Dyslexia In Coding: An analysis of the pedagogy and synthesis of compensatory teaching methods with the conceptual design of a supportive web application

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Abstract:

Dyslexia is one of the most common learning disorders, said to affect approximately one in ten of the UK population. Despite the high prevalence of this disorder in all levels of education, the pedagogy does not account for dyslexia to the extent required for sufficient support in the higher levels of education.

Software development and coding have been identified as occupations which show links to the cognitive strengths of people with dyslexia. In order for these strengths to be explored, higher education needs to cater to a broader range of learning styles, inclusive of students with dyslexia.

This paper presents the conceptual view of LexiNet, the early development, and how this application is designed to support both educators and students with more inclusive teaching methods.

1. Introduction

1.1. Dyslexia In Higher Education

First styled as word-blindness in 1877, dyslexia is a learning difficulty which is neurobiological in origin and primarily affects phonological processing. Neurobiological disorders originate in the brain and in the case of dyslexia, the part of the brain affected is associated with reading functions which include *phonological processing, comprehension, and speech planning* - this also includes attention and inhibition (Soares, 2019).

The key educational stigma with dyslexia, is the treatment of dyslexia as a cognitive disability, opposed to a neurological or cognitive diversity (Marco Pino, 2014). A more nuanced understanding of dyslexia in higher education is necessary to provide a supportive and nurturing academic environment. In an extensive systematic review of various studies of the experiences of dyslexic students in higher education (HE), Pino (Marco Pino, 2014) discusses the numerous cases of non-nurturing academic factors which are of a negative impact to students with dyslexia. Pino (2014) is not the first to highlight the need for a more understanding environment, many pieces of relevant literature discuss the issue of a non-nurturing academic environment. Richardson, (Richardson, 2021), in the discussion of academic barriers in their paper, found that 67% of female participants named a non-nurturing academic environment as an obstacle in their learning with dyslexia.

Richardson (2021) provides an insightful view on the theoretical perspectives of disability and discusses how treating dyslexia with a medical view is not as beneficial as focusing on the behavioural aspects. By focusing on the development of compensatory techniques, working around the limitations becomes easier. Furthermore, though the development of compensatory techniques is a viable solution, it is not supported by the existing pedagogy - Richardson (2021) provides a comprehensive discussion on the attributes of educational pedagogies, the concept that if a person is unable to perform in the standard way, they are considered to have a disability.

A new pedagogy is needed to reform the education system. As it stands, the current system, throughout the literature, alienates and discourages students with learning disorders for learning in a way that is not considered standard. This narrow view leads to high rates of dropouts, and students who persevere feel stigma and reluctant to disclose their dyslexia or other learning disabilities. In a paper discussing two educational models, Griful-Freixenet (Júlia Griful-Freixenet, 2020) presents an overview of a educational model - the UDL, Universal Design for Learning. The UDL has three core principles: multiple means of representation - the way information is presented, multiple means of action and expression - students have multiple ways to demonstrate knowledge, and multiple means of engagement - different methods for garnering interest in a subject. The purpose of this model is to promote an inclusive educational environment which doesn't stigmatise different capabilities. The rigidity of the current pedagogy can have negative effects on students with different learning capabilities, this is what the UDL seeks to overcome.

In education and dyslexia, not all approaches are going to be accepted. In the fields of education and neurobiology, or even the medical field for diagnosis, there are differences in what is considered to be the best approach to dyslexia and similar learning difficulties. The Rose Report, (Rose, 2009), contains what is considered to be the working definition of dyslexia - adopted by the British Dyslexia Association. Despite this, there are those who do not agree with the report. J.G Elliott's *The Dyslexia Debate* (J.G Elliott, 2014) discusses this report, and claims that Rose ignores the underlying complexities of dyslexia and fails to consider the difference between a conceptual definition and a functional definition which is more applicable to educational settings.

The literature on dyslexia in higher education highly emphasizes the need for a reform in the pedagogy. In a study examining the difficulties of dyslexic students in higher education, the conclusion indicated that the number of problems encountered demands attention from the universities, as the extent of these issues is clearly not isolated or minimal (Tilly Mortimore, 2006).

Despite the failings in certain aspects, not all is lost. Pino (Marco Pino, 2014), also discusses positive factors which can benefit students with dyslexia in higher education, and how educators can support this. In particular, students with dyslexia reported that having a range of different resource types, and the ability to discuss concepts with their educators was highly beneficial.

1.2. Dyslexia In Coding and Software Development

Programming, and computer science are considered to be occupations which play to the cognitive strengths of

dyslexia. However, in order to make the most of these cognitive strengths, there needs to be more support in the learning environment. Powell, (Norman Powell, 2004), discusses the relevance of people with dyslexia and their strengths to software development. In particular, Powell (2004) demonstrates the breakdown 3 things - a generic software lifecycle, the negative skills of those with dyslexia, and the positive skills. By mapping the strengths and weaknesses to a generalised problem, Powell diagrammatically demonstrates the attributes of dyslexia in programming.

The discussion of dyslexia and programming is not a new one, Steinen-Durand & George (Silke Steinen-Durand, 2014) discussed the benefits of multimodal approaches to teaching, as opposed to one way only. Proposed teaching methods include a generic overview of standard dyslexic teaching practice such as self-awareness teaching methods, the use of personal motivation and managing a short attention span. The field of teaching programming specifically, to students with dyslexia, in higher education is not widely addressed. If the goal is to create a pedagogy which will encourage educators to adapt teaching styles which are strongly inclusive of students with learning disorders, there needs to be more support for educators as well as students.

In his article entitled *Why Dyslexics Make Good Coders(* (Stein, 2018)*,* Professor John Stein mentions that people with dyslexia *excel at statistic holistic analysis,* the ability to visualise a system and to spot patterns that others might not see - this holistic analysis by people with dyslexia is commonly discussed throughout discussions on the coding talent of people with dyslexia. This conclusion shows an interesting link to Dixon's (Dixon, 2004) paper discussing dyslexia in identifying possible usability issues in software which others might not see. In pattern recognition at the system level, and then the usability level, it appears the cognitive strengths of people with dyslexia is highly valuable to the field of computing and should not be ignored.

1.3. The Prevalence of Corrective Software

Whilst there are many software suites aimed at aiding people with dyslexia in their general computer usage, there are few aimed specifically at helping students or non-students with dyslexia learning to code. However, there are two suggested solutions which shall be the focus of this section.

Multi-modal teaching and learning have been repeatedly addressed throughout the literature, and with good basis. With dyslexia, the collection of symptoms does not manifest exactly the same in all cases - it can manifest in varying degrees of severity, with different symptoms across a range. This concept of a multi-modal model is the most adaptable approach to dealing with multiple different requirements. One such discussion of a model was made in an article by Wilson (Wilson, 2004) with the suggestion of a multimodal programming environment designed to help dyslexic users as they write code, with a particular focus on vocal input and feedback.

Contrary to Wilson (2004), is a much newer approach by Zingoni (Andrea Zingoni, 2021). Zingoni (2021) presents a software platform known as *BESPECIAL,* - an artificial intelligence and virtual reality-based platform designed with the intention of supporting students with dyslexia. This platform is designed to work by assessing the needs of the user and streamlining the support based on the key symptoms of an individual's dyslexia. Despite this complex, and highly intelligent tool, the author discusses in their conclusions that whilst supportive tools are helpful, strategies in place at the institution level providing support are considered to be more beneficial to students, by those students with dyslexia. This conclusion further emphasizes the need for a solution tailored to bolstering supportive strategies in a more accessible manner.

2. Methodology
2.1. Methods
This research is qualitative in nature. The purpose of this study is to analyse the effects of dyslexia on students' ability to learn to code in a higher education (HE) setting, with a focus on compensatory skills in order to guide the development of technology designed to support in an educational setting.

2.2. Participants
The participants were invited to apply for the study if they met the following criteria: at the time of the study were an undergraduate at the University of Plymouth, studying within the School of Engineering, Computing and Mathematics, had some experience of coding either recreationally or as part of their degree and were either diagnosed dyslexic, or strongly suspected they had dyslexia.

For this study, five students participated with three out of the five having a formal diagnosis.

2.3.   Instrumentation

For this study, the interview protocol chosen was semi-structured, leaving room for elaboration from the participants based on how they chose to respond. There were three key types of information to be yielded from these questions: (1) Challenges, personal learning, confidence (2) Tools, setups and software (3) Concerns, dislikes and hinderances.

2.4.   Questions

[1] Which aspects of learning to code do you find most challenging? – this can be anything, from variable names to IDE (integrated development environment) visual aspects.

[2] When learning something new, are there any particular learning approaches which you find more beneficial than others?

[3] How confident do you feel regarding programming? Are there areas of programming that you feel more confident with than others?

[4] Do you think having Dyslexia impacts the way you learn to code?

[5] Do you choose to use aids such as coloured overlays or text-to-speech? Do these help? Please elaborate on if you find these tools helpful or not.

[6] Do you have a preferred set up for your programming environment? If so, what is that?

[7] Have you noticed features in teaching software that you think really worked for you – or could work for those with Dyslexia?

[8] Are there any features in a piece of teaching software that you feel would hinder a Dyslexic student learning to code? If not in a piece of software, are there any practices you've experienced which are a barrier to learning?

2.5.   Interview Process and Data Collection

The total number of interviews conducted was 5. One-on-one interviews were conducted via Zoom chat for each of the 5 participants. Each interview was conducted, starting with a list presented of the questions, and participants were given the option to display questions one at a time while answering, or to leave the questions as a list on their screen - all 5 participants chose to view one question at a time while answering.

The interviews were recorded, with the permission of each participant, and then transcribed.

3.   Results

Research conducted shows that there is a distinct issue with the support provided to dyslexic students in higher education, and that there is a tendency to throw compensatory tools at the issue, rather than to provide strategies and guidance. This attitude of expecting students with dyslexia to manage their learning difficulty by themselves, as well as expecting them to learn the same way and at the same rate as students without dyslexia is harmful. The pedagogy needs to be adapted to be more inclusive towards alternative learning requirements.

3.1.1.   Challenges, Confidence, and Personal Learning

As a response to question 1, all participants, A-E answered that variable and class names were a source of trouble for them. Additionally, mentioned by two participants was difficulty decomposing the problem to begin designing a solution.

For the second question, participants all mentioned the use of videos in their learning. One participant further described the use of visual methods, diagrams and videos were much easier to process than reading from a power-point or book. One participant described the use of step-by-step tutorials were also a helpful way to work through the process.

The answers were more varied in the third question, compared to the first and second. Two participants discussed that between projects, it was a struggle to get into coding, but once they understood and decomposed a problem it was easier to program. One participant had experience with coding prior to their degree and felt very confident. Two participants felt that they were not extremely confident with their coding but were able to complete coding tasks.

Participants for this study had different levels of coding experience, all had some experience and used coding as part of their undergraduate degree, however not all to the same extent. This may be a contributing factor to confidence level.

The final question for this section evaluated how participants felt their dyslexia, if at all, impacted on the way they learnt to code. Three participants stated that they did not feel dyslexia had a large impact on the way they learnt to code. Two participants, contrastingly, felt their dyslexia was an advantage in

learning to code. One of the participants who felt their dyslexia was an advantage discussed how they felt it was easy to visualise how a coding project should work together, whilst they felt like peers did not always understand.

3.1.2.   Tools, Setups, and Software

In this question block, participants discussed their preferred set ups, if they used any software tools or if they used any physical aids to support programming and learning computer science with dyslexia. All five participants discussed their preferred use of dark mode in their IDE's, and three discussed dual monitor setups along with the benefits of being able to have one screen for reference.

In terms of screen overlays, and tints, four out of the five participants discussed some form of overlay or tint. One participant discussed the use of coloured glasses. When asked the colour of the tint, warm tones and yellow hues were preferred - however this is too small a sample size to make any definitive statement on the ideal-coloured overlay for people with dyslexia.

Finally, with the tools students utilised to aid them, Grammarly (Grammarly, 2022) was discussed by two of the five participants with a further two discussing some form of spell check or spelling corrective software. Three out of the five participants also discussed teaching methods available, and the impact of the way material was delivered by lecturers along with their use of technology. It was found that participants who worked with a lecturer understanding of the needs of dyslexia felt much more comfortable with the material and asking questions.

3.1.3.   Concerns, Dislikes, and Barriers

This section saw a broader amount of discussion than other sections. The question asked was "Are there any features in a piece of teaching software that you feel would hinder a Dyslexic student learning to code? If not in a piece of software, are there any practices you've experienced which are a barrier to learning?".

For the first part of the question, only two participants specifically discussed software features they think would hinder learning, which was tightly grouped text and overly complex writing. The responses were primarily in regard to the second half of the question concerning teaching practices.

In this second part of the question, two participants discussed feeling mocked by lecturers, with one participant elaborating that they had "Nothing to say about software, but lecturers who sigh or *kind of troll*

when you're doing group analysis of your code". This participant went on to discuss that this behaviour made them feel embarrassed or nervous about presenting.

Besides the discomfort, the other participants talked about hard-to-follow layouts, black text on white backgrounds and too much text, as well as the speed at which topics were presented. Many felt the lectures were not designed to include students with dyslexia in mind.

4.   Design

4.1.   LexiNet Concept

The research discusses dyslexia and coding in higher education. The literature overwhelmingly points at a disparity between the pedagogy and dyslexic students - therefore a solution is needed which creates a point of communion between students with dyslexia and their educators. Educators are, for the most part, unaware of the needs of students with learning difficulties such as dyslexia.

The conceptual design of LexiNet is a system which will allow educators to upload resources for use by dyslexic students, wherein these students may provide feedback on these resources - by rating in categories such as readability, information presentation, colour schemes. This concept is designed with both students and educators in mind, by allowing educators to understand the positive elements of their resources, as well as the aspects which could be changed to improve the accessibility.

4.2.   LexiNet Design Features

Figure 1: LexiNet Concept - Resource Rating Page

Figure one shows the conceptual design of the rating page for a resource. This page would allow users to view a resource, its ratings and then select review resource in order to enter their own reviews. These resources will be stored on a

database, along with the resource ID. The create a rating page will be in the format of a form, allowing users to select ratings from 1-5 for each category. Each category pertaining to a feature of a resource which is desirable to students with dyslexia - readability, spacing, word simplicity, colour.
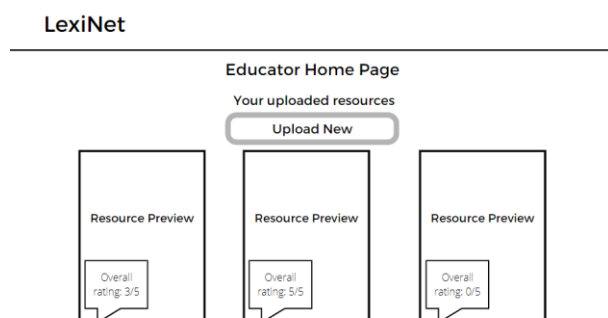

Figure 2: LexiNet concept - educator uploads page

Figure 2 demonstrates the concept for the educator page, through which they may upload resources and review them. Each resource displaying the "overall rating". Resources should be able to open to a modal which displays a summary of the ratings by category.

5. Discussion and conclusions

The literature presents an overview of the understanding of dyslexia in higher education and in programming. Though many tools are designed to deal with the symptoms of dyslexia, there are even fewer which aim to create supporting strategies for students with dyslexia.

With the pedagogy failing to adequately support students with dyslexia and similar learning disabilities, it falls to the educators and students. The design of a system which promotes feedback for educational resources, from the students with dyslexia themselves, allows for the development of educational resources which will help many students with learning difficulties feel that they are welcome in the learning environment.

The study conducted has limitations, with such limitations being not only the sample size, but the lack of formal diagnosis for all participants - with three out of the five having a formal dyslexia diagnosis. A broader sample would need to be used to obtain more comprehensive results. For future research, a better question to ask may be in relation to ways in which the

pedagogy could better support these students in order to create a nurturing academic environment, rather than a limiting one.

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