Designing Integrated Development Environments to Support Students with ADHD

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Abstract

Accessibility in education is a consideration whose importance cannot be understated, especially in such important fields like computer science. While we are in a time where technology develops at a rapid pace and our programming education works to keep up with the pace of industry, we must ensure students with disabilities are not left behind. This paper will discuss how students with Attention Deficit Hyperactivity Disorder can benefit from better design of Integrated Development Environments and how by creating a more inclusive and usable digital ecosystem, students will be able to better engage in programming education and as a result the wider computer science curriculum with the absence of barriers in one of it's major topics. The paper outlines a research through design approach to the work, involving think aloud and co-design as core components of identifying and understanding design considerations and discusses the work done so far.

Keywords

HCI, Integrated Development Environment, computer science education, ADHD, digital accessibility

1. Introduction

Accessibility is one of the core challenges for education today. Students with disabilities face numerous barriers and challenges when taking part in learning [1], especially students with Attention Deficit Hyperactivity Disorder (ADHD) [2].

While there are many aspects of education that might be in need of more support for students with ADHD, this work takes a focus on learning to program which forms a key part of the computer science curriculum, specifically how accessibility of Integrated Development Environments (IDEs) impacts ability to engage with learning. Despite the promise already shown by making better use of assistive technology in education for students with ADHD [3, 4, 5] there is a lack of knowledge around how it should be used and designed, and who the support would be applicable for [6, 7, 8] with little work done around learning to code. This work intends to address this gap and better understand how assistive technology and principles of digital accessibility can be applied to IDE design for students with ADHD.

The literature demonstrates much variation in understanding around ADHD. Current diagnostic criteria [9, 10] conform to stereotypes around ADHD, such as the condition primarily being an inability to focus and having bouts of hyperactivity [11]. The exclusive use of the diagnostic criteria to define ADHD in some academic research [12] means that the research may not possess a full understanding of ADHD. However, these criteria are not universally accepted; even as far back as 1997 the diagnostic criteria have been scrutinised and questioned [13]. Despite this, the current criteria still holds many of the descriptions that have been condemned by researchers such as how to reliably detect symptoms in multiple settings and their failure to adequately associate ADHD with issues of executive function [13, 14], which could potentially lead to biased research without an alternative reference for researchers to use. This unwillingness to change perceptions is a major motivator for this work; to prove that by working with a fuller understanding and view, a positive difference can be made to the educational experience of students with ADHD. To help develop this understanding, this research makes use of the extensive work of Barkley [14] around better understanding the condition, in combination with planned studies as part of this research to better understand the in-situation impact of ADHD.

In this research we intend to address the barriers impacting students and to demonstrate a realistic and appropriate kind of support for students with ADHD when learning to code. This PhD will show what tools and design approaches can most benefit students with ADHD while following a research through design approach to create a prototype tool alongside a cohesive and flexible framework of requirements that other user facing systems could follow and evaluating how IDEs can best support students.

2. Key work

Research has shown how a reduction of barriers can impact student motivation. Svensson et al. [15] find when barriers impacting students with disabilities are reduced, not only does this improve their ability to engage with content, it also has the effect of improving their overall motivation to engage with their learning. This is a particularly pertinent observation for supporting students with ADHD due to the barrier they face of difficulty around self-motivation [14]. By understanding the impact IDEs have on ability to engage with learning, it could help address these issues to allow students with ADHD to more meaningfully engage.

Buidling on the work of Svensson et al. [15], recent work has also begun to look at the impact of IDE design on users. The work of Kasatskii et al. [16] highlights how aspects of the user interface design can impact software developers with ADHD. The work focuses on the efficiency of workers in industry but has interesting applications around how perceptual loads impact can have a varying effect on users with ADHD. The work also takes an interesting approach of using an executive function scale as part of the methodology to help identify certain symptoms of ADHD. This work establishes the impact of IDE interface design on the user, though leaves room to explore details beyond just perceptual load and also allows for work to examine the impact of design in an education setting rather than industry, a point

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strengthened by work which highlights the benefit experienced by students with ADHD when receiving appropriate technology based support [4].

Another important area of work is how we design digital tools for people with ADHD as shown by Sonne et al. [17]. In this work it is highlighted that little work has been done into creating meaningful design guidelines for people with ADHD. While this work makes a significant contribution in laying a foundation for such guidance to be built on, it is heavily routed in the Diagnostic and statistical manual of mental diseases criteria for ADHD [10] and is also primarily approaching the issue from a medical model perspective [18]. The work is incredibly useful in how it highlights the different areas of support and uses examples of technology that can be helpful and the aspects of their design which work for people with ADHD. The work primarily contributes an understanding of what tools are useful for people with ADHD with some focus on design considerations, but leaves a gap in regards to expanding on the work, including in the specific context of IDEs. The design considerations in this work also work well as they give consideration beyond the simple access consideration of accessibility which is often not considered for users with ADHD [8].

One other area of current research is around the benefits of Universal Design for Learning (UDL) and how it can help students with disabilities overcome barriers that would otherwise drastically reduce their ability to participate in education. Cumming et al. [19] highlight the need to follow the major principles of UDL developed by the Centre for Applied Special Technology (CAST) including the major theme of providing multiple means of engagement in learning for students to be able to best engage with content [20]. This is further emphasised by Weis et al. [7] and the understanding that simply deploying standard accommodations to support students is often not enough and there needs to be dynamic and adaptable support in place that can be tailored to the individual. The reason for this is that support that is not relevant or beneficial to an individual can actually become an additional barrier rather than a means of overcoming the original barrier which may still be affecting the student [21]. An example of an accommodation that conforms with universal design would be text captions on videos or lecture recordings, as it makes the base medium more accessible without requiring an additional tool or process for someone to access the content.

3. Specific objectives, goals and questions

The aim of this research is to understand the impact IDE design has on learning and propose new design considerations to better support students with ADHD in their learning. My primary question is "What impact does the design of integrated development environments have on students with ADHD learning to code?" with the following sub-questions:

1. **In what ways does interface design impact usability for users with ADHD?** This question will explore how the current design of user interfaces in user facing software impacts users with ADHD. For this research the work will be focusing on IDEs though there will be lessons that could be applied to other contexts. This will compliment existing guidelines on accessibility and usability [22, 23].

2. **How well do IDEs conform to principles of digital accessibility and usability?** This question will explore the current design principles that are observed in the IDE interface and comparing them with existing accessibility standards for other contexts and use cases. This will again draw on existing guidelines [22, 23] to help create a standard IDEs can be compared against. By examining the accessibility of IDE it allows the research to understand them from a more generic standpoint in addition to the more specific context of ADHD.

3. **How can plugins facilitate individualised user experience for students with ADHD in IDEs?** This question will explore the ways in which plugins currently facilitate an individual user experience when using an IDE and also how a new plugin might be able to specifically help users with ADHD when learning how to code. The reason it is important to consider the application of a plug in approach is to allow for adaptability and for tools to be personalised for students with ADHD and their individual strengths and weaknesses.

4. **How can IDE accessibility impact the engagement and learning activities of students with ADHD?** This question will explore the impact IDEs have on the engagement with learning of students. The intent is to answer this question by comparing the impact of different IDEs on student learning and how easy it is to engage with content when learning to code. Examining engagement is important due to coding being an important part of computing education and by ensuring the topic does not become a barrier it can facilitate better engagement in the wider subject of computer science.

These sub questions will all help to answer the overall primary question and give a holistic view on how creating accessible user interfaces for people with ADHD can improve learning to programme with an understanding of each aspect of learning and design.

4. Research approach, methods and rationale

The research can be divided into four primary phases; Understanding design issues, Gathering requirements, Prototype design, and evaluation. At each phase I will be using principles of constructive alignment, which is an approach focusing on "emphasising the alignment between the intended learning outcomes (ILOs), TLAs [teaching and learning activities] and assessment tasks (ATs)" [24]. Another key factor that I will consider is the incorporation of accessibility from the start of the process, as shown by Dolan et al. [25] who demonstrates that trying to ensure accessibility as an afterthought often leads to a flawed implementation, and difficulties in making the most of the intended functionality.

Throughout the project the research will keep the following principle in mind; How can IDEs be designed to be more accessible as standard? This principle is most relevant in relation to research question 2 due to the importance of ensuring that the tools we design are keeping more than just ADHD in mind. This is because not only should user interfaces be designed in a way that is accessible to all, regardless of intended audience, it is also important to consider the impact of co-morbidity. ADHD has a high rate of being present alongside other conditions that can impact someone's accessibility needs [26]. This rate of co-morbidity means that any support for ADHD must keep in mind the likelihood that there will be additional accessibility barriers to the student. Therefore, it can be a pointless exercise in creating a tool

that can support aspects of ADHD but becomes detrimental to other impacting factors. The question of overall accessibility would be best addressed again using principles of universal design [20] to ensure that the prototype would be accessible regardless of additional conditions. The high rates of co-morbidity in ADHD also makes it an excellent case study for designing accessible tools due to the need to often accommodate multiple types of needs.

4.1. Understanding current user experience

The first phase of my research is to **conduct a think aloud study with computing students with ADHD** to help give insight into the user experience of students with ADHD learning to code in IDEs with VS Code serving as a case study. The study will be conducted in order to discover what challenges and advantages students with ADHD experience when using these applications, and how they feel ADHD impacts this experience. The study will also gain an understanding of the students experience more generally outside of the study. These results will give a more informative view of what challenges need to be addressed. This initial phase relates to the first research question around developing an informed understanding of the current user experience which will underpin the research going forward.

4.2. Gathering requirements

The second phase will involve **co-design sessions with students with ADHD** to get input from them on design, while also being an opportunity to understand approaches to the barriers they face from their own perspective. The co-design session will be beneficial as it will add to the knowledge gained from the previous stage to create a user informed perspective on the needs and possible solutions and finding the overlap rather than making the mistake of being dependent on a single view. The co-design will also give insight into how personal preference impacts accessible design for people with ADHD and allows the research to explore both the aspects of variety and commonality amongst these perspectives. The inspiration for this approach can be found in works such as Rubegni et al. [27] which highlights the benefits that can be gained from involving the users in both design and feedback on such systems. This phase is driven by the first and third research questions by using the co-design session to help understand how tools could be supportive from the perspective of students with ADHD and their accessibility needs that come from the condition.

These studies will then lead to allowing the information gathered to be collated into a well-informed understanding of the needs of students with ADHD and what support is currently in place, in addition to an understanding of what does and doesn't work, and why.

4.3. Prototype design

The information gained from the more explorative stages of my research will then be used to **develop a prototype IDE plugin**. The previous phases will inform what features this prototype will deploy aswell as how the user interface should be designed for a user with ADHD. The design phase will be driven by the second and third research question in terms of implementing the functionality that will support students while also ensuring the design is accessible to the intended user.

The prototype would be able to provide various functionality as needed by the individual student, due to the variety of ways ADHD can impact on an individual and their learning [28]. This would be best achieved through a modular design to allow customisation to the needs of the individual user based on required functionality and individual preferences. The accessibility of the tool would be universal in some respects due to following the principles of Universal Design [29] to ensure that the needs of all users would be met, including aspects such as compatibility with screen readers, or even the implementation of an optional native screen reader functionality.

The prototype phase will also include creating a detailed breakdown of what functionality and design considerations had been included, which could serve as a guide on what practices should be followed and considered when creating similar assistive technology.

The prototype should be able to function as a normal IDE tool for programming in a learning environment with additional features and adaptations to make the tool more accessible to a student with ADHD. The exact features will be determined by the data gathered in the studies as part of the research. This will differ from existing plug-ins due to being designed to specifically support ADHD and the prototypes intention should be to simulate an altered interface to demonstrate concepts identified in the research rather than a stand-alone tool.

4.4. Evaluation

Once a prototype and detailed description of design and functionality considerations have been created, **an evaluative study involving teaching novices to code** will be conducted. Such a study will additionally include consulting academics who research ADHD and Technology Enhanced Learning, and educational professionals who work with students with ADHD to get feedback on the design and functionality of the prototype. The rest of the study will consist of running a small module style coding class over a number of weeks with novices. The study will consist of some participants using the prototype while others use a standard IDE and documenting the impact that is had on the learning in the course. These objectives will tie primarily to 4th research question to help demonstrate the impact that the different IDEs can have on learning while also contributing to the primary research question behind this PhD research.

4.5. Ethical considerations

With this work it is important to consider the care that must be taken when working with students with disabilities, especially when researchers also have potential teaching responsibilities for those students. To manage these considerations, the research ensures students at no point experience pressure to take part in the research if they do not want to, and are assured that participation will be confidential and have no impact on their academic outcomes. As this research also accepts self-diagnosis, meaning students may disclose information to researchers which may not be available to the department, extra confidentiality is applied to ensure student privacy. At all points the research works on the understanding of the individuals experience and perspectives and avoids making assumptions at any point.

5. Results and contributions to date

I am currently conducting the analysis on the results of the think aloud study which involves a thematic analysis utilising open and axial coding of the transcripts from the study and short interviews. I have also conducted interviews with teaching professionals around their experiences of supporting students with ADHD. The data from these studies will inform my first major publication which I will be submitting to an appropriate conference. The data so far is promising for the topic highlighting a need for better design practices in IDEs and indicating that students with ADHD require more support than they currently receive, including needing more appropriate adaptations to the learning environment

6. Expected next steps

After the conclusion of the think aloud study, the next major objective will be organising the logistics and ethics approval for running a co-design workshop. The workshop will gather informed user requirements and preferences from students with ADHD.

Once the co-design workshop has taken place and results have been written up, I will be submitting to the International ACM SIGACCESS Conference on Computers and Accessibility (ASSETS) as an appropriate venue for the results of the work. ASSETS would be the most appropriate community to provide knowledge on the findings and considerations before consolidating the results of the first two stages in the prototype and evaluation stage.

7. Dissertation status and long term goals

I have begun work on my thesis, primarily around the structure and topics to cover while also beginning work on background and literature sections. The long term goals of this research will be to find ways to make education as a whole more accessible to students with disabilities, and help contribute towards a solution for the equality vs equity problem that is often encountered in education [21]. The equality vs equity problem is the difficulty of trying to balance giving everyone equal access to the resources to succeed, while also ensuring those who are disadvantaged have adequate support to counteract such disadvantage.

The next steps after this project would be around refining and improving the tool and testing it in more varied settings to help validate findings and possibly developing a more standalone IDE for use in education. This could even lead to testing the tool in education outside of university level.

My personal long-term goal would be to continue researching ADHD and the benefits the condition can experience through technology and expand into other areas of digital accessibility. I have the intention of expanding access to other areas of life that might currently hold barriers to people with disabilities, especially those with variations of neurodivergence.

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