
A study into the perceptions of students with dyslexia in Higher Education on the effectiveness of the Livescribe Smartpen in accommodating their lecture note-taking needs and if it impacts on their academic self-efficacy

Introduction

Lecture notes are essential for recalling learning material and promoting reflection afterwards. Indeed, empirical evidence has established a positive relationship between producing rich lecture notes and academic performance (Kiewra et al., 1991; Williams and Eggert, 2002b). The cognitive process of taking notes during lectures is complex and taxing on the brain. Skilled note-taking is dependent on the parallel execution of low order and high order cognitive processes within a limited-capacity working memory system. Peverly et al., (2007) maintain that low order cognitive skills relating to word recognition and transcription must be mastered to an acceptable degree of fluency, so that available space in working memory can be used for executing high order cognitive skills needed for language comprehension. When taking notes during lectures students must

interpret and select the most important ideas; hold the information in working memory and write them down before they are forgotten (Peverly et al., 2013, p.115).

Through the voice of students with dyslexia in Higher Education (HE) this research explored the effectiveness of the Livescribe Smartpen in accommodating their lecture note-taking needs and if its use impacted on their academic self-efficacy.

Theoretical framework – specific learning difficulties

Students with dyslexia have notable deficits in the skills required to take effective notes namely Working Memory, Attention, Listening Comprehension and Transcription fluency (Suritsky and Hughes 1991; Suritsky, 1992; Mortimore and Crozier 2006). Asselin (2014) argues that the heavy reliance placed on lecturing in HE does not recognise the cognitive, language, sensory and motor difficulties experienced by students with disabilities.

Cognitive Deficits

Working Memory	Note-taking ability is highly dependent on the capacity of the working memory to manage selection and comprehension of information and produce written output concurrently under time constraints.	Baddeley (2000)
Attention	Attention and note-taking during lectures are closely related In order to take notes students must consistently focus, sustain, stabilize, shift and encode.	Donaldson (2005)
Listening Comprehension	An important skill involved in note taking is the ability to listen and understand uninterrupted and spontaneous speech."	Heaton (1977)
Transcription Fluency	Transcription fluency is directly related to note quality, i.e., the faster a student can write, the more information they can record during lectures.	Peverly et al. (2007)

It is important to note that difficulties experienced by students with dyslexia are not limited to academic tasks such as note taking, they also struggle to keep pace emotionally. They have significantly lower levels of self-esteem and self-concept compared to their non-dyslexic peers. Riddick (1996) in her study of higher education students with dyslexia, documented that they felt 'disappointed, frustrated, ashamed, fed up, sad, depressed, angry and embarrassed by their difficulties' (p. 129). Poor academic performance diminishes students' belief that they can achieve academic success. It is hardly surprising that they are more likely to withdraw from courses after their first year compared to their non-dyslexic peers (Richardson and Wydell, 2003).

Academic Self Efficacy

Academic Self Efficacy	'An individual's belief or conviction that they can successfully achieve at a designated level on an academic task or attain a specific academic goal'. Students with dyslexia are more likely to have low levels of academic self-efficacy and less able to manage their learning environment.	Bandura (1997, p.3) Klassen (2008)
Self-Esteem & Self-Concept	students with dyslexia have significantly lower self-concept and self-esteem compared to their non-dyslexic peers. They identify themselves as 'different' from their non-dyslexic peers and less efficacious in academic achievement.	Riddick et al (1999) Armstrong and Humphrey (2009)
Anxiety	Students with dyslexia are significantly more likely to suffer from anxiety with academic and social situations in than students without learning difficulties.	Nelson and Harwood (2010) Carroll and Iles (2006)
Learned Helplessness	Students with dyslexia often exhibit learned helpless behaviour, that is, the giving up reaction, the quitting response that follows from belief that whatever you do doesn't matter'. Such behaviour manifests following regular exposure to academic failure.	Seligman (1991)

The Role of Assistive Technology

It is widely established that Assistive Technology (AT) reduces learning barriers and creates a more autonomous learning environment for students with specific learning difficulties. AT is valuable in increasing academic engagement, productivity, independence and motivation (Day and Edwards, 1996; Raskind and Higgins 1998; Forgrave, 2002). Hand-held recording pens are one of the most commonly used AT tools by students with dyslexia in HE in the USA to facilitate Forgrave and review (Asselin, 2014). The audio capture of lectures is an increasingly popular strategy in alleviating note-taking difficulties in HE. Students place high value on lecture recordings as it allows them to write less and listen more during lectures and revisit material as often as required (Leadbeater et al. 2013). Audio recording therefore proves to be particularly beneficial for examination revision as it aids their retention and comprehension of material as well as reducing anxiety levels while they revise (Woo et al., 2008; Owston et al., 2011). Bjork et al (2013) recommends that learners use technologies to transform their notes into an interactive form in order to facilitate optimal review and retention of lecture content.

Using the Livescribe Smartpen

The Livescribe Smartpen is a computerised pen that works in conjunction with a digital notebook, which consists of plain paper embossed with microdots. As the student takes down notes the Smartpen's microphone records audio and its infrared camera reads the microdots on the notebook paper. After lectures students can tap on what they have written to hear exactly what was recorded at that time. Students also upload their recordings to the Livescribe desktop where they can:

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1. Save, search, and play back notes and recordings
 2. Search handwritten notes for keywords
 3. Organise notes
 4. Export and share notes and audio

Methodology for this study

The objectives set out in this study were

1. To identify the lecture note-taking difficulties experienced by students with dyslexia and to explore how and to what extent the Smartpen has changed their experiences.
2. To determine if the Smartpen has impacted on their academic self-efficacy and if so how.

This research study adopted a mixed methods approach and was carried out in two sequential phases. The initial phase applied a quantitative approach by means of an online questionnaire using closed questions. The second phase adopted a qualitative approach through the use of semi-structured interviews using open questions.

Mixed-method approaches to research are undertaken in an attempt to overcome contrasting ideologies of quantitative and qualitative fundamentalists and instead 'focuses on the pragmatic value of each approach' (Trahan and Stewart, 2013 p. 60). Pragmatic researchers put aside the philosophical debate between quantitative and qualitative approaches and concentrate on what works best.

Online questionnaires measured the participants' levels of difficulty with note-taking and the usefulness of their notes prior to and after the Smartpen. Following this the researcher qualitatively analysed the data from the online surveys to inform the qualitative instrument. Semi-structured interviews facilitated the researcher in procuring an in-depth understanding of the participants' note-taking experiences, prior to and after the Smartpen and to determine if this assistive technology impacted upon their academic self-efficacy.

- **Quantitative Data Collection:** Online Survey
- **Quantitative Data Analysis:** Bar Charts and Graphs
- **Qualitative Data Collection:** Semi-structured Interviews
- **Qualitative Data Analysis:** Coding
- **Interpretation of Entire Analysis:** Thematic Analysis

A purposive targeted sample approach was adopted by seeking out students who had self-identified as having dyslexia in one HE Institute. Fifteen students participated in this study; five in their second year, eight in their third year and two in the fourth year of their studies.

Presentation and discussion of Findings

Obstacles faced with lecture note taking

More than half of the participants reported that they were not at all able to demonstrate the core cognitive competencies required to take effective notes. The most prominent notation obstacles experienced by participants during lectures pertained to keeping up with the pace of lectures, simultaneously listening, processing and taking notes, and maintaining concentration.

Participants' level of ability with specific lecture note-taking tasks

	Not at all able	Somewhat able	Mostly able	Not sure	Completely able
Taking down material delivered orally quickly enough	53	47			
Taking legible notes	20	47	33		
Maintain attention	50	33	17		
Understand material delivered	54	33	13		

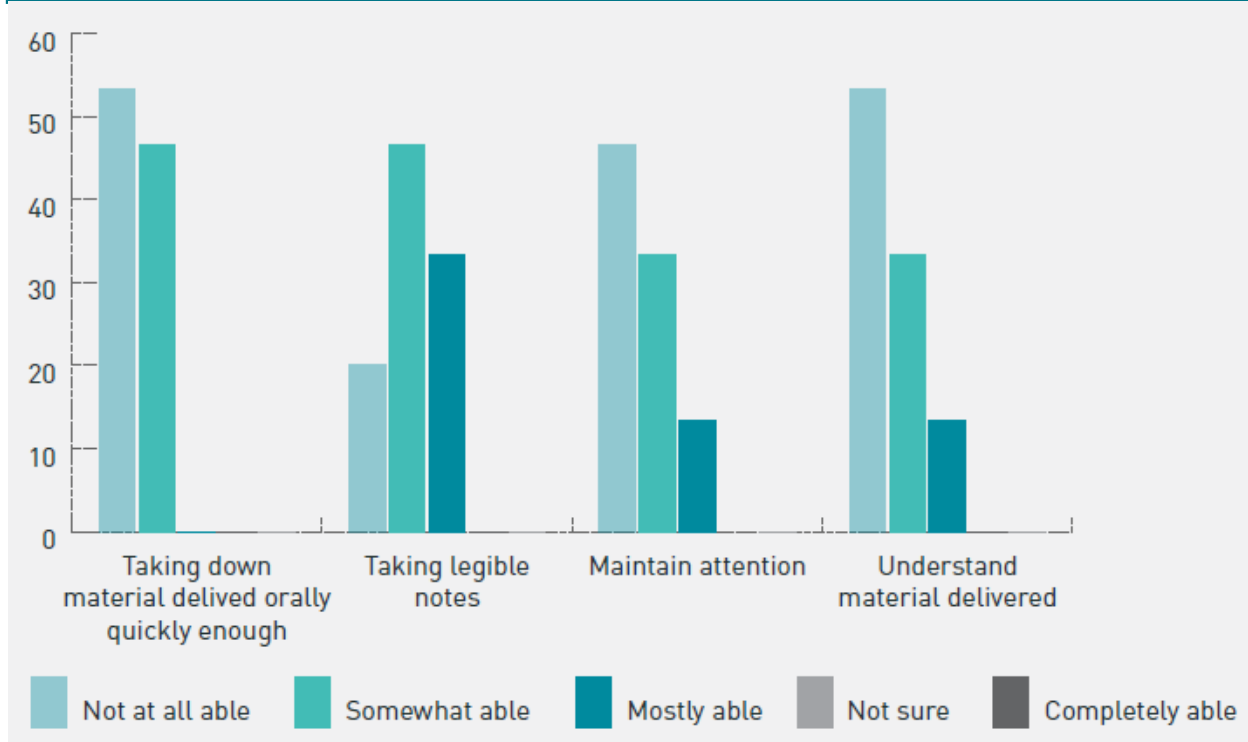


Figure 1:

Participants' level of ability with specific lecture note-taking task

Working Memory

The complexity of taking notes during lectures placed high demands on the participants working memory. Peter had significant difficulty with the task of simultaneously listening, processing and taking down information. On a few occasions he decided to just listen to the lectures but this proved ineffective, as he did not have any handwritten notes for review. Peter noted:

I literally could not listen and write at the same time, I either had a choice to sit and listen to the lecturer or try to take notes, I couldn't do both. I decided to sit and listen to the lecturer, but then I had nothing to look back on afterwards.

Transcription Fluency

Weaknesses in writing fluency coined with the prompt and dense delivery of verbal constructs impeded the participants' ability to make note of it. John was unable to take down key information as his handwriting speed was not sufficient to keep pace.

The bulk and the speed that lecturers were moving at was massive. There is so much additional detail and explanations given around the PowerPoint slides and I would try to get it down but I couldn't because the lecturer is moving on to the next part.

Attention

Attending to lecture content is an essential component of lecture note-taking ability. In order to produce complete and meaningful notes students must maintain focus throughout the lecture to ensure that they do not omit important information. Participants frequently fell behind and missed key information due to lapses in concentration, Sarah notes:

I have always had trouble with concentration and this really affected me in lectures because, if you miss one word or one phrase, you have missed the whole concept of the lecture.

Losing concentration was a major concern and cause of anxiety for students. Unfortunately, states of anxiety in students with dyslexia restricts already deficient working memory capacity. Donna noted that losses in concentration was a major concern for her:

I would just float off into the distance for a few minutes. Then when I missed information I would start to panic and when I panicked I would fall behind even more, it was like a vicious circle.

Disengagement

The participants were faced with many note taking obstacles for which they believed they had no control. Their cognitive constraints lead to difficulty in striking a balance between producing notes and understanding information. Their low sense of ability to take notes resulted in frustration, diminished motivation and disengagement. Matthew explained:

You wouldn't be able to take down the notes fast enough or hold your concentration and be just like what's the point. I would get frustrated and throw down my pen. Everything would just shut down and a wall would go up, I know it sounds terrible, but there was nothing I could do about it.

Note Quality

Participants attributed little value to their lecture notes. A high proportion indicated that their notes were not at all useful as they were incomplete and unstructured. Eve explained that she was unable to make connections with her notes and had to turn to her peers for notes:

I had to use other people's notes because my notes were all over the place and there would be bits missing so they didn't really make sense.

Usefulness of notes taken for specific academic tests

	Not at all	Slightly	Moderately	Extremely
Understanding key components	67	13	20	
Reviewing after lectures	47	40	13	
Making additional notes	60	36	4	
Assignment work	65	35		
Exam revision	80	20		

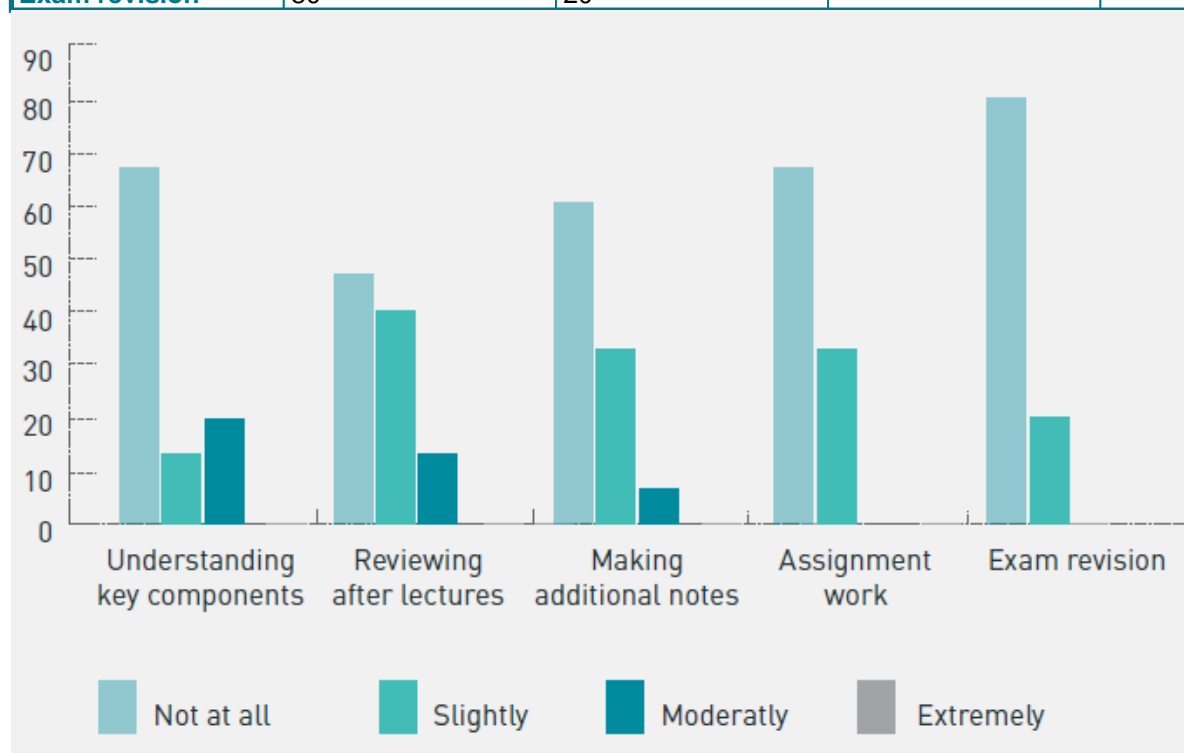


Figure 2:

Usefulness of notes taken during lectures

Academic Performance

Ineffective notes and poor levels of understanding of material gave rise to impoverished performance. All participants reflected that their academic performance was not indicative of the amount of effort they put into exam preparation. Sarah stated:

I got extremely high points for this course. I was very academic, throughout my whole life, you know A's B's, in here it was barely passes, I feel that my notes really affected me.

Disempowerment

As participants related back to their difficulty with creating effective notes and the ensuing impact on their academic performance, a sense of disempowerment emerged. They consistently compared themselves to their peers and felt less efficacious in academic achievement. All participants reported to putting considerably more effort and time into academic tasks compared to their non-dyslexic peers and yet achieved poorer grades. These circumstances resulted in feelings of inferiority and disappointment. Ciara explained:

First year was a full on disaster because I really far behind compared to everyone else. I remember failing two exams that I had studied really hard for and the rest of my class passed. I was so disappointed, I always had to use my friends' notes after that and you feel really down about it; you feel so inadequate.

Smartpen Note-Taking Experiences

Having identified the academic and emotional consequences of the participants' difficulties with note-taking prior to the Smartpen, this study will now investigate to what extent the Smartpen impacted upon the participants' note-taking experiences and determine if it has impacted upon their academic self-efficacy.

Assistive technology plays an important role in supplementing traditional approaches to learning lectures, however in order to truly empower students its usability is paramount. With that in mind, participants were asked to indicate their ease of use with of the Smartpen. Almost all participants indicated a level of ease with using the Smartpen.

Ease of use

Very easy	53%
Easy	47%

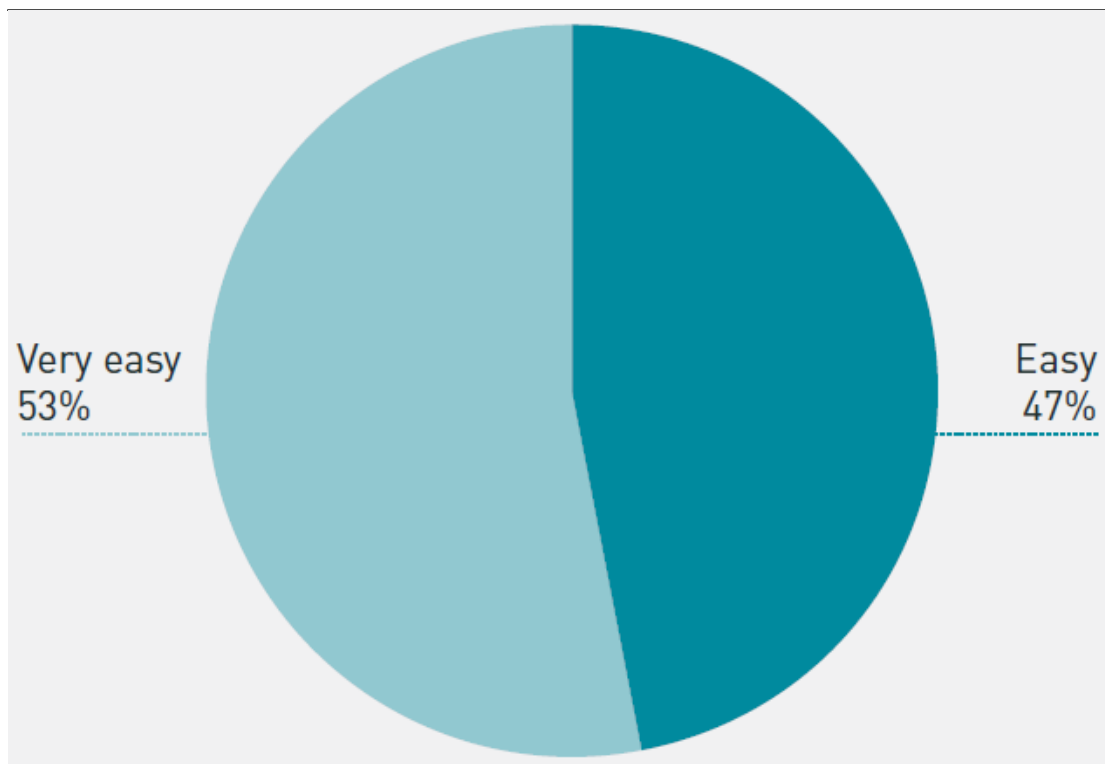


Figure 3: Ease of

Use

Accessibility

The Smartpen alleviated the cognitive demands placed on participants during lectures by allowing them to write less and listen more. When using the Smartpen, participants were only required to make note of headings from PowerPoint slides or key words. The Smartpen, in minimising the negative effects of their learning difficulties, accommodated their note taking and created a more accessible learning environment. Matthew explained:

I found with the pen, lectures are a lot easier, because before I didn't have a clue what was going on because I couldn't write and listen at the same time. I was writing down stuff and then I was missing stuff after that. With the Smartpen I just write down keywords and key point and I can concentrate more listening.

Autonomy

Participants became more relaxed and motivated during lectures knowing that they have recordings to listen back on. Mary stated:

I'm actually enjoying college a lot more because I don't have to worry. Let's say there is a big project due and the lecturer was talking about it way too fast, I don't have to stress because the pen is recording it all.

Engagement

Levels of engagement increased upon using the Smartpen as participants no longer had to contend with striking the balance between listening and producing notes. When participants could take fewer notes during lectures they

were afforded the opportunity to actively participate in their academic environment. Stacey noted that:

It makes class more interactive. I like that you have to write down the headings of the slides because I can manage that and it makes me pay attention more. It feels good because I can really focus in class now.

Quality of Notes

The Smartpen positively impacted on the usefulness of the participants' notes with regard to revisiting difficult concepts, reviewing notes and examination revision. It allowed participants to have more control and flexibility over their learning as they could review material as often as needed in their own time and at their own pace. Darren:

for exam revision, you can use the pen to go back and listen to the recordings. Its great that you can tap on a heading that you have written down as listen back to that specific topic. I even listen to the recordings on my MP3 player when I'm driving home from college. I can listen as many times as I need to, I just think it's brilliant.

Usefulness of note using the Smartpen

	Not at all	Slightly	Moderately	Extremely	Does not use pen for this task
Revisiting parts of lecture that was not understood			8	92	
Reviewing notes			26	74	
Making additional notes		12	34	54	
Assignment work	8	26	40	26	
Exam revision	7		7	86	

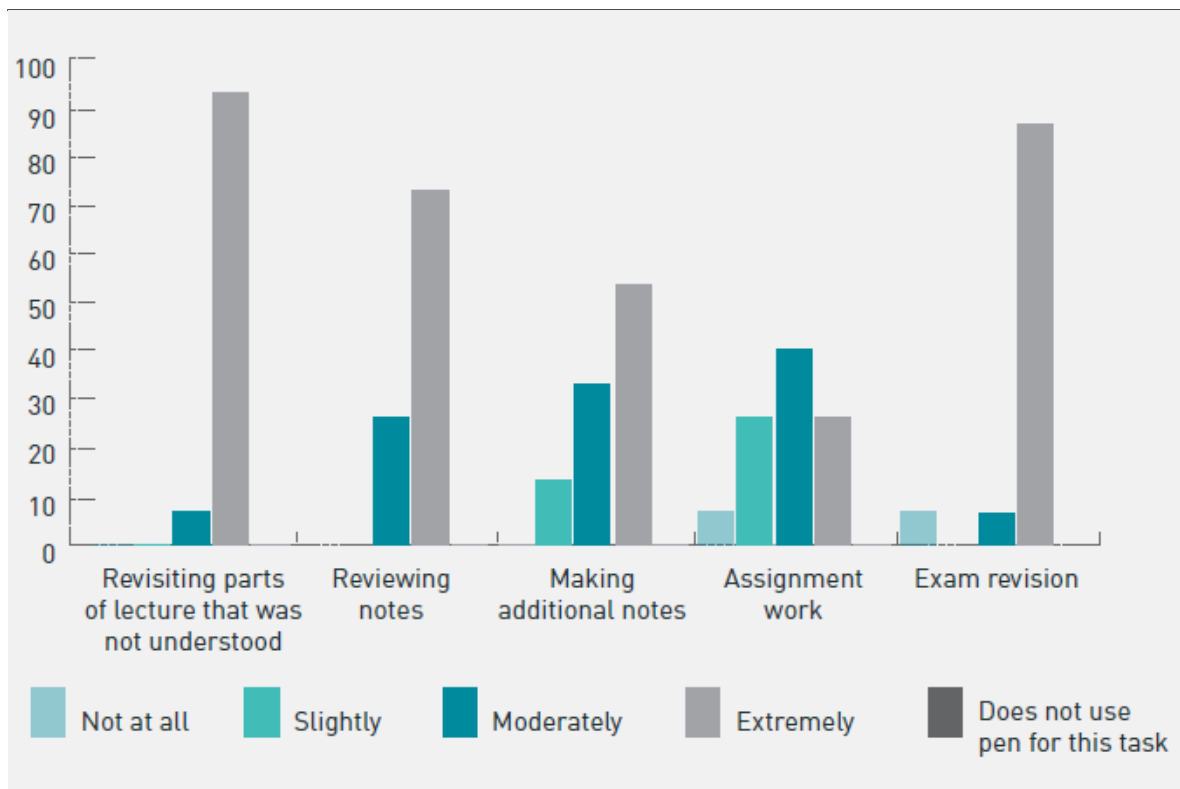


Figure 4:

Impact of Smartpen on usefulness of notes

The Smartpen was least effective in supporting participants with assignment work and making additional notes, this may be due to the self-directed nature of these tasks.

As the quality of the participant's notes increased so too did their understanding of learning material. When participants were asked to indicate the level of impact the Smartpen had on their understanding of lecture material, all participants indicated that it had made notes easier to understand. The recordings aided retention and comprehension of learning material as it allowed them to revisit difficult concepts as often as required. Matthew stated:

If I don't understand something I can listen to it again and sometimes I could listen continuously four or five times to a three-minute segment just to cement it in my mind.

Impact of Smartpen recordings on understanding of lecture material

Made material significantly easier to understand	53%
Made material somewhat easier	47%

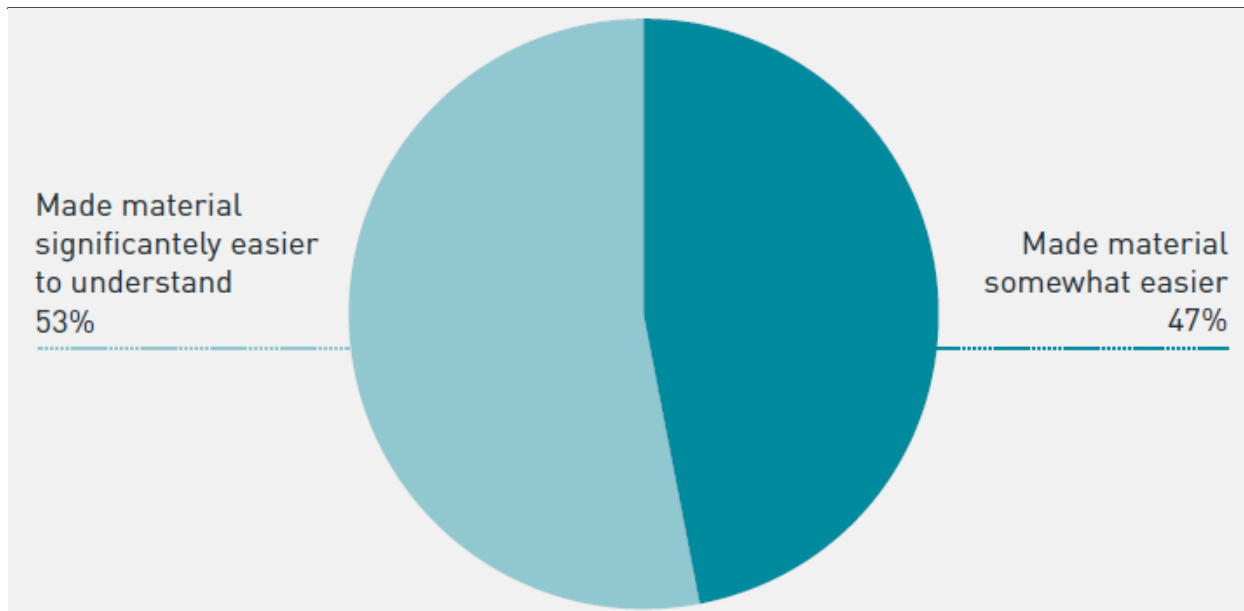


Figure 5:

Impact on understanding

Empowerment

Upon using the Smartpen participants became more confident and independent. Philip explained:

I'm way more confident now, like I don't have to use my friends' notes anymore because I have my own notes and they are good.

All participants noted an improved academic performance. Kate stated:

My grades have gone up, they are all up basically across the board because of my notes and being able to listen more in lectures.

Shane explained that his lab report results have improved because as he is able to put more information into them:

I am doing a lot better now, my lab report results used to be 40 to 50's and now they are up 60 to 70's, they have gone up a lot because I have a lot more information.

Need for Continued Diligence

Although, participants feel equipped to deal with note taking challenges and have a more positive outlook their ability to achieve academic success they noted that even with the Smartpen they must apply more effort and time with academic tasks compared their non-dyslexic peers.

Jason stated

Keeping up is difficult, even with the pen. Some subjects are very hard, you have to put the work in, you know the pen isn't magic. If you want to hit the high ones you have to put the work in. I still have to work harder my friends.

Strengths and limitations of the Smartpen

There was a consensus that the most positive aspect of the Smartpen was the recording and playback features. The recording feature made participants more relaxed and confident taking notes during lectures. The playback features were instrumental to their understanding of material particularly when reviewing difficult concepts and revising for examinations.

Limitations of the Smartpen

Participants considered the transfer, download and organising of recordings onto their desktop software as a limitation. They noted that it was an additional filing system and is time-consuming.

Evaluation of Findings

Objective One: Effectiveness of the Smartpen in Meeting Note Taking Needs

Prior to the implementation of the Smartpen, participants perceived meeting note-taking demands within the lecture environment as being above their ability. Upon using the Smartpen the negative effects of their specific learning difficulties were minimised and the lecture environment became accessible. Undeniably, this device positively impacted on the participants' note-taking experience, with all noting increased academic achievement.

Nonetheless, two important factors must be considered to offer a more balanced view. It would be negligent to attribute the participants' improvements in performance solely to the Smartpen. Whilst the Smartpen certainly accommodated their note taking needs the participants' noted that they still needed to work harder than their non-dyslexic peers. Additionally, it is possible that as time passed, and as participants adjusted to the higher education learning environment, they developed skills that may also have impacted positively on their academic performance.

Objective Two: If the Smartpen impacted upon the participants' academic self-efficacy.

Findings from the study reveal that use of the Smartpen positively impacted on the participants' academic self-efficacy. Upon using the Smartpen, participants gained a sense of autonomy within the lecture environment. As their learning environment became more accessible, they became more motivated and engaged. When the participants note taking needs were met and the quality of their notes improved, they became empowered and less reliant on their peers.

Conclusion

With an increase in the number of students with dyslexia pursuing HE, it is critical that practitioners actively explore strategies to support their note taking needs within the lecture environment. Institutions must recognise the

importance of Assistive Technologies such as the Livescribe Smartpen in supporting learners with dyslexia in achieving academic success in a confident and independent manner. The Smartpen alleviated note-taking difficulties during lectures whilst enhancing the quality and effectiveness of notes. In doing so participants reported to feeling more independent, confident and engaged during lectures and revision. Dyslexia practitioners and Assistive Technology specialists may use this research to assess the potential of the Smartpen in facilitating students' note taking and enhancing their academic self-efficacy. Indeed, findings from this research will be encouraging for students with dyslexia in HE and second level students wishing to pursue higher education. They may consult findings from this research to help them evaluate if the Smartpen may be advantageous relative to their note-taking needs.

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