see if we have connected something wrong (with the micro:bit)."	
8	Student 2	(Checks the wires) "Okay, the wires are connected properly to the micro:bit, but what's weird is to be seen here!" (Holds the pins up in the air and micro:bit shows that it conducts electricity)	*Have you checked that the wires are connected?*
9	Student 1	"Maybe the air does conduct electricity then."	
10	Student 2	"No!" (Frustrated) "If the current had moved through then you would have seen it. Then it would have jumped lightning and you would have heard it."	
11	Student 1	(Looking at the code for the micro:bit) "Press B for conductivity and A for resistance ..., but there is something wrong here … . Look here. I did not hold them close to each other and the micro:bit shows 0.001! And it is physically impossible."	*I will help you solve the problem. I will give you a list of possible solutions – type yes to the solution that you have tested.*

Table 2 presents data extract 2, where the pupils are discussing how to use micro:bit to test conductivity on different objects.

Table 2: Data extract 2: Using micro:bit to test conductivity on different objects

Line	Participant	Verbal utterance (comments in parenthesis)	AI chatbot
1	Student 3	"All the measures get the result of 0,001." (Using the micro:bit to measure the conductivity on his own finger)	*Greetings, what are you using the micro:bit for today?*
2	Student 4	"I'm not holding them (the pins on the micro:bit that measures conductivity) to anything, and the micro:bit shows 0.001, and it's physically impossible. Okay, then we have to find out what happened." (Using the micro:bit to measure the conductivity in the air)	*Right now, you are not measuring Conductivity in the air, I can feel that I am not connected to anything with pin 1 and pin2. Please plug the pins to the object you are going to measure conductivity through, and I will give you the answer.*
3	Student 3	"It probably has something to do with the fact that there are salts (sodium compounds) and minerals that conducts electricity relatively good." (Measures the conductivity of Farris (mineral water)	*What are you measuring the conductivity of now?*
4	Student 4	"We can look at the nutritional content and ingredient list of Cola and Pepsi afterward to see if there are any differences." (Measures the conductivity of Pepsi and Cola)	
7	Student 3	"What do we think? Do we think the orange juice or lemon has the highest conductivity?" (Measures conductivity of a lemon)	
8	Student 4	"Acids have pretty good conductivity I have heard."	

5. Discussion and conclusions: Implications for future design

The main argument in this position paper is that integrating HCAI in education has a significant potential to reduce teachers' workload. As shown above, we present two data extracts regarding how programming is practiced in schools in our country, and we extended our view of learning by adding a column describing a design scenario concerning how an AI chatbot can scaffold these learning processes. The AI chatbot integrated into the micro:bit can be interacted with in two ways: 1) requesting the chatbot directly in the chat window (top-down invocation) or 2) it infers the need for scaffolding based on the learner's actions and what the learner says (bottom-up invocation). When the computer is connected to the micro:bit, the chatbot uses the microphone on the computer, listens to the conversations, and tries to suggest scaffolds connected to what the learners are talking about.

However, as we can read out from extract 1 (Table 1) and extract 2 (Table 2) the AI chatbot interacts in a multi-user context, which impacts how the AI chatbot reacts. In extract 1 and 2 we have group collaboration as a premise, meaning several students are working together to create the code, however, there is only one student that interacts with the computer and creates the program. This implies that there is only one student that directly interacts with the AI chatbot during this time. However, it is important to reflect upon how one can design a chatbot that also takes the interaction among several interacting pupils into consideration. Can a future design scenario be that the AI chatbot can take questions from different pupils at the same time into consideration? It would be useful with an interactive AI chatbot that also can handle social interaction in groups. Recent research on chatbots shows that a role for a chatbot could be to encourage non-active pupils to be more active, engaging them in the discussions with peers and with the chatbot, helping students to become better collaborators, identified as an important 21st century skill [13].

Another interesting reflection around a future design issue with the AI chatbot is to examine how it can take advantage of context-awareness. A context aware chatbot must seek to understand and support the aims of the user. In our case, in extract 1 and 2, which is a programming context, it quite essential that the AI chatbot can be aware of this context to be able to support the pupils in their specific learning activity. This means that the AI chatbot should have some built in mechanism for adaptive learning that enable to learn over time through interaction pupils of different need and background knowledge. The IA chatbot we have profiled is a programming expert with the aim of scaffolding pupils in K-12/lower and upper secondary school when learning programming.

Summing up, the research contribution with this position paper is discussing a scaffolding scenario for using an integrated chatbot in the online micro:bit programming environment for pupils to learn together how to use a new technology in an educational context from the challenging position of relating the technology to domain knowledge (e.g., middle school physics as we have profiled here).

It is interesting to reflect on the impacts of HCAI on both learners and teachers. For instance, learners get faster and instant feedback, with a greater chance of receiving more accurate answers. There are several benefits of integrating HCAI into programming processes in schools, such as reducing teachers' workload and enabling a more flexible and accessible teaching experience to students. However, one of the most important challenges with creating an AI chatbot is providing it with accurate context to enable effective interaction with the learners. As seen in previous research, scaffolding pupils is not easy due to many complex factors that may impact the learning process. In conclusion, the main findings in this paper are as follows:

- An AI chatbot can provide meaningful scaffolds to pupils when learning to program
- Exploring HCAI from a sociocultural perspective on learning leads to interesting aspects of how HCAI can be designed as scaffolds in an educational context, e.g., classrooms.
- Integrating HCAI in the educational context can reduce teachers' workload.

Future research regarding how an AI chatbot could be designed and implemented into the micro:bit environment is warranted. Integrating HCAI in education, especially as an approach to "learning with AI," has great potential to reduce teachers' workload in classroom settings.

6. References

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