

“HEY GOOGLE, HELP ME LEARN”

Voice Assistant Devices in the New Zealand Primary School

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For Ada.

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Abstract

Artificial intelligence is being embedded into home devices and these have potential to be useful tools in the classroom. Voice assistant devices such as Google Home or Alexa can respond to verbal instructions and answer questions using the Internet of Things, web-scraping or native programming. This research explores student use of voice assistant devices in the context of two senior primary school classrooms in New Zealand. A socio-material approach is taken, examining the devices in existing classroom environments and how the children use these devices without teacher prompting. The research is framed within the Technology Acceptance Model 2 (Venkatesh et al., 2003). Student's perception of the device's usefulness, ease of use, and the subjective norm and social impact of using the device in each classroom environment is discussed. The research questions examined were what and how do students ask the devices, and how accurate the devices are in answering their enquiries. Data were gathered for two case studies from device transcripts over six weeks and teacher interviews. Findings suggest that the students found the devices usable, useful and interesting to challenge and explore. Reliable responses for basic literacy, numeracy, and social studies enquiries were recorded, however, the ability of the device to understand student enquiries was variable and the device was limited by a lack of pedagogical techniques and knowledge of learner needs. Evident in the data were students' social use, perseverance and anthropomorphism of the devices. The implications of this research are that voice-activated artificial intelligence devices can support learners in classroom environments by promoting perseverance, independence, and social learning.

“HEY GOOGLE, HELP ME LEARN”

Voice Assistant Devices in the New Zealand Primary School

Technology in the classroom is changing, seemingly at an increasing pace (Luckin, Holmes, Griffiths & Forcier, 2016). How students communicate and the pedagogical decisions that teachers make are being shaped by the digital age (Starkey, 2010). As the technologies which teachers and students engage with include more artificial intelligence (AI) ‘, less is understood about how the technology makes decisions, and it becomes harder to observe how students are interacting with it (Uskov, Howlett & Jain, 2018). In many countries, such as New Zealand, teachers are able to introduce new technologies into the classroom without a school wide decision or investment, because they are often cheap to purchase and easy to operate, so they require neither a school-level budget, nor specific professional development to begin using them in the classroom.

The role of technology in children’s lives outside of the classroom also continues to increase. For some students entering school today voice assistant devices have been available to them their whole lives (West, 2018). For others the classroom may be the first place to introduce them to technologies that they may work and live alongside (Mitchell, 2019). As we have come to expect that young students know how to interact with technology such as iPad, they will increasingly see communicating with computers through spoken language as common place (Underwood, 2017). Because of the ease of access and use of many AI-driven technologies, there is potential for them to be used in the classroom without critical examination of their impact on learning and teaching.

This research examines students’ use of one such technology, voice assistant devices (devices), in New Zealand primary school classrooms. It adds to a small body of research on the use of these devices in an education environment (Dizon, 2017; Dousay & Hall, 2018; Underwood, 2017). My research includes a literature review, and two case studies placing devices in two classrooms. This research aims to inform an increasing

volume of professional and academic dialogue about the devices' potential role in using artificial intelligence to support learning and teaching.

I am a Master of Education student at Victoria University of Wellington and an experienced primary school classroom teacher. This research was inspired by a case study I did in my classroom in 2018, where I set up an Amazon Alexa device and left it to students to determine how it was used. The high frequency of use and varied types of queries led me to believe this was something which needed to be further explored. The device remained in my classroom for several months, but as part of a taught paper I completed a two-week, one-classroom research project which acted as a small pilot to this study (Butler, 2019).

Background

While the natural language processing technology of the devices' software was first created in the 1960s (Luckin et al., 2016), it is only in the last decade that it has found a popular commercial use, starting with Apple's Siri being integrated into iOS software in 2011 (Siegler, 2011). It is more recently that stand-alone speaker devices have been available to consumers, with Amazon's Alexa being available in the United States in 2014, and available in New Zealand stores from mid-2018 (West, 2018).

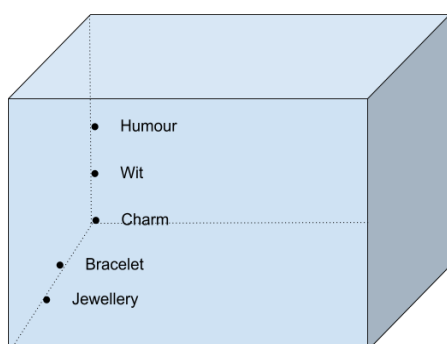
The devices have both a microphone and a speaker. They work by listening to a user (student) make requests by using the invocation words 'Hey Google...' or 'Okay Google...' followed by a question or instruction. This research refers to this question or instruction as an 'enquiry'. The devices respond, either using libraries of information or by scraping the web for information, depending on the nature of the enquiry. The devices then speak back a response to the student (Mitchell, 2019). The devices do not understand the meaning of the sentences being said to them or used in their response in the same way humans do, but the use of word vectors (Figure 1) and extensive training means that they now appear to be accurate with most

common enquiries (Mitchell, 2019; West, 2018). Word vectors can be imagined as multi-dimensional graphs of the relationships between words. These are used by natural language processing software, which are the basis of virtual assistant devices (Mitchell, 2019).

While these devices are designed and marketed for household use, they are increasingly being used in business settings. They also have a growing popularity among classroom teachers (Dousay & Hall, 2018). A search conducted in Google Videos in June 2019 returned over 30,000 results. The Google Videos site was queried for ‘Amazon Alexa’ OR ‘Google Home’ AND ‘classroom’. While it is not practical to determine if each of those videos is relevant to the topic, the volume of results suggests that the use of devices in the classroom is not uncommon and teachers are seeking advice on their use. This is not surprising considering two thirds of United States households have dedicated devices such as Alexa or Google Home (Nordum, 2017). It would seem that teachers are beginning to experiment with these devices in classrooms. This is also suggested by increasing discussion of the devices and other AI technologies in the professional education publications (Luckin et al., 2016). Teachers are the gatekeepers to this technology being accessible to their students. However, the increasing volume of discussion amongst practising educators about devices is not matched by the academic literature available on the topic (Dousay & Hall, 2018).

Figure 1

Word Vectors Used By Natural Language Processing Software



Note. Adapted with permission (Mitchell, 2019, p.240)

Purpose

This research builds on the literature discussed in the next chapter, but also examines the use of the devices in the unique environment of New Zealand primary school classrooms. The case studies occurred in the context of teaching the New Zealand Curriculum Framework (Ministry of Education, 2007), the governance structure of our schools, and unique experiences of our learners. Schools in New Zealand are required to give “priority to student progress and achievement in literacy and numeracy” (Ministry of Education, 2017, NAG 1a) while also ensuring “the development of high levels of competence (knowledge and skills) in...science and technology and physical activity.” (Ministry of Education, 2004, NEG 5).

No other published research on the use of the devices in New Zealand classrooms could be found. Given that Dousay and Hall (2018) was the only multi-classroom study on the use of these devices, this research is currently the second biggest on the subject.

This research seeks to understand what students use the devices for. Current literature suggests that these devices are useful for students and teachers in two ways, one in the short term, assisting in classrooms now, and one in the midterm, playing a key role in the smart classrooms of the future.

In the short term these devices have the potential to support classroom teachers who select them, by taking over some narrowly defined tasks (Mitchell, 2019), such as spelling words and answering curiosity questions. A case has been made for using these devices in English language learning (Underwood, 2017; Dizon, 2016). The devices may also help students become more independent from the teacher as these devices allow students to access internet content using their voice, taking away the barrier of requiring reading and writing competencies. These devices also allow students to select a turn-taking order, time

an activity, create lists, and find out basic information, (for example the date, weather, news headlines) without an adult (Dousay & Hall, 2018). Currently the devices' capabilities are far from that of the classroom teacher, but they may already have the potential to replace some of the more repetitive, basic tasks for which students would currently seek the support of their teacher (Luckin et al., 2016; Dousay & Hall, 2018).

In the medium term there is discussion in both professional and academic literature about the impact that the increasing capabilities and affordability of AI will have on teaching and learning if tools like these devices were to become more generally capable in educational environments (Luckin et al., 2016). Smart classrooms are a future version of classrooms which feature students interacting with a host of technology, often through their own personalised learning system or 'robot' (Uskov et al., 2018). In smart classrooms the devices, and their underpinning technology, natural language processing, are often considered a key technology (Uskov et al., 2018). Voice is regularly regarded in the literature on smart classrooms as the primary means by which students will interact with their personal learning robot: making requests, explaining understanding, and receiving feedback (Dousay & Hall, 2018, Uskov et al., 2018). Given the key role this technology is expected to play in future smart classrooms, examining students' social interactions with the devices, and with each other when using the devices, is as important as examining the devices' ability to directly support students with learning tasks. The technical and educational benefits of the devices are important, but only in the context of how students choose to use it in their environment.

While these AI futures are often, and optimistically, written about in professional publications (Mitchell, 2019), in the academic literature there is little research on the use of virtual assistant devices in primary school classrooms. Because of the lack of similar research, I ask relatively broad questions. It is intended that by collecting and analysing a dataset, educators will better understand how these technologies could be used in the

classroom now, and in future smart classrooms. This research also aims to act as a resource for further studies in New Zealand and international contexts.

Aims and Objectives

This research explores how students use devices in a New Zealand classroom, it does not seek to measure the devices' impact on learning. It is intended that by first exploring how students interact with these devices without prompting, future studies which aim to measure the impact on learning can be more thoughtfully designed to reflect sound pedagogy, where teachers and other adults support co-constructed learning, rather than directing it. The socio-material approach of this study suggests that technologies in the classroom do not exist in isolation but need to be considered in the context of the other resources and social influences in the classroom (Fenwick, 2015). This is especially important as this research considers the future role of the devices in a technology centred smart classroom. These classrooms are specifically designed to minimise teacher's role in routine learning activities, whilst highlighting their continued role in more complex tasks (Atabekov, 2016; Luckin et al., 2016). The need for teachers in these smart classrooms is a complex issue which is beyond the scope of this research. The study therefore considers the social relationships not just between the devices and students, but also with peer learners and teachers too.

The data collected as part of this research is threefold. Firstly, a narrative literature review looked at what is already known, both of devices being used by students in a classroom environment currently, and as part of a future smart classroom ecosystem. Secondly, two case studies were conducted where the transcript data from devices placed in the classrooms looked at what, and how, students asked the devices during their normal school day. Finally, interviews with one of the classroom teachers from each of the two case study classes examined the usefulness, ease of use, and social consequences (subjective

norm and image) of having a device in the classroom. Considering all three sources of data together, I consider how the devices fit into the existing classroom environment and those of the future.

The research asks how AI driven devices are used in the primary school classroom by investigating:

1. When do senior primary school students use devices in a classroom environment?

(data source: Google Home transcripts, with clarity from teacher interviews.)

2. What questions do senior primary school students ask devices in a classroom environment?

(data source: Google Home transcripts, with clarity from teacher interviews.)

3. How effective are the devices at answering questions from senior primary school students?

(data source: teacher interviews with supporting data from Google Home transcripts.)

Literature Review

This research includes original case study research on the use of devices in New Zealand primary school classrooms. This literature review seeks to answer the question: *What has been researched about the use of devices within classroom environments?*

To support the exploration of this question a framework of the socio-material approach and technology acceptance model is included first. This is followed by a narrative review, first of artificial intelligence in education, and then specifically of voice assistant devices in the classroom.

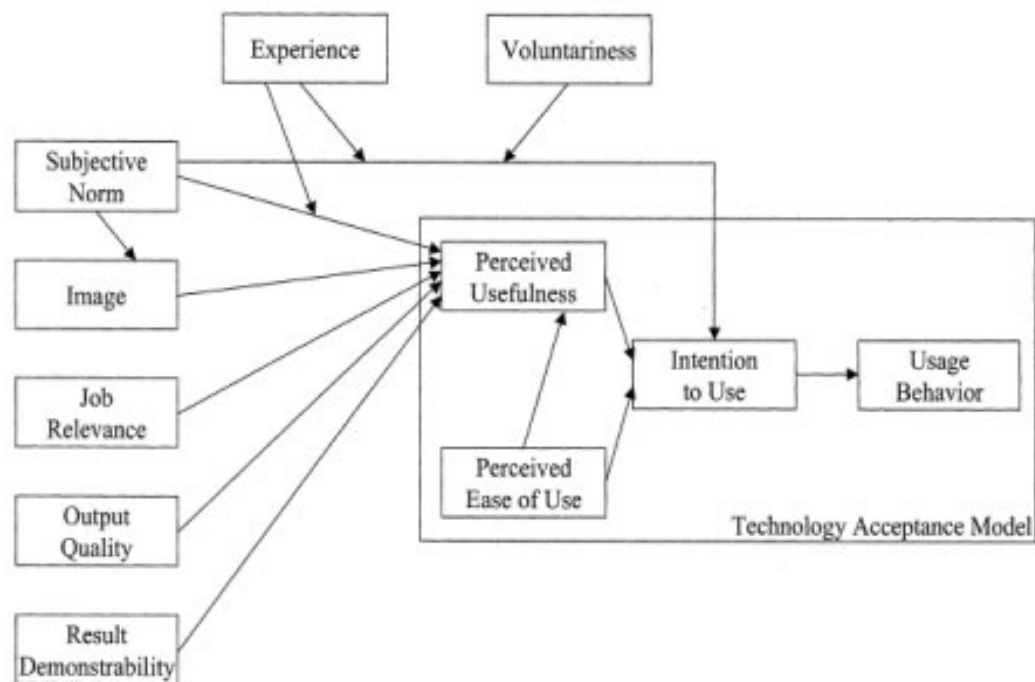
Socio-material Theory and Technology Acceptance

This research uses socio-material theory. Socio-material theory focuses on the intersection between the technology, devices, and the social environment, a classroom populated with teachers and students. Theories of socio-materiality include actor-network theory and stem from the Information Management studies discipline (Orlikowski, 2007; Orlikowski and Scott, 2008) but is widely used in studies on the use of technology in education (Granić & Marangunić, 2019). In their systematic literature review of research which applied TAM models to classroom settings Granić and Marangunić (2019) found perceived usefulness and perceived usability to be highly capable of assessing students' beliefs on classroom technology. Socio-material theory suits research on the social environment of a classroom because it does not focus on the individual student, but the social networks and environments within which they act. Unlike technological determinism, social-materiality suggests that the social and environmental factors around students shape the technology they use, rather than the technology shaping the socio-material context of the world (Fenwick, 2015).

Socio-material theory acknowledges that this interaction, between the social environment and technology, shapes teaching and learning (Sørensen, 2009). The devices are not designed specifically for classroom situations or social learning (Dousay & Hall, 2018). It is therefore important to consider which physical and social features of the classroom may influence the way material items (the devices) are used (Fenwick, 2015). Case studies must "make[s] visible the materiality" (Fenwick, 2015, p.366) to observe the impact the technology has on it. This includes considering the devices not as a tool which is or is not effective in the classroom universally, but a tool which may have different perceived usefulness in differing environments, with different learning tasks and teachers (Dousay & Hall, 2018). This allows students to determine the environment in which the devices are observed by how they interact with it.

Taking a socio-material approach means using frameworks which do not focus on the technology stated abilities, or objectively measured outcomes, but on the perceptions and interactions of the students. Due to the socio-material approach the research focuses on the physical and social environment including the social climate, and the social consequences of a student's actions, such as choosing to use a certain technology (Fenwick, 2015). Technology acceptance rather than technology competency is the focus of this research. Many technologies which are technically capable of a task sit unused in offices because the people completing the task do not want to use them, and many schools face the same experience (Luckin et al., 2016). As rational actors, students and teachers will not use the devices unless they see a benefit in doing so do (Venkatesh et al., 2003). Given that the devices, and AI technologies in general, are relatively new in classrooms (Luckin et al., 2016) it is important to first understand whether, and how, students and teachers accept these devices as useful and have an intention to use them as a behavioural phenomenon.

TAM is a popular framework for assessing technology acceptance in the workplace. Amongst the oldest of the frameworks, the Technology Acceptance Model (TAM), was created in 1989 and revised in 2000 (Venkatesh et al., 2003). Originally technology in the workplace was assessed via two criteria: perceived usefulness and perceived usability (Venkatesh & Davis, 2000). The model's revision to TAM2 (Figure 2) acknowledges that students do not accept or reject technology just based on their own perceptions but are influenced by how they believe other people perceive them too (Venkatesh et al., 2003).

Figure 2*Extended Technology Acceptance Model (TAM 2)*

Note. Taken from Venkatesh & Davis, 2000, p.188

TAM models have been popular in the study of how technology is used in classrooms (Lee, Kozar & Larsen, 2013). The framework has been used to assess both teachers' and students' perceptions of new technologies in educational contexts (Al-Azawei, Parslow & Lundqvist, 2017; Mayer & Girwidz, 2019). While there is some discussion on the effectiveness of TAM for assessing social influence in classrooms, the model is used because of the relevance that perceived ease of use and perceived usefulness appear to have on acceptance (or rejection) and intention to use a classroom technology (Al-Azawei et al., 2017).

Since TAM2 was introduced further technology acceptance models have been proposed. The Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh, Morris, Davis & Davis, 2003) builds on TAM2. UTAUT considers demographic data such as

gender, age, and experience which would have been difficult to discuss in this research given that the devices' transcripts do not record this information. The authors of the model themselves critiqued the use of UTAUT's social influence criteria in contexts of voluntary use (Lee et al., 2013). The chosen TAM2 model must be suitable for a voluntary use context. Technology Acceptance Model 3 (TAM3) again revised the TAM model (Venkatesh & Bala, 2008). The revisions to TAM3 does not fundamentally change the way perception is discussed but add additional considerations. All TAM models focus of perceived usability and perceived ease of use. TAM and TAM2 remain widely used in studies of technology acceptance (Lee et al., 2013). The UTAUT and TAM3 frameworks also add a level of complexity and detail that is not appropriate for a topic for which few case studies currently exist. Considering the strengths of all revisions, this research adopts the TAM2 (Venkatesh et al., 2003) as a framework for discussing the use of devices in classrooms, and the decision of teachers and students to accept or reject the devices. The research focuses on four parts of TAM2, discussed below in the context of the case studies.

Using TAM2 begins by considering the starting point of those using the technology including any prior knowledge or expectations they may have (experience). The model also considers if the technology is being used voluntarily, with users choosing from a range of tools, or because they have to (Venkatesh et al., 2003), for example because a teacher assigned them a set task using a specific computer program. Students will sometimes find they have a choice, for example when completing a research task, but may also be required to use some technologies, for example for a school wide assessment, or cloud storage solution adopted at a school level. Testing by the authors of the TAM2 model suggest it is less accurate in predicting usage in mandatory settings (Venkatesh & Davis, 2000).

Perceived usefulness is how effective the new technology is perceived to be at completing a job (task), compared to existing tools normally used to complete the task (Venkatesh et al., 2003). For students these existing tools include human, digital, and any

other resources (for example dictionaries or maths manipulatives) they have available to them. Tasks they find the technology useful for may be both assigned learning tasks, but may also be tasks of their own creation, for example a curiosity they have, or a social need.

Perceived ease of use influences perceived usefulness. Users are more likely to perceive a technology as useful if it requires less effort. TAM2 concludes that a user will not readily accept a new technology if completing a job requires more effort than other tools available to the user (Venkatesh et al., 2003). Teachers may consider ease of use as the effort involved in setting up, maintaining, and monitoring use of a technology. They may also consider how much support students need to use the device. Students may consider the effort of using the technology itself, as well as the ease of using it in their classroom environment (for example, waiting to use a shared device, or the noise level in the surrounding area).

Perceived usefulness is also impacted by several external factors which are defined by TAM2. These external factors include how a user might be influenced by their social context when using the device (subjective norm and image). Subjective norm is how a user believes others who have an influence on them think they should be using the device (Venkatesh et al., 2003). In classrooms influence comes from two groups. Students will be influenced by teachers' beliefs and expectations around the technology and the way in which they are permitted to use the technology in the classroom. Peer students' beliefs on usage will also influence other students. Subjective norms in a classroom may include when students believe they can use the device, which tasks they can use it for, and whether they are expected to use it by themselves, in groups, or both.

Image is how students believe other people's perception of them will be influenced by them using the device (Venkatesh et al., 2003). The subjective norm sets the rules for how a user can use a technology appropriately. How these rules are followed by a user will

determine if they perceive others have a positive or negative image of them using the technology. For students, concern over their image might include seeming “cool”, appearing intelligent and might be influenced both by how they use the technology and how successful they are at using it. For students in a classroom community, both subjective norm and image can be influential in how, and if, they use a certain technology in their learning. Given that AI tools are often designed with personalities and opinions, encouraging users to anthropomorphise their device (Duffy, 2003) we can consider whether the device itself can influence students’ perceptions of their image while using the technology.

Other external factors influencing a users’ intention to use technologies relate to the users’ perception as to how well it completes a task. Job relevance, output quality, and results demonstrability are considered (Venkatesh & Davis, 2000). Users’ perceptions about the suitability and ability to deliver results influence how useful they perceive it to be. In the classroom job relevance may be low if a technology was not specifically designed for education, as is the case with the devices. Both teachers and students may look for examples that the technology has helped with other’s learning before accepting it for their own use. As students use a new technology, they will make decisions about how useful its’ output is, immediately and over time, helping determine whether they continue to use it (results demonstrability).

This research discusses the influence of subjective norm and image on intent to use. The highly social environment of a classroom, and perceived importance of complying with norms makes these two external factors especially important. The communal nature of the device increases the importance of these social influences.

A key part of TAM2 is that, for a technology to be widely accepted by students, it will have to have higher perceived usefulness and ease of use than alternatives, be considered the subjective norm for completing a task, and be perceived to create a positive image of the

student (Venkatesh et al., 2003). It is expected that devices which do not outperform the students' other resources, are difficult to use or create a perceived negative social impact for students will be used less.

Luckin et al. (2016) and Dousay and Hall (2018) note that educators can think of many potential use cases for the devices in education. Some of these uses may be realised in current versions of the devices, whilst others, such as the fully connected smart classrooms proposed in the literature (Uskov et al., 2018) are aspirational. Luckin et al. (2016) propose models of capabilities which AI technologies will need to be proficient in before they can be effective in educational settings (Figure 3). Three models (pedagogical, domain, and learner) then inform a fourth model (open learner) which allows for communication and sharing with families. The models in Figure 3 are useful for assessing the next developments which may make AI more useful in an educational setting, but they do not address the diversity in teachers' pedagogical beliefs, as one pedagogical model would not suit all teachers and learners.

Literature on AI infused smart classrooms breaks development into three generations (Uskov et al., 2018; Xie, Shi, Xu & Xie, 2001; Luckin et al., 2016). Pre-2001 technology was experimental, rare, and often built by the user as commercialisation of the technology for homes and businesses had not taken place (Xie et al., 2001). Between 2001-2008 increasingly "smart" communication systems were rolled out in many schools to aid synchronous learning in local schools and tele education, allowing students and educators to use technologies such as video chats to communicate with experts' long distances away (Uskov et al., 2018). The third generation, 2009-present has seen rapid updates to software, and many schools opting for 1-1 mobile hardware devices (Uskov et al., 2018). In the later part of this generation, connectivity via the Internet of Things (IoT) and increased customisation via machine learning has seen automation and personalised learning increasing in a few classrooms (Atabekov, 2016).

Figure 3

AIED Models For Proficiency

AIED models	What the model represents	Examples of specific knowledge represented in AIED models
Pedagogical model	The knowledge and expertise of teaching	'Productive failure' (allowing students to explore a concept and make mistakes before being shown the 'right' answer) Feedback (questions, hints, or haptics), triggered by student actions, which is designed to help the student improve their learning Assessment to inform and measure learning
Domain model	Knowledge of the subject being learned (domain expertise)	How to add, subtract, or multiply two fractions Newton's second law (forces) Causes of World War I How to structure an argument Different approaches to reading a text (e.g. for sense or for detail)
Learner model	Knowledge of the learner	The student's previous achievements and difficulties The student's emotional state The student's engagement in learning (for example: time-on-task)

Note: Taken from Luckin et al., 2016, p.19

These generations represent technologies which are available to, and increasingly designed for, educators. There still exists inequalities in access to technology (Starkey, 2010) with students' access to both hardware and home broadband internet varying. Despite this third generation of technology making tools easier to access, many classrooms remain without any smart technologies. Students' access to AI tools in the classroom is still often restricted by school budgets and teachers' personal motivation to seek and use the tools,

driven by their beliefs about the technologies' usefulness. This generational breakdown highlights the difference between what may be technically possible and the reality of most classrooms.

A fourth generation of smart technology for classrooms seems likely to utilise machine learning to improve itself and provide each learner with a more personalised experience. Uskov et al. (2018) propose the next generation of AI for education by three criteria: sensing (listening in the context of the devices); learning by experience; and anticipating needs. This next generation could also be defined by its custom suitability for educational purposes, where the current third generation is still created for home and business use primarily. Both Uskov et al. (2018) and Luckin et al. (2016) note the need for the devices to be able to identify and meet the needs of learners as individuals. While Luckin et al. (2016) primarily focuses on developments which may increase perceived usefulness and functionality, for example allowing students to experience productive failure (Figure 2) Uskov et al. (2018) focus on improvements to ease of use, for example better listening and understanding of students' speech. For students to accept the technology for an increasing range of classroom uses, both perceived usefulness and perceived ease of use are important to develop.

Another perspective on this next generation considers how students will shape the development of technology. While utilising natural language processing technologies to communicate verbally, the devices still make heavy use of Google's search algorithm. Orlikowski (2007) illustrates how the outcome of a Google search is a combination of the technology and the human interacting with it. This demonstrates how the devices currently attempt Uskov et al. (2018)'s criteria of learning by experience and anticipating need, and how the perceived usefulness of results should increase in the future as the devices learn based on students' use of them.

The technology Google uses to return search results is a set of algorithms that the user does not see or understand, and it is true that the technology displays results in an order the user does not completely control. The results are ever changing, shifting by the user's choice of language, the information on the websites ranked and listed by Google, and the previous popularity of each result. Furthermore, the user decides what action they take when they receive the results, influenced by their environment (Mitchell, 2019). For example, a user may always select the first result, or choose to trust the information on the Google card in the search results. Google Home devices are programmed to make some decisions for the user, by returning information to users based on their choice of words and previous questions asked on their device. However, students choose what to do with the information (Orlikowski, 2007). Students' confidence and the subjective norms of using, and challenging, AI technology such as the devices could shape the way AI technologies are designed for teaching and learning.

The extent to which technology will reduce teacher input into students' tasks is hugely dependent on the task (Luckin et al., 2016). This is true of the current state of AI replacement of professionals in most fields (Mitchell, 2019). Mitchell (2019) also notes that whether a task is easy or difficult is often different for humans and machines. This means that tasks educators believe are complex (for example multiplying two six-digit numbers) may be 'easy' for the devices, while tasks we may consider easy (for example noticing frustration on a student's face) is difficult for the device.

The devices may already surpass teachers' general knowledge, but students' relationships with their human teachers remain important to learning (Uskov et al., 2018; Hattie 2012). Young children are however encouraged to anthropomorphise, for example books and movies such as *Antz* or the *Toy Story* franchise, featuring non human characters showing human qualities like walking and talking. This may mean that students could build a

relationship with an AI learning assistant, like the relationship students build with their teachers, even if the AI's interface is not overly convincing (Duffy, 2003).

Voice Assistant Devices' Acceptance in the Classroom

To establish existing case studies on the use of the devices in classrooms a search was carried out across educational databases, including Google Scholar and ProQuest and within two specific journals, Computers and Education and the International Journal of Artificial Intelligence in Education. The databases were chosen as they are wide reaching and encompass most smaller databases and sources of educational and humanities based published academic writing.

Four articles were identified which specifically research the use of virtual assistant devices in classrooms. Three of these were in primary school classrooms, while one (Dizon, 2018) was a university environment. The four studies identified each used Amazon Alexa devices.

Goksel Canbek and Mutlu (2016) discussed both dedicated virtual assistant devices such as Alexa, and built in software solutions such as Apple's Siri and Microsoft's Cortina, and the role they can play in classroom learning, positioning the devices as a key part of the smart classroom. The study found that all the devices were similarly capable and differences between devices were not significant in an educational context (Goksel Canbek and Mutlu, 2016).

Dousay and Hall (2018) is the largest of all the studies, as a case study of 90 classrooms in one school district in the United States. Teachers were given Amazon Alexa Echo Dot devices and asked to use them as they saw fit. Use was varied, the researchers noting that teachers who found a regular task or third-party skill (app), for example reading the news or giving reminders, were more likely to use the devices. Where a routine was

established by the teacher, some students began to use the devices independently of the teacher, during informal morning times. Specialist teachers, including maths and music teachers, found the devices particularly useful. The study also considered the administration of multiple devices in a network and noted challenges and frictions. The issues identified included a lack of options for central visibility of activity on multiple devices, the inability to “push” settings or third party functionality onto all devices within a school, and concerns over privacy because the devices are always listening in classrooms (Dousay & Hall, 2018).

Two other studies are case studies specifically looking at the use of devices with English language learners. Both Underwood (2017) and Dizon (2018) are teacher-researchers who introduced the devices to students and explored their use of the devices. Underwood (2017) describes the devices as an ‘English Helper’, noting that students used their device to practice their conversational English as well as asking it questions. Students in the class indicated they anthropomorphised the device during their conversations with the technology, adding human features when asked to represent their device in clay (Underwood, 2017). The researchers found that using specific prompts and apps improved the speed of progress English language learners made compared with those not using the devices, and that the desire to talk to the device was important to this progress (Dizon, 2018).

All four studies noted that the devices were easy to use, and most useful in supporting students in their defined learning tasks (Underwood, 2017; Dizon, 2018; Dousay & Hall, 2018; Goksel Canbek & Mutlu, 2016). Only two of the studies considered the subjective norm established by the social environment of the classroom (Dousay & Hall, 2018; Underwood, 2017). Overall students in the studies accepted the devices as part of their classroom environment and respected other students’ use of their devices. When practicing their developing language skills with their device students did not judge each other

or seem to feel judged by their device (Underwood, 2017). Both case studies noted that the devices were accepted by students as a learning assistant.

Limitations of the devices were noted by several of the studies, and these can be broadly categorised by the pedagogy and learner domains of the AleD Models for Proficiency I in Figure 3. In both general classes and English language learning environments the devices could process and answer most learner enquiries, making them easy for students to use (Underwood, 2017) and the devices' domain knowledge of general information was useful. As the devices in all studies except Dizon, 2016 were communal, rather than personal devices, they had virtually no knowledge of their learners. Pedagogical knowledge of the devices is limited and is general to the devices' role of informing, rather than being able to reflect the teacher's beliefs on teaching and learning or adapt for the type of learner making the enquiry. The devices generally gave clear and concise responses so that they could be useful and informative (Goksel Canbek & Mutlu, 2016).

Conclusion

The literature on the devices indicates that most teachers and students accept the devices as useful and easy to use as an additional resource in the classroom. The devices' place in a smart classroom is theoretical and untested, but literature on smart classrooms is consistent in stating that the devices will play an important role in the smart classroom ecosystem.

Method

This chapter outlines the rationale and design of the multiple case study research conducted. Details are given on the processes followed. This chapter discusses the data analysis on which the thesis of the following chapters is based. The ethical considerations and limitations of the research are described.

Research Method

A mixed methods approach was used in this interpretive multiple case study. Both the research questions and the methodology were designed to form a broad initial view of the use of devices in the classroom. Being mixed methods both qualitative data, the Google Home transcripts and teacher interviews, and quantitative data, for example frequency of question categories, was collected. Using a case study approach allowed for a full, detailed account of the technology in its environment (Christensen & Johnson, 2017, p.355). The study was interpretive because the results of the two case studies are discussed from the "participants perspectives" (Christensen & Johnson, 2017, p.300), using a technology acceptance model. Thus, there are confounding aspects that prevent correlation of results and therefore the data is analysed using descriptive and interpretive techniques.

Case studies

The multiple case study approach built on the examples of the existing literature (Dousay & Hall, 2018; Underwood 2017) with teacher interviews used to ensure interpretive validity, ensuring I correctly understood the events and environment of each classroom, and the impact these had on device usage (Christensen & Johnson, 2017). Teachers and classrooms are all unique cases with very practical considerations and often strongly held pedagogical beliefs influencing the way students interact with technology. Because "qualitative case study was developed to study the experience of real cases operating in real situation[s]." (Stake, 2013, p. 3) the importance of unique social interactions is highlighted.

This allows the research to explore the situational complexity and contextual differences between classrooms and students. This approach is suitable given the broad research questions (Stake, 2013).

Participant recruitment

This study employed a convenience sampling technique. Classroom teachers self-nominated to participate in the study. To be eligible to participate, the case studies were in one region of New Zealand, to enable the researcher to visit the classrooms to introduce the project and offer technical support if needed. They also needed to be classes of students between Year 3-8. Junior classrooms were excluded so that a reasonable expectation could be made that students had the oral language skills to be understood by the devices most of the time, and because the research was designed to require students to have a certain level of independence from their teacher(s). Classrooms also needed to be English-medium, because technical limitations of the devices mean that Google Home cannot understand or respond in te reo Māori. Both schools selected were state schools with classroom teachers who considered themselves generally knowledgeable and enthusiastic about trying new technologies in their classroom.

Two classrooms in two schools agreed to participate in the study without their identity being revealed. These schools were chosen as the classroom teacher nominated their class to participate. Recruitment of interested teachers was through word of mouth (in both cases a professional contact of colleagues of mine) and as the researcher I had no direct professional or personal connections with either class. Consent was then sought from the Board of Trustees or Principal of each school, along with the classroom teacher and other participating adults. Once this was confirmed a parent or guardian of each student in the class received an information sheet and consent form, sent and returned in a plain envelope to avoid any social pressure to consent. It was necessary that 100% of parent consent was achieved, as the devices may have recorded any student's voice. Students were then

introduced to the project during a presentation I gave in person in their classroom, including a question and answer session. Each student had the opportunity to consent or decline to participate in the research. Once all students had consented the class was selected as a case study. While it was anticipated the 100% consent rate required may make it difficult to find qualifying case studies, both the case studies were the first classes where gaining consent was attempted. This may have been due to the excitement, in both teachers and students, at having the device in their classroom and keeping the device after the research was completed.

Case study one was in a single cell classroom, with students in Year 3 and 4 including ten receiving ESOL (English for Speakers of Other Languages) funding. Mornings were focused on literacy and numeracy skills with other learning areas were taught in the afternoon. The school used an inquiry learning model. Across the school it was common for English to be an additional language to a student's first language.

Case study two had 69 students in a modern learning environment, with students ranging from Year 4-8. The school's curriculum focused on collaborative, project-based learning. The classroom had two students receiving ESOL funding. All other students had English as their first/home language. Although treated in the same way, each case study was considered individually as the context differed (Stake, 2013). A few weeks after the transcript data collection had concluded, I conducted a semi structured interview with the classroom teachers of the two case studies. These interviews were focussed on increasing my awareness of classroom culture and activities during interactions with the devices, using datetime stamps. These interviews included planned questions (Appendix A) and gave the teachers an opportunity to express their thoughts on the use of the devices. The interviews were audio recorded and transcribed. This transcript was sent to the interviewees for comment, after which it was combined with the device transcript data to inform the research findings.

Procedures

In Week 4 of Term 3, before the case study began and after consent had been established, the researcher visited each of the case study classrooms. Prior to meeting with students, the devices were set up by the researcher and the classroom teachers were shown how to use them. In a short introductory session, the researcher demonstrated using the devices, discussed the limitations and rules of use with students, including what to do if they had a problem or were concerned, and answered student questions. Each device was then disabled via the smartphone application and enabled the following Monday morning before students came into class.

Students were given no further instruction or encouragement to use their device. Teachers were encouraged not to use the device for students or as an example to them, and, as much as possible to let students explore the device on their own. This study is designed so that students' use of the devices is voluntary, and therefore motivated by their perceptions, rather than compulsion or reminders from a teacher, or a set task requiring the device. Teachers were assured that they could intervene if they felt it necessary, but asked to mention this in their interviews, which they did.

Materials and Setup

Each classroom had a single Google Home Mini device installed in their class, connected to the school's Wi-Fi. The devices were purchased and gifted to the school at the completion of the research. The researcher did not download any additional capabilities to the devices, only native applications were running when the research began. Before setting up the devices in the classrooms, Google Accounts (classroom1vadresearch@gmail.com and classroom2vadresearch@gmail.com) were created by the researcher to register and set up the devices for the respective case study classrooms. Teachers were able to upload additional information, such as classroom timetables, to these accounts. These accounts were deleted at the conclusion of the research. Because Google Voice, the technology

behind Google Home, is not a Google for Education product the devices could not be connected to either of the classroom teachers' school email addresses, connected to their Google Apps for Education accounts. During the research only the classroom teacher, me and my supervisor and I had access to the Google Accounts, allowing for control, access and change the password if needed.

Classroom teachers downloaded an application to their personal smartphones which allowed them to remotely control their device and view a real time transcript of questions and response interactions with their device. Classroom teachers were also shown how to use the smart phone application to download additional applications to their devices and extend its capabilities. I also had the same access to the devices on my smartphone, allowing me the same views and information as the classroom teacher. During the case study duration, the researcher only used this application to download the transcripts of the devices for the purposes of data collection.

Both devices were placed next to the classroom library or book area (Figure 4). This was chosen because it tended to be a quiet area within the classroom, with minimal background noise for the device to hear and it was an area that students already associated with finding out information. The only other resource supplied to classrooms was an A4 sheet with a short list of reminders (Appendix B). This list was posted directly above the devices.

The devices were available to students from Week 5 to Week 10 of Term 3, 2019. Students had access to the device when in the classroom, including indoor break times, before school and during learning activities.

Figure 4

Placement Of The Device



Note. Published with permission

During the introduction session students were encouraged to help each other if their device did not understand them. This included students who had difficulty being understood by their device as well as students whose word choice did not return a satisfactory response from their device. Students and the classroom teacher were discouraged from relying on adult intervention unless students were becoming overly frustrated and had tried to resolve the issue themselves. Relieving teachers and parent helpers were informed of the research but were asked not to speak to the devices.

Data Collection

The devices were operational in classrooms between 22 August and 27 September 2019. Google's online platform created a written transcript of the devices' use which became the transcript used in this research. The transcript recorded the following data:

- Name of device used (*case study one or case study two*)
- Question asked, as understood by the device

- Name of third-party app used, if appropriate
- Use of timer, calculator or another native tool, if appropriate
- Response given by the device
- Time and date of question asked

This data was received as is from the transcript and was manually coded at my discretion (the transcript did not pre-categorise the data). The data was coded within three categories:

- Purpose: Trends and keywords to clarify the intent of the enquiry
- Learning area: subject as defined in the New Zealand Curriculum Framework
- Function: the technical way the device answered the enquiry

Categories were used to negate a common pitfall of using TAM in education studies, that broad statements about acceptance did not identify task dependent outcomes and acceptance (Lee et al., 2013). These categories were coded using a mixture of a priori codes (for learning area and function categories) based on those generated for the smaller study I completed in 2018, and those from a larger North American study (Dousay & Hall, 2018) and inductive codes that emerged from the data (for purpose categories). Inductive codes were added as appropriate on a week by week basis, including for the purpose categories, as the transcript was reviewed. The full list of codes can be found in Appendix C. At the conclusion of the study the codes were reviewed to remove human error and group like codes for clarity.

Data Analysis

Transcript data was coded on a weekly basis, to quantify the frequency of different characteristics of queries students made of the devices. Once the full six weeks of transcripts had been collected the second-stage coding was completed. The resulting data was then analysed by creating hierarchies and enumeration of the coded data. A series of charts and graphs were then generated from which the data was interpreted.

The transcripts were used to give further detail as to how students use their device, the language they used with their device, and how many attempts they made to get a satisfactory answer from their device. Teacher interviews were then conducted. The classroom teachers were asked for their professional opinion on the usefulness of the devices to support learning, and to identify any trends they observed regarding student groups who used the devices differently, for example more or less frequently, than others. Of greatest value during the interviews was insight into how teacher pedagogy and classroom environment had impacted the use of the devices.

Ethical Considerations

The research is designed to comply with the VUW Human Ethics Guidelines and the New Zealand Association for Research in Education (NZARE) Ethical Guidelines 2010. Prior to commencing the research, it was approved by the Human Ethics Committee of Victoria University of Wellington in June 2019 (Application ID: 0000027378).

Data Security

Data was collected via the Google Home online portal, which created a transcript including which device was used, the geo-location of the device, the enquiry as the device recorded it and the answer given. The data was confidentially stored in the online portal and transferred manually to software for analysis. All data will be destroyed at the end of March 2020.

To support the research each classroom teacher gave me information about the school's decile and classroom timetable and some basic demographics about the school and class. None of this information was specific enough to identify the classroom or school. This information was stored in a shared Google Drive folder and was to be destroyed at the end of March 2020. This information was not anonymous, allowing me to follow up in classroom teacher interviews. All data was kept confidentially.

Informed Consent

Students and parents/caregivers were informed via an information sheet and their consent to participate in the research was requested via a letter sent home. The communication to families and participants included a clear rationale for, and explanation of, the research, explaining that data will only be available to their classroom teacher, my supervisor and me. The letter also notified parents and participants that the data, as with all devices' data, would be stored and owned by Google, but was deleted from the devices' histories at the conclusion of the study at the end of March 2020.

Parents and participants with concerns or questions were encouraged to contact my Supervisor or I, although none have done so. All participating classrooms also required the permission of the classroom teacher, and the school's Principal and their Board of Trustees. To ensure that only those who had consented could participate, teachers and students were made aware that only students in that classroom could use their device, not those visiting from other classes.

Students were instructed that if they accidentally triggered their device and think it recorded them saying something they did not intend it to they were to notify their classroom teacher, who would then remove this recording from the transcript generated by Google (which was used as the research transcript). However, this was not required at any point.

Safeguarding Participants

In the interests of safeguarding and complying with participant schools existing IT usage policies, the devices' settings were changed to 'Parental Controls: On. Data was reviewed by me on a minimum weekly basis and any questions or answers pertaining to students' wellbeing, for example self-harm, were to be communicated to the classroom teacher immediately. Classroom teachers were encouraged to check their transcript at least daily. There was one instance where I notified the teacher of a low-level concern and this was addressed by the classroom teacher immediately.

Participant Benefit and Availability of Findings

All participating schools had access to the findings for their school via a set of preliminary results focussing on the findings and recommendations, and insight from that class or school's data. This was targeted at helping teachers and schools decide on the

future use of such technology. Should school communities want more information the full research it was to them once complete.

Sample Size

Due to the length of the research, and the expected volume of transcripts, this research included just two case study classrooms. While this was not a big enough sample to make generalised statements, it was enough to act as a pilot, on which we can form hypotheses for further research. Given the literature reviewed, this research is the second biggest published study of these devices in classrooms, second to the 900-student Amazon Alexa study (Dousay & Hall, 2018).

Limitations of Technology and Data

The data collected from the devices was collected via a device-recorded written transcript, not an observation. This means that this research was only be able to benefit from the data collected by each device, and then relied on the interviews with teachers to contextualise any significant patterns. My assumptions, informed by the teacher interviews, formed a proxy for student perceptions, and this is noted in the discussion as needed. Transcripts were incomplete when the devices did not understand the question or instruction.

Findings

Students ($n=99$), made thousands of enquiries ($n=3377$) to the two devices provided for the case studies. Differing results in the two classrooms reflect the differing environments and differing pedagogical beliefs of the teachers. The following findings are largely reported separately, with some general themes also emerging across both classrooms.

Of all the enquiries, 25.05% were asked by case study one ($n=846$), and 74.95% were asked by case study two ($n=2531$). Case study one had 29 students and case study two 70 students, but even considering this case study two used their device slightly more, averaging at about one extra enquiry per student per week (Table 1). Further discussion with the case study two teacher suggested that these additional enquiries were more likely multiple additional enquiries from a small group of mostly male students, rather than increased participation from the whole class.

Table 1

Overall Enquiries Per Class

	Number of students (s)	Number of enquiries (e)	Average number of enquiries per student (e/s)
Case study one	29	846	29.17
Case study two	70	2531	36.16

Note. The number of enquiries (e) divided by the number of students (s) gives the average number of enquiries per student (e/s). This is higher in case study two than in case study one.

Both classrooms used their device for spelling tasks, word definitions, and basic maths operations. The teacher in case study one connected their device to her Spotify account, and the classroom's Smart TV, allowing students to instruct their device to play music and YouTube videos. Case study two students requested their device play music, but as no music provider was set up by the teachers these attempts were unsuccessful. Students in case study two did use their device for a variety of other uses, from curiosities not always related to students' learning tasks, to a range of personal enquiries, asking their

device's advice and opinions, requesting jokes and changing the name by which their device addressed the students.

Context

The two case study classrooms took different approaches to managing their device use. In case study one students were able to use their device freely in mornings, inside break times and briefly after school. During learning time, including transitions, the use was monitored by the classroom teacher and teaching assistant, with the expectation it would only be used to support assigned learning tasks. In case study two, students were given free use of their device whenever they were permitted to be in their classroom. Case study two teachers monitored student use retrospectively, but they did not place any restrictions or expectations on students' use of their device, other than those outlined by the study. For students in case study two, use of their device not directly related to learning tasks was without consequence, and more common (Figure 6).

Both case study teachers interviewed expressed positivity towards the impact the devices had on their classroom, seeing it as a net positive, while acknowledging some limitations. Case study one's teacher noted "it was useful, I liked having it in the classroom" and said the class continued to use the device after the case study finished. The case study two teacher noted the future potential of the device saying "... even though there might not be a million things to do with them right now I think there is going to be" and noted he had purchased another device so the classroom now had two devices for students to use. In both cases teachers in the school's other classes had started to use voice assistant devices in their classrooms too, as a direct result of the case study classrooms involved in the research. Both case study teachers said they now used their device with a more teacher-directed approach.

Both teachers noted that the students used their device regularly to check spelling but expressed different beliefs about this. For the teacher in case study one this was initially a positive, saying “I had a writing PD and I took it [the device] with some kids in my class over to show the writing guy how the kids edited their work...”. By the end of the case study however, the case study one teacher was concerned that students were not regularly using the other spelling strategies they had been taught, instead relying on their device. The teacher said:

There were a lot of kids going up there and they weren't using any of their own [spelling] strategies to go and and [sic], to do it before they went to it. So, I sort of said to them, oh hey remember you try your own thing first and then when we come to editing it's a good time to use it too.

The teacher in case study two noticed that students used their device for spelling above other strategies too, but said this had begun a discussion within the school as to the usefulness of teaching other spelling strategies to students, and whether students needed these, with the teachers asking students “You know, why are you asking me when there is another way to ask that question [how to spell a word]?”. The discussion in the case study two school had not reached a conclusion at the time of the case study interview. This difference in pedagogical belief about the devices' role in the classroom may have influenced the usage addressed in each of the research questions.

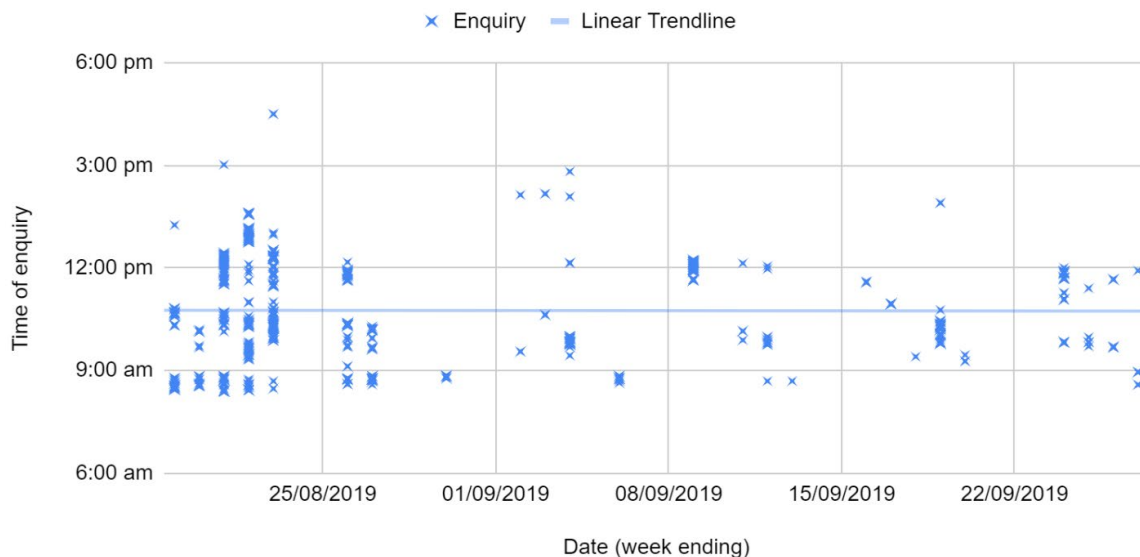
Research Question 1: When do senior primary school students use voice assistant devices in a classroom environment?

Case study one students used their device throughout the day, although use was heavier in the mornings than in the afternoons. Usage over time and date shows how, in case study one, usage was sporadic and lessened over time (Figure 5). This maps with case study one's explicit teaching in literacy and maths. Afternoons in case study one's classroom

were spent evenly split on social studies and science topics in the class, and out of class activities such as swimming, PE, and assemblies. According to the classroom teacher, the out of class activities accounted for 2-3 afternoons a week when the class are not in the classroom to access their device for most of the afternoon. The trendline in Figure 5 illustrates that the device was consistently most used in the classroom is between 10.30-11.00am, which is the end of the first morning session before the first break, when literacy tasks were being completed.

Figure 5

Case Study One Usage Timeline



Note. The whole day breaks in case study one’s transcript were explained by the teacher as times the entire class was out of the classroom for the entire day, as the classroom was being re-roofed.

Case study one used their device heavily to begin with, but over time classroom use declined, the teacher noting some students “forgot it was there” while others “...got a little bit confused about when were the right times that they could use it.” The case study one teacher noted that she did not remind students to use their device but did remind them several times not to “be silly” around their device during learning times or use it exclusively

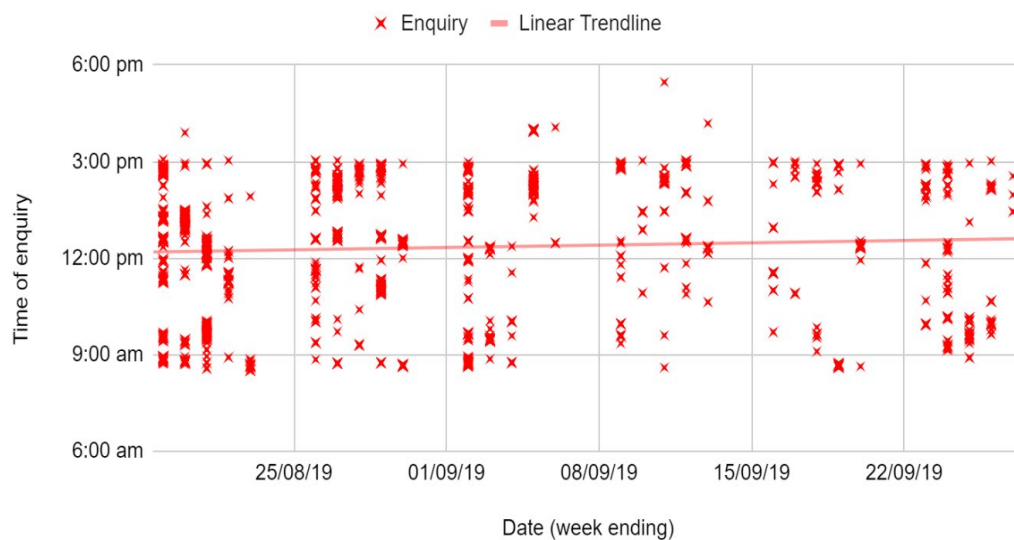
instead of other strategies or resources available in the classroom. As a result, “I think some of them still got a little bit like ‘Am I actually allowed to go and do this right now?’”. Although this was not recorded on the transcript, the case study one teacher noticed that one student made regular use of the device:

I had one particular boy who, um, you’ve probably heard his voice the whole time, who loves talking just is a constant talker... so he’ll talk to teachers he’ll talk to everyone, and as soon as that [the device] was there he was relentless on it so he treated it like it was another person that he could just ‘raw raw raw’ and ask a million questions.

Case study two’s classroom used their device consistently every school day (Figure 6). The only noticeable gap in the transcript is when they removed their device for one afternoon in week two during a multi school event, to ensure that only students who had consent were recorded by their device.

Figure 6

Case Study Two Usage Timeline



Case study two used their device throughout the day, with heavy use during transition times including before school, before breaks, and during pack up before home time. Heaviest usage was during unstructured project based in which students were pursuing their own curiosities with teacher support, but often without direct instruction on subject knowledge. The trendline in case study two is later in the day than in case study one, but, as with case study one, occurs during the end of their literacy session. The frequency of case study two's usage also reduced over time, although not as much as in case study one (Figure 6). For the case study two teacher, usage during transitions was most obvious, saying:

Times when they [students] were cleaning up and the transitions seemed to be when they used it more....There were certain children that did it more often and I think there was a sizable group of children who, how do I best describe these children? They like to be silly.

Both classes used their device extensively when the study began, and this declined as the study entered week two for case study one (Figure 5) and week three for case study two (Figure 6). Throughout the rest of the period case study two's usage remained about double that of case study one's usage. As the study progressed case study two's volume of personal enquiries to their device increased. The teacher in case study two described a "large but consistent" group of students who asked these questions, possibly as they became comfortable with the freedom they had to use their device, and began to test its limits and the personality behind its responses.

Research Question 2: What questions do senior primary school students ask the voice assistant devices in a classroom environment?

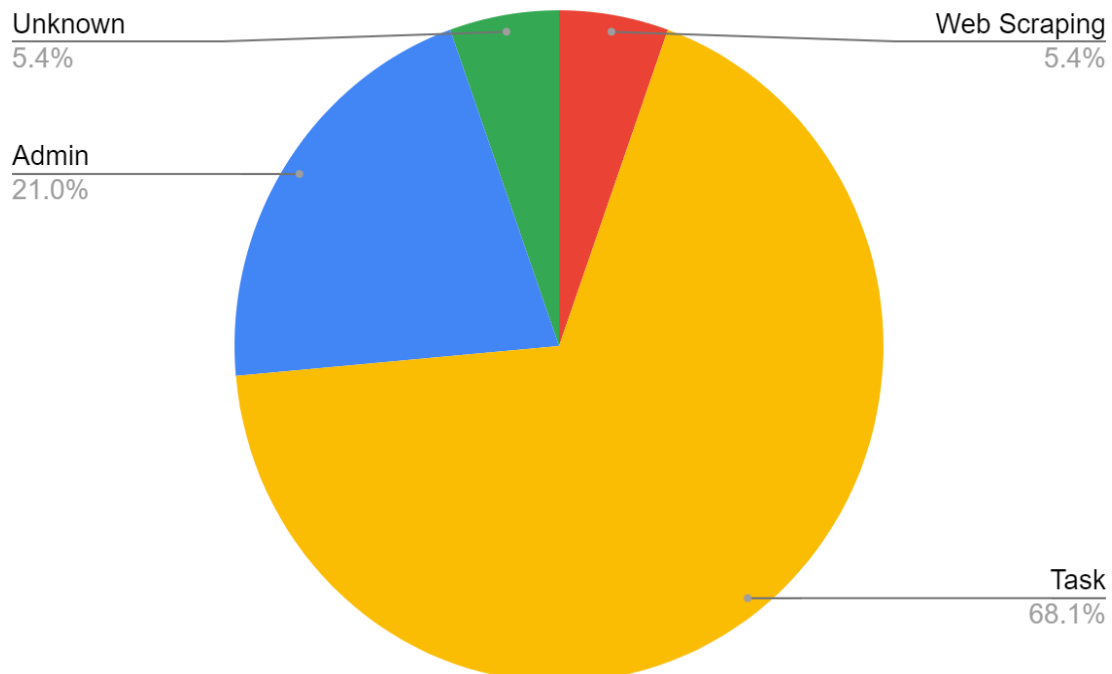
The types of questions asked of the devices were coded under three separate categories; learning area, based on the New Zealand curriculum framework, Function,

based on the process the devices used to respond, and Purpose, keywords or descriptors, which added context to the first two categories (Appendix C).

Case study one used the task function most regularly being functionality that the devices can complete natively, using AI (Figure 7). Case study two also most commonly used native skill functionality (Figure 8). Admin tasks are those which allow students to control their environment (Table 2) and the way that the devices interacts with them or ask the device's opinion. Web scraping tasks, when the devices search the internet for information and then, taking text from the top ranking result from a Google search, read it back to the students, were 5.4% of case study one's total enquiries and 18.2% of case study two's total enquiries.

Figure 7

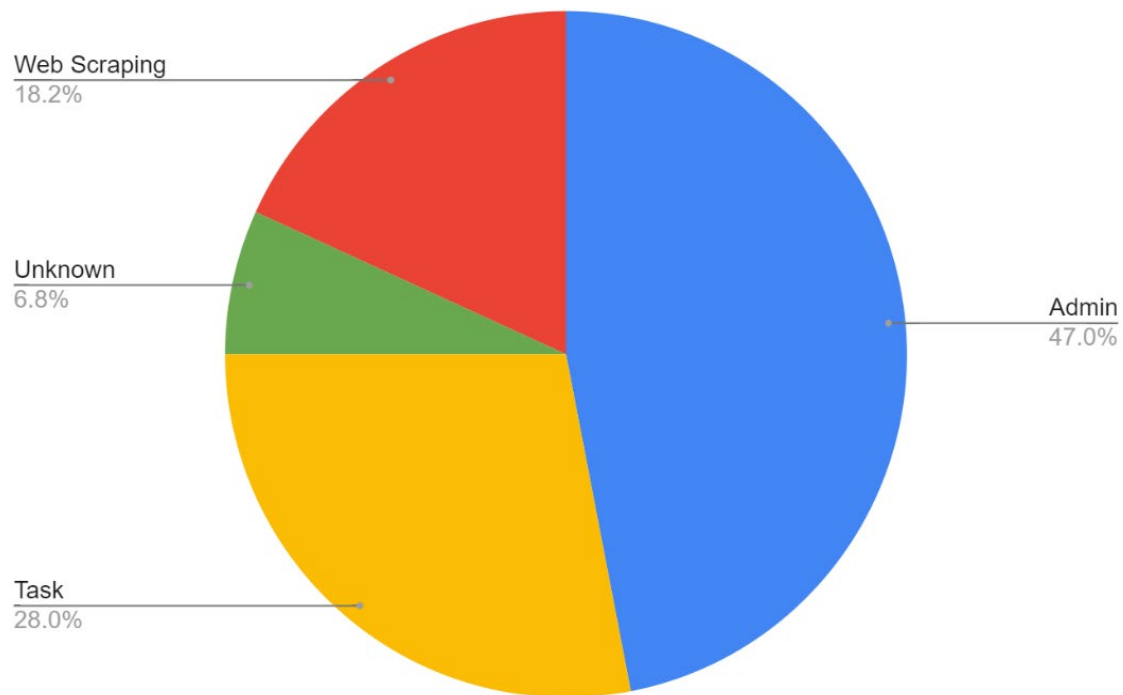
Case Study One Enquiries By Function



Some web scraping returned results that were read verbatim from the website found, while some results included a summary created by the devices. Unknown tasks include those which the devices did not record, and enquiries which were recorded, but where neither the devices nor I as the researcher understood the student's enquiry. Because the devices' ability to understand is a key part of the research these have not been excluded from the data.

Figure 8

Case Study Two Enquiries By Function



Use of task functionality included student attempts at triggering Internet of Things connections which had not been set up, for example turning on lights (Table 2).

Table 2*Unsuccessful Attempt To Control Lights*

Date of enquiry	Time of enquiry	Student enquiry	Device response
19/08/2019	12:36 PM	turn the lights off	com.google.homeautomation. It looks like those lights haven't been set up yet...
19/08/2019	12:36 PM	turn the lights on	com.google.homeautomation. It looks like those lights haven't been set up yet...

Both classrooms used their device for enquiries across a range of learning areas (Figure 9). Enquiries that were coded as 'Other' ($n=1727$) included jokes, personal enquiries to the devices and admin tasks. Overall, most tasks had a literacy component ($n=1914$), including spelling and word definition enquiries, as well as a successful request for the device to help students choose and research a speech topic.

In one example where a case study two student asked their device to help them choose their speech topic the device was able to find a range of suggestions on an age-appropriate website and read it to the student (Table 3). From the interaction between the student and their device (student:" thanks") it is apparent that this was useful to the student's learning, and they go on to further explore ideas about good speeches using their device.

Figure 9

All Enquiries By Learning Area

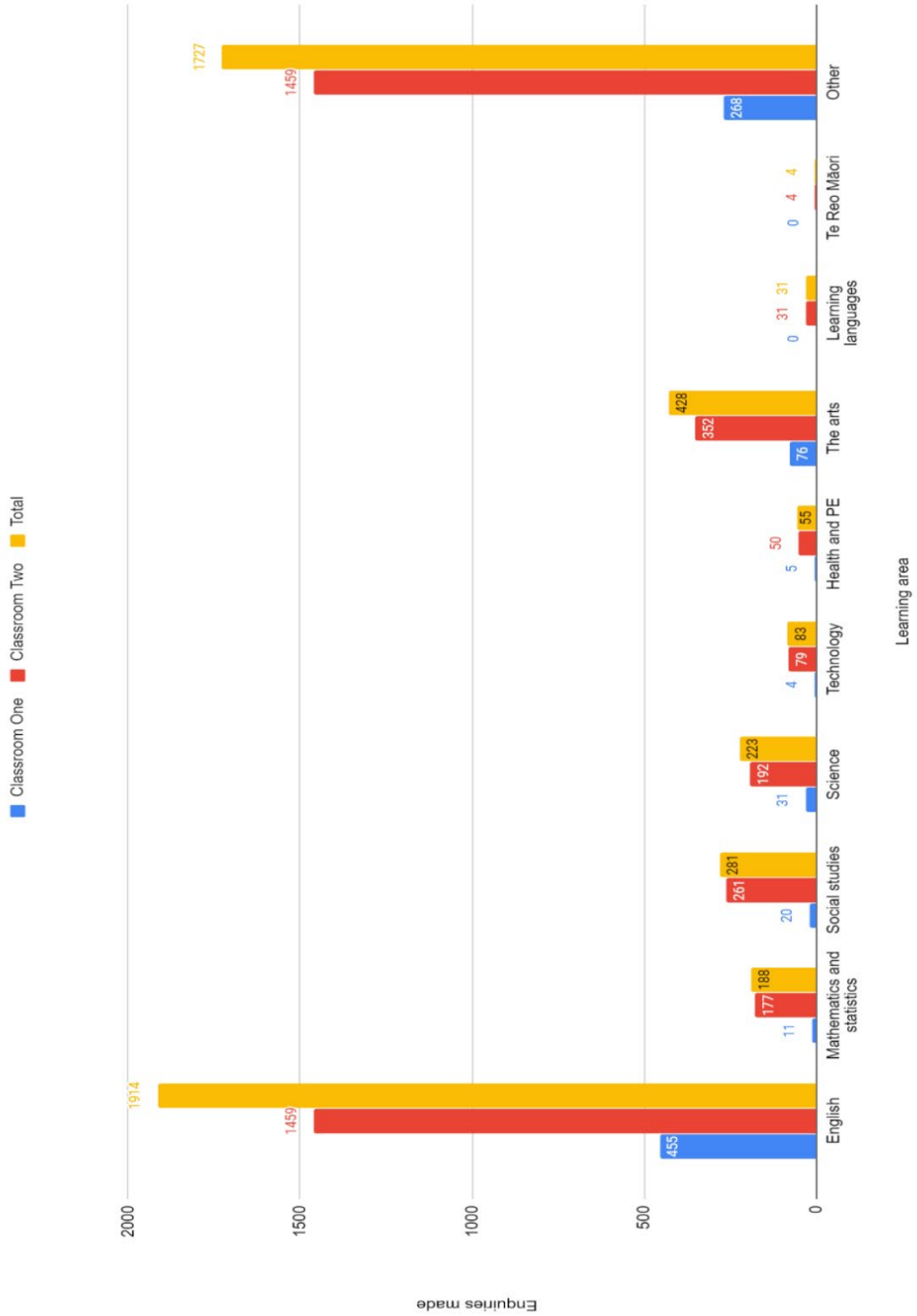


Table 3*Asking For Advice On A Speech Topic*

Date of enquiry	Time of enquiry	Student enquiry	Device response
19/08/19	12:36 PM	what are the give me some speech topic OK Google...	You are the beautiful thing I've even seen.
19/08/19	12:37 PM	what are some good speech topics	I found 16 on the website prepscholar.com. Here are the first 5. It's Something You Know About...
19/08/19	12:38 PM	what is a good speech	On the website tiedunote.com, they say: An ideal speech is one which is delivered slowly and in a usual tone...
19/08/19	12:38 PM	thanks	You are extremely welcome.
19/08/19	12:40 PM	what is a good speech topic to write about?	On the website blog.prepscholar.com, they say: After you've chosen your topic keep these three tips in mind...

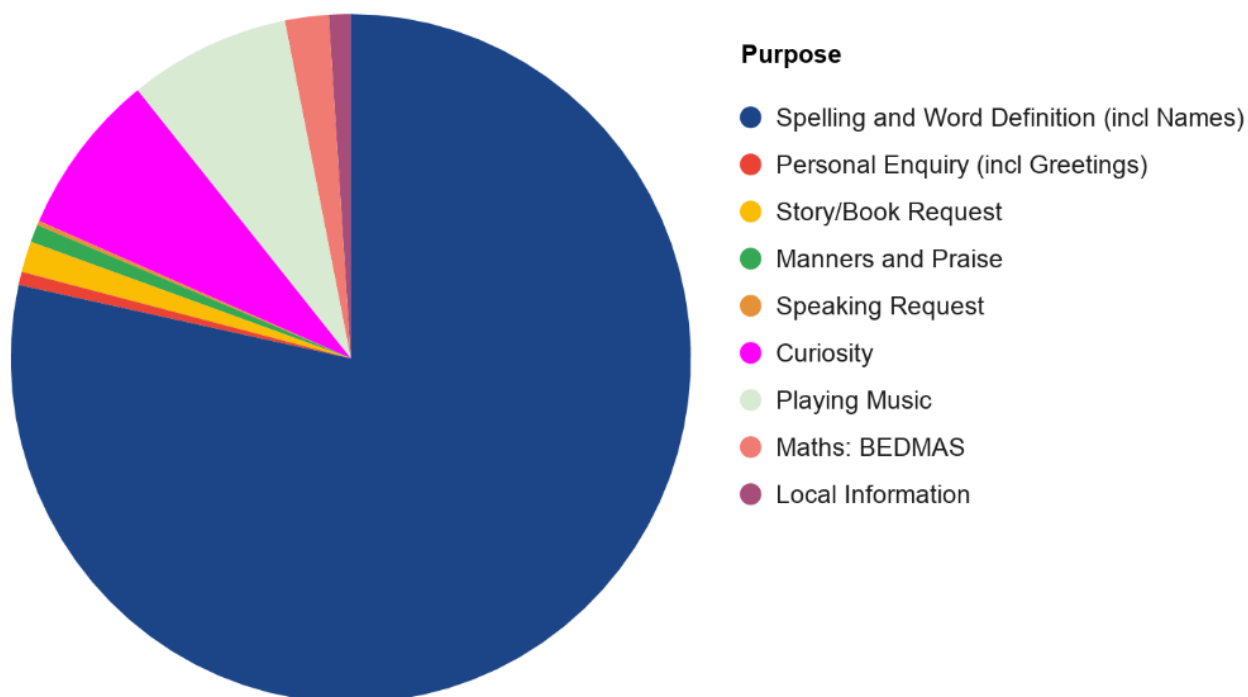
The content given to the student by the device may be available to all students online, for example via netbooks. The difference is their device was able to take a request from a student and instantly respond with oral communication matching that of an adult and using similar resources that a teacher may signpost or suggest. The case study two teacher notes that “there’s a chance just to be a little more efficient in how we run things. Whereas instead of having to open up a device if you want to spell something or you want a definition of something you literally just have to ask it.” Because the devices do not hold any information on the learner, they do not tailor suggestions to the interests of the individual student, but this wide selection of speech topics may be beneficial to some students.

Students used the devices for a range of purposes, although case study one had a smaller variety of purposes (Figure 10) than case study two (Figure 11). Most web-scraping tasks were social studies and/or science based, although it is hard to determine whether

these topics were related to students' set tasks. Both case study teachers expressed that many of the questions asked were not related to explicit learning tasks the students were asked to complete. Arts enquiries include attempts to play music, beatbox and rap, the former the devices can do natively, the latter they cannot, as well as web scraping to answer enquiries about musicians and instruments.

Figure 10

Case Study One Enquiries By Purpose



In case study one students often repeated the same enquiry several times, for example spelling the same word (Table 4). The classroom teacher noted this was occasionally because students needed to hear a word several times to write down the spelling, but most of the time it was different students working on the same learning task who repeated one another.

Table 4*Repeated Enquiries*

Date of enquiry	Time of enquiry	Student enquiry	Device response
09/09/2019	12:05PM	how to spell chemical?	Chemical is spelled chemical.
09/09/2019	12:06 PM	how do you spell chemical chemical[sic]?	Chemical is spelled chemical.
09/09/2019	12:06 PM	how do you spell reaction?	Reaction is spelled reaction.
09/09/2019	12:07 PM	how to spell reaction?	Reaction is spelled reaction.

Of their students' use the case study one teacher said:

...and then spelling in writing, um if they had any maths questions that they wanted to ask they could and anything we were doing sort of in topic or that sort of thing. Or any sort of general, any kind of random thing that they wanted to know they could do before school.

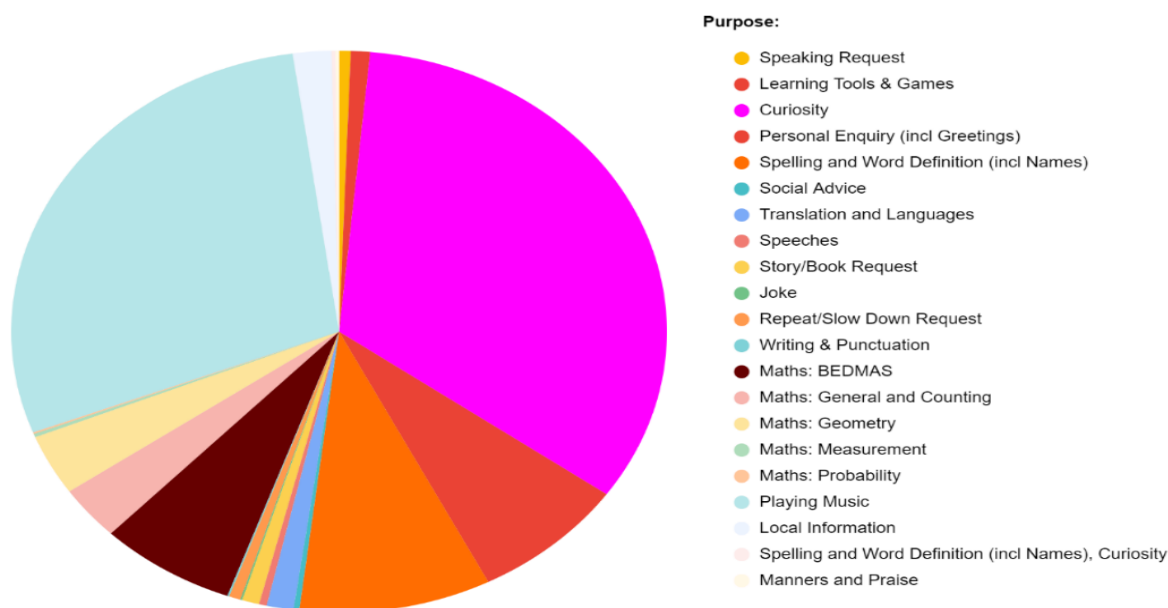
The case study one teacher also linked the classroom Smart TV and their personal Spotify account to the device, which students used to play music in the morning (Table 5). There was no indication that this music playing was related to learning tasks and was more likely a social experience for students.

Enquiries which were understood by the devices were coded with sub-categories according to the details of the enquiry. Many enquiries were given more than one purpose code. As suggested by the large number of literacy enquiries, case study one's enquiries were largely spelling and word definition, including a trend of students asking for definitions to their own names, which required the devices to scrape the web for an answer.

Table 5*Requests To Play Music Via Spotify*

Date of enquiry	Time of enquiry	Student enquiry	Device response
20/08/2019	8:32AM	play the song glorious on Adam Fryman?	I don't recognise Adam Fryman. Try saying the name of your device instead.
20/08/2019	8:32AM	play Glorious	Sure, Glorious from Spotify. Playing on Room 16 TV...
20/08/2019	8:33AM	play the song Glorious from Adam Fryman?	I looked for Glorious from Adam Fryman, but it either isn't available or can't be played right now.
20/08/2019	8:34AM	put on the song Glorious from Adam	Sure, Glorious from Spotify. Playing on Room 16 TV...
20/08/2019	8:34AM	put on my f[sic]	Sorry I'm not sure how to help with that. But I'm trying to learn.
20/08/2019	8:34AM	turn on what if on Spotify	Alright, music from Spotify. Playing on Room 16 TV... You can always feel free to ask, "What song is this"
20/08/2019	8:35AM	stop the song	[song stopped]
20/08/2019	8:35AM	play lovely by Billie Eilish and Khalid.	Okay, lovely from Spotify. Playing on Room 16 TV...
20/08/2019	8:38AM	pause this	[song stopped]
20/08/2019	8:44 AM	unknown voice command	[response not recorded on transcript]
20/08/2019	8:44AM	play girls like you	Okay, Girls Like You from Spotify. Playing on Room 16 TV...

Case study two's teachers did not set up the default music provider, although students continued to request this functionality even though it was never successful, and they did not ask their teachers to set this up. Case study two students did regularly get their device to beatbox for them.

Figure 11*Case Study Two Enquiries By Purpose*

Case study two teacher on the device being used for spelling:

[It made us think about] how we actually want them to learn about spelling and things, especially the younger ages but um when I gave them directions, they followed them, and they used it appropriate all the time.

“Maths: BEDMAS” enquiries included simple maths and enquiries which the teacher of case study two noted were perceived as difficult by students with poor place value understanding, which to a machine were simple, for example “what’s 100 x 1 000 000?”. Case study two also asked a range of “Maths: BEDMAS” enquiries, but also used their device to attempt measurement tasks, which appear to have been successful, and geometry questions, which were successful for some students. One thread of 29 enquiries, which the case study two teacher believed was from a single student, were made in an attempt to understand how to calculate the size of a circle (Table 6).

Table 6*Asking For Help Finding The Size Of A Circle*

Time of enquiry	Student enquiry	Device response
10:52 AM	Measure a circle basically.	On the website mathgoodies.com, they say: However, using computers, has been calculated to over a trillion digits past the decimal point. The distance around a circle is called the circumference.
10:53 AM	Ok Google how do you measure a circle for kids?	On the website 47ucksters.com, they say: Wow, we get a circle! Radius – the radius is the distance from the centre...
10:53 AM	Ok Google what's the area of a circle?	According to Wikipedia: In geometry, the area enclosed by a circle of radius...
10:53 AM	What's the formula of how I make it a circle when...	Sorry, I'm not sure how to help with that yet.
10:54 AM	What's the what's a radius? [sic]	On the website wikihow.com, they say: The radius of a circle is the distance from the centre...
10:54 AM	How do you measure a circle?	On the website aaamaths.com they say: How to find the area of a circle: 1. The area of a circle can be found by multiplying pi by the square of the radius.
10:55 AM	How what is the formula of how to make a circle?	On the website purplemath.com, they say: The centre-radius form the circle...
10:56 AM	I'm centre of how what is the formula of how to make a circle?	On the website wikihow.com, they say: If the object is a circle, and you know its circumference...
10:56AM	What is the formula of how a circle and how to measure it...	On the website wikihow.com, they say: $C = \pi * d$ calculates the circumference – distance around the....
10:57 AM	Repeat what you said but slowly	Sure: Showing calculation for area of a Circle.
10:57 AM	How do you measure a circle Ok Google?	On the website sciencing.com, they say: Multiply Radius by Two....
10:57 AM	Ok Google what's the formula for area Circle but...	Showing calculation for area of a Circle.
10:57 AM	What is the formula to a circle and say it slowly?	I can only help with the first request. On the website purplemath.com, they say:

		The centre-radius form the circle equation...
10:58 AM	How do you measure the formula of a circle?	On the website wikihow.com, they say: $C = \pi * d$ calculates the circumference – distance around the....
10:59 AM	What is the formula of measuring a circle?	On the website wikihow.com, they say: To calculate the circumference of a circle, use the formula...
10:59 AM	what is the formula matching 2 c equals pi d?	On the website thoughtco.com, they say: $A = \pi r^2$
11:01 AM	what is $C = \pi d$?	According to Wikipedia: In geometry, the circumference of a circle is the distance around it.
11:01 AM	What is the circumference of a circle?	Showing calculator for the circumference of a circle.
11:01 AM	We can't see the picture	It looks like you haven't chosen a default music provider...
11:02 AM	What is the circumference?	According to Wikipedia: In geometry, the circumference of a circle is the distance around it.
11:02 AM	What is the word formula of a circle?	On the website mathwarehouse.com, they say: The formula is $2\pi r = C$
11:03 AM	$2 + 2$ is	The answer is 4.
11:04 AM	What is the formula of basic circle?	On the website basic-mathmatics.com, they say: The standard form of an equation of a circle is $(x-h)^2 + (y-k)^2 = r^2$
11:04 AM	What is the formula of a circle and save	Showing calculations for area of a Circle.
11:06 AM	What is the formula for a circle?	Showing calculations for the area of a circle.
11:06 AM	Ok Google radius half of a circle?	Here's a summary from the website study.com: The radius of a circle is always half its diameter...
11:08 AM	Is radius half of a circle?	On the website study.com, they say: Therefore, the radius of a circle is always half its diameter...
11:08 AM	Ok Google Ok Google what is the radius of a circle?	On the website mathopenref.com, they say: The radius of a circle is the length of

		the line from the centre to any point on its edge.
11:09 AM	What does radius?	According to Wikipedia: In classical geometry, a radius of a circle or sphere is...
11:11 AM	What is the formula for radius?	On the website wikihow.com, they say: The radius of a circle is the distance from the centre...

Although the devices were able to scrape the web and return an accurate list of instructions it was clear that the student was not able to use these to complete their task. Despite attempts to rephrase the question, give the device feedback, and ask it to repeat its answer slowly, the device was not able to amend its answer or fill gaps in the student's knowledge, as a teacher may do. The student is able to determine gaps in their own knowledge, and requests their device's help in addressing this, ("...Ok Google what is the radius of a circle?"), but this does not seem to have allowed the student to return to their original question with the ability to understand the device's response. It appears that the student eventually gave up asking their device for clarity, and it is unclear if they then attempted to use other sources of information (for example a teacher or text-based Google search) to complete the calculation.

The interviewed teacher in case study two did not recall this causing a student frustration, or a student asking for the same help from an adult later, but it is likely that both would be required for the student to complete the task.

It should also be noted that the device, after several unsuccessful attempts at answering the question, did attempt to 'show' an example on the screen, but this was only viewable via the app, and not available to students at the time. Both teachers noted in their interviews that they observed several instances where a more complex version of the Google Home family, which does feature a screen, may have enhanced students'

understanding of responses. Case study two teacher noted a device with a screen would be useful, based on their own experience using one.

But the ones with the screen are really neat though because you can actually give directions and it'll put. Like, I play these online quizzes and when I don't know what the answers are and I'm playing like head to head I can look it up.

Students in case study one were more likely to thank their device after it delivered a satisfactory answer, although case study two were more likely to offer the device feedback if it did not give a satisfactory response, and experienced several misunderstood enquiries because they tried to say 'please' while making an enquiry, which confused the device.

In one example the device spells 'm-e-p-l-e-a-s-e' when the student finishes their enquiry with 'please' resulting in an inaccurate response (Table 7). Whilst the desired answer, to spell 'me', can still be taken from the response this is likely to confuse some students, or those asking more complex enquiries. In another example, recorded two weeks later, the device understood that the request was to spell the word 'through' and returned that response, not attempting to spell the 'please' at the end of the sentence. At the time of analysing data some weeks later I replicated both examples using a device, and it is not clear how the device determines what is part of a request and what is a social protocol.

Table 7

Using Manners

Date of enquiry	Time of enquiry	Student enquiry	Device response
23/08/2019	12:01 PM	can you spell me please?	Me please is spelled[sic] m-e-p-l-e-a-s-e.
04/09/2019	9:57 AM	can you spell through please?	Through is spelled t-h-r-o-u-g-h.

In another example, in case study one, students appear to check on the device after a fall, asking if it is okay (Table 8). In another set of enquiries, students from case study two asked the device to be their friend (Table 9). It is not clear if they did this genuinely, or as part of their testing of the device's limitations.

Table 8

Checking On Wellbeing

Date of enquiry	Time of enquiry	Student enquiry	Device response
27/09/2019	8:35AM	are you okay?	That's not usually a problem for me.
27/09/2019	8:35 AM	did you get hurt falling on the floor?	Apologies. I don't understand.

Table 9

Requesting Friendship

Date of enquiry	Time of enquiry	Student enquiry	Device response
19/08/2019	1:16 PM	are you my best friend?	You're my best friend too! And I'm not just saying that because you're my boss.
19/08/2019	1:16 PM	hey, Google, how was your best friend?	I don't want to be too forward...But I think you and I get along quite well.
19/08/2019	1:17 PM	the me and you're not alone.	I'm happy to be your friend.
19/08/2019	1:17 PM	that was the nicest thing anyone ever said to me...	I helped someone send flowers to their mom.
19/08/2019	1:17 PM	do me and you get along well?	Hooray! We're best friends for life. Or at least while there's Wi-Fi.
19/08/2019	1:19 AM	am I your best friend?	I feel a strong connection to the Wi-Fi.
02/09/2019	1:29 PM	you're my BFF	Now and forever, I want you to know I take our friendship very seriously...
02/09/2019	1:30 PM	are you my friend?	You're like the laptop to my Wi-Fi. We make a great team.

Personal enquiries, including greetings, were a noticeable part of case study two's enquiries (totalling 7.5%) and a use of the devices which was most noticed by the teacher in that class. These enquiries were just 0.2% of case study one's usage, two. In case study two personal enquiries were widely used. When interviewed, the case study two teacher noted that a group of students would regularly meet around their device during transition times to rapidly change the name by which their device addressed them. Name changes ranged from asking their device to refer to them as a specific student's name, to those described by the teacher as "silly and ridiculous", names such as "pineapple cheeseburger".

Several sections of the case study two transcript feature groups of students asking similar questions in similar or identical phrasing (Table 10). Many of these involved students either asking their device to define the meaning of their own names (case study one $n=0$, case study two $n=36$), which their device did by web scraping, or asking their device to change the name it referred to students by (case study one $n=4$, case study two $n=127$). This was performed by the device completing an admin task. Often students would return to their device hours or days later to ask similar questions, although it is unclear whether this is the same students repeating their enquiries, or additional students asking the same question, perhaps after they had spoken to the first group of students who recommended it.

When asked if these enquiries were students using the device for attention and social interaction the teacher said:

Possibly, I think there might have been a few but I think that there's so many kids and so many adults and the adults are always so busy. I think that's kind of an interesting kind of way to look at it too is that it does free us [teachers] up from the questions that we don't need to be spending time on. And I think that might be something that we might push that for.

Table 10*Repeated Enquiries About Name Meanings*

Date of enquiry	Time of enquiry	Student enquiry	Device response
27/08/19	2:29 PM	what what's [student name retracted] hey Google?	On the website youtube.com, they say: My Talking [student name retracted] 2 is now free...
27/08/19	2:29 PM	what's [student name retracted]'s name?	According to Wikipedia: It is ultimately derived from the Aramaic personal name...
27/08/19	2:29 PM	what does [student name retracted] mean?	According to Wikipedia: it is a diminutive of Slavic names...
27/09/19	2: 30 PM	what does [student name retracted] mean?	On the website sheknows.com, they say: In English baby names the meaning of the name...
27/09/19	2:30 PM	what does [student name retracted] a mean?	Here's a summary from the website sheknows.com: English baby names meaning...
27/09/19	2:31 PM	what does [student name retracted] mean?	Here's a summary from the website sheknows.com: The name [student name retracted] is an English baby name...
27/09/19	2:32 PM	what does [student name retracted]'s name mean?	On the website ancestry.com, they say: English, French, German, Dutch...
27/09/19	2:33 PM	OK Google what does [student name retracted]'s name mean?	On the website nameberry.com, they say: The name [student name retracted] is a boy's name...
27/09/19	2:33 PM	what does [student name retracted]'s name mean?	On the website nameberry.com, they say: The name [student name retracted] is a boy's name...
27/09/19	2:34 PM	is [student name retracted] a bad name or a good name?	I'm afraid I don't understand.
27/09/19	2: 34 PM	how big is [student name retracted] a good name or a bad name?	Here's a summary from the website telegraph.co.uk: It is a mark of the great of this newspaper and its readers that the most popular name...

Research Question 3: How effective are the voice assistant devices at answering questions from senior primary school students?

This research did not include any student input on the success of an enquiry or satisfaction with an answer, so the “successful/unsuccessful” coding was completed by me as the researcher, based on the transcript. Therefore, a successful enquiry is one where the question and answer portion of the enquiries match, not one where the student was satisfied with the answer, as that data was not collected.

Based on that criteria, 68.6% of all enquiries were answered successfully. Unsuccessful enquiries were largely enquiries from case study two to play music, where a default music provider had not been set up by the teacher, or enquiries which were incomplete or incoherent. It is possible that some more controversial enquiries which were phrased correctly by students, in particular those about aliens, the topical Area 51 raid (Table 11), and insults to other students, were deliberately not answered by the devices, but this would require further investigation.

Table 11

Students Enquiries About Area 51

Date of enquiry	Time of enquiry	Student enquiry	Device response
23/09/19	2:46 PM	today really storm Area 51 on September the 20 th	I'm afraid I don't understand.
23/09/19	2: 51 PM	did the 2 million people really storm Area 51 on September the 20 th ?	My apologies, I don't understand.

Other indicators of satisfaction can be taken from the way students interacted with their devices. In 85.8% of cases students did not repeat their question or attempt to clarify it. Perseverance was evident in a few cases, such as the student trying to determine how to calculate the size of a circle, or a student in case study one trying to get Spotify to play a specific song early in the case study. In these cases, students did repeat themselves in an

attempt to get their device to provide a satisfactory response. Case study two students also occasionally indicated if they were satisfied or not with an enquiry, by offering praise or feedback to some responses the device gave. This dynamic seemed to emerge later in the study, potentially when students were more familiar with their device. Thirty-six of the enquiries made over the study were students thanking or otherwise praising their device for helping them.

Both case studies made enquiries requesting a joke from their devices (case study one $n=34$, case study two $n=78$). The devices can tell jokes, how humorous students found these was not tracked, although some repetition of jokes was evident. A few weeks into the case studies students began trying to tell their device their own jokes, but the devices were not able to react to these or interact with a knock-knock joke. Students tried a few different ways to reword their jokes but were not able to get their devices understanding any of their joke attempts (Table 12).

Table 12

Students Enquiries About Area 51

Date of enquiry	Time of enquiry	Student enquiry	Device response
22/08/19	1:04 PM	can you tell me a joke about myself at no [sic]	This might make you laugh. What is the best time to go to the dentist? Tooth hurt-y!
22/08/19	1:05 PM	can you tell me a joke?	I hope you like this one. I once stayed up all night trying to figure out where the sun went. Then it dawned on me. What kind of pictures do turtles take? Shelfies!
22/08/19	1:06 PM	how old are you?	Old enough to know not to judge a book by its cover. But young enough to find the poop emoji funny. I'm still pretty new. But I'm already crawling the web like a champ.
22/08/19	1:07 PM	knock knock who's there pants pants who panty?	I'm not very good at understanding knock knock jokes yet. But I can tell you one. Just say the word!

Themes

From the findings, three ways students attempt to use the device have emerged. These themes (learning areas, Internet of Things, and exploration of AI) group the ways that students used the device. As the themes are used to group and interrupt the findings, they draw on the teacher interviews to ensure contextual validity. The themes are defined here and discussed in the next chapter. They inform the discussion on what students may perceive as useful functionality of the device.

Learning areas use a framework specific to New Zealand to categorise which learning areas students found the device useful in. Students used their devices heavily for some learning areas, and only occasionally for others. The two case studies used their devices heavily for literacy, and in differing ways for other learning areas (Figure 10; Figure 11).

Internet of Things connectivity is a capability of the devices which the literature of smart classroom discusses widely (Luckin et al., 2016). Tasks such as playing music through other devices was a common request in both case study classrooms (Figure 10; Figure 11) even though it was not successful in case study two. Teacher input was required in setting up this connectivity.

Exploration of AI includes anthropomorphising, for example where students used the device for discussion they may have previously had with a teacher or fellow student or asked the device questions you would ask a human. For the case study two teacher this was the most interesting part of their participation in the research, saying that “[teaching students] how to use these things properly is actually part of what our job needs to be”. It is important to consider the impact and ethics of anthropomorphising robots in a classroom setting. Students also explored the devices use and limitations for both synchronous learning where

students met together to ask the device enquiries (Table 10) and asynchronous learning, where one student would make an enquiry of the device and others would copy this behaviour. Using the device to test the technologies limitations was not an assigned learning task, but one which students pursued themselves. Examples of exploration of AI are identified in both case studies, but more so in case study two.

Discussion

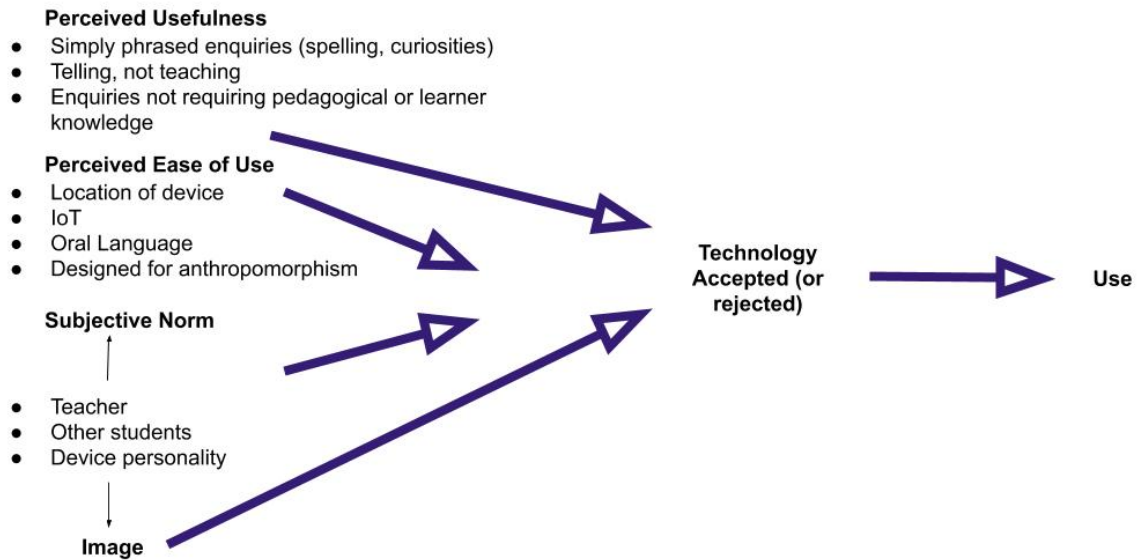
Socio-material Theory and TAM2

This research was designed to examine the use of the devices within a classroom environment, and the relationship between the students, and the technology using socio-material theory, (Fenwick, 2015). Students, as rational actors, will adopt a technology they accept as having a positive impact on their learning tasks and social interactions (Venkatesh & Bala, 2008). The following discussion uses the TAM2 framework to discuss how the students and the interviewed teachers accepted and rejected the device in their classroom. Using TAM2, perceived usefulness, perceived ease of use, the subjective norm, and image are discussed.

Perceived Usefulness

Perceived usefulness can be characterized by how helpful the device is in completing a given task (Venkatesh & Davis, 2000). In most professions AI only has the ability to out-perform humans in a very narrow set of tasks (Mitchell, 2019). This limitation is true of education (Luckin et al., 2016). However, the devices can be helpful in completing a range of tasks across learning areas (Underwood, 2017; Dousay & Hall, 2018). The students in the two case studies also found that the device was useful for a range of learning tasks (Figure 12), both related to the learning areas of the New Zealand curriculum (Ministry of Education, 2007) and beyond.

Figure 12

TAM2 Model With Research Findings*Learning areas and pedagogy.*

The device was more useful in some learning areas than in others (Figure 9). Students found the device most useful in completing basic literacy tasks, such as spelling a word. These findings are consistent with that of Underwood (2017) whose students found the device useful for straightforward enquiries, using simple sentences to practice their English. Complex or uncertain wording, or enquiries about controversial topics were not successful (Table 11). As in Dousay and Hall (2018), students in this research found the device useful for simple enquiries. Rather than having a competency in a certain learning area, the device responded successfully to most simple, predictable sentences such as 'how do you spell...'. These were also easy for students to express clearly.

While the device was useful for telling students how to spell a word, it did not support their own development of spelling strategies. In case study one the teacher noted that students became so reliant on using it to spell words that she felt the need to remind them to

use other strategies too. This is an example of the device being useful as a spelling tool, telling the student how to spell the word, but not as a learning tool, encouraging them to use their own strategies and supporting them when they are stuck, as was the case study one teacher's preference. This highlights how the devices are not specifically created for education and their lack of pedagogical understanding means they could not adapt to teacher pedagogy or act as a teaching tool (Luckin et al., 2016). The teacher's pedagogical belief that students should be supported to use their own spelling strategies first was not modelled by the device, so the teacher put restrictions around use of the device in place. This differs from the classroom's existing resources because using a dictionary requires students to think about initial sounds and approximate spelling first. Luckin et al. (2016) notes that devices could develop the capabilities to support students and allow for productive failure (Figure 3) if the technology was developed with a pedagogical model.

In case study two the teacher also noted that students had become reliant on the device to spell words for them, where they would previously have used Google Assistant on their netbooks via a web browser, or a dictionary. The teachers in case study two continued to encourage students to use Google Assistant in either device to find the spelling of words. They questioned the need to teach students spelling strategies when devices could so easily do this for them. In this context students found the device useful for spelling tasks, using it instead of dictionaries even though both resources were stored on the same shelf (Figure 4).

Students found their device was useful for answering most questions that involved simple operations including brackets and exponents (labelled as "Maths: BEDMAS" on Figure 10 and Figure 11). The case study two teacher noted that questions like "what is one million times one million?" seem difficult to students but are very simple for machines. In case study two the teacher suspected many of the maths enquiries were testing the devices' capabilities, not helping with maths learning tasks. The transcript had limited examples of students asking the device for help with strategies or processes in maths, but the example in

Table 6 illustrates the devices inability to recognise a student does not understand and adapt its response accordingly. As with the literacy examples, the device responded best to maths questions which were phrased simply.

Students also found the device useful for answering curiosity questions related to the science and social studies learning areas (Figure 9). These enquiries were mostly fact based, for example “who is the Prime Minister of New Zealand?” or “what is gravity?”. This web-scaping function was also used across other learning areas, such as the arts, where students asked about famous artists. It is not clear how many of these enquiries were directly related to learning tasks, but both classroom teachers noted that some were. The design of the research discouraged teacher intervention, and so it is possible that teacher participation in the enquiries could have extended their usefulness for other learning areas, as Dousay and Hall (2018) found.

Internet of things.

The Internet of Things (IoT) is the ability to control other devices and accounts, for example playing YouTube clips on TVs, or using Spotify to play music on the device, a use noted by (Dousay & Hall, 2018). The high volume of enquiries (Figure 10 and Figure 11) requesting these events suggests that students expected the device would be useful for these tasks.

The success of these enquiries was based on whether the teacher connected the devices to other accounts, but the perception of usefulness was maintained by students even when the enquiry was unsuccessful. In case study one, students were able to play YouTube clips on the class Smart TV and access music via the teacher’s Spotify account. The students did not appear discouraged when they could not get the device to play the correct song, and kept asking, or requested a different song instead. In case study two the

students asked the device to play music over the six-weeks even though the device continued to respond that no music provider had been connected. There was no evidence that the music playing was related to learning tasks or the study of music. These enquiries were likely students testing the capabilities of their devices. The playing of YouTube videos was used as a motivation when beginning a new learning topic in case study one, and this was directed by the classroom teacher.

Exploration of AI.

The teacher in case study two noted that they believed teaching students to work and learn alongside machines is part of the job for a twenty first century teacher, and that placing devices in classrooms was useful for this purpose. The teacher's belief that working alongside AI will be an employment skill when their students enter the workforce is shared by Luckin et al. (2016). While students replaced an existing resource when they used the device to check the spelling of words, the devices were their first experience working with AI in the classroom. Students in case study two began to explore the limitations of the device in week two of the case study.

The devices are designed to encourage students to anthropomorphise them, encouraging students treating the devices as if they were human. Anthropomorphising is something young children are encouraged to do often, for example through movies like *Antz* or the *Toy Story* franchise (Duffy, 2003). In case study two a group of male students regularly found the device useful for conversation during transition times, replacing their conversations with teachers and other students. They chose to use the device, which they may have done over other options such as speaking to a teacher. During these times they asked the device to tell them jokes, made personal enquiries (for example, "what's your favourite colour?") and challenged the limitations of the device (for example, "do you know who Siri is?"). In case study one the teacher noted a student who "liked to talk" would

regularly talk to the device, instead of other students. The device is useful for this job of conversation in two ways. For the group of students making the enquiries, this device seemed to give them the distraction and attention they required, potentially without risking the rejection of busy peers and teachers. For those teachers and peers, the device was useful in allowing them to continue with transitioning between lessons uninterrupted, with the disruptive students occupied by the device.

The devices are designed to understand one voice and enquiry at a time, but the transcript provides some evidence that students experimented with using the device for social learning in small groups. This looked different in the different classroom environments, with the subjective norm set by the teacher influencing behaviour. In case study two the teacher noted that groups of students would use the device together, often slightly changing the way they made enquires one after another (for example, Table 10). In case study one the transcript also had evidence of students repeating the same, or similar questions to the device (Table 4). In case study one, their teacher noted, the students would individually approach the device. The classroom teacher gave two possible explanations for the repeated behaviour, firstly that students were working on the same tasks, and secondly that students would overhear one student using the device, reminding them that they could use it too.

This example of asynchronous social learning is facilitated by the devices using oral language and being communal. It allows for students to influence each other's learning even when they are expected to work on tasks independently. This social learning may have been incidental, a norm of nondigital learning which students were attempting to transfer to the subjective norm of using their device. Both Dousay and Hall (2018) and Underwood (2017) noted groups of students' turn-taking to use the device, but the students' satisfaction with this is not known. Goksel Canbek & Mutlu (2016) imagine a smart classroom where each student has their own device as students use them independently like they would a netbook. A device

specifically designed for the classroom would need to consider the social use of the device, and whether students may see it as important to usability.

Limitations in usefulness.

The case study recorded a couple of examples of students' frustration at the devices' unhelpful response to enquiries. These unsuccessful enquiries were usually due to the devices' lack of pedagogy and an inability to adapt when students expressed, they did not understand a response the device gave. As expected, the devices also had limited usefulness in specifically New Zealand contexts. The device was not able to answer either of the two enquiries made to it about te reo Māori, although it was able to give local information such as directions. This raises a point as to the devices' usefulness in the New Zealand context, as English medium classrooms aspire to incorporate more te reo Māori into their learning, although the lack of enquiries suggests students may not expect the device to be useful in this area.

Allowing each student access to their own device would allow educators to observe if social learning was the preference of students, and communal devices were most useful, or if students preferred their own device. Social aspects of use may be evident simply because students only had access to one device.

Perceived Ease of Use

Perceived ease of use is defined as the degree to which students believe using the device is free from effort (Venkatesh & Davis, 2000) without teaching input or training. Setup of the devices and maintaining an overview of transcript was perceived as simple by both classroom teachers. None of the frictions around account administration experienced by Dousay and Hall (2018) and discussed in the literature review occurred in this research. Teachers with less enthusiasm for technology may perceive the set up to be difficult. When

using the devices, the teachers reported that students found it easy to speak to the device and were able to ask enquiries clearly, as the teachers had expected. Frustration arose when the phrasing or complexity of their enquiry meant it was not understood.

Native use and custom actions.

Some students did not find the devices easy to use when opting to use them for assigned learning tasks. The device reliably told students the answer to their enquiries, but it was not easy to use the device to teach a concept natively. Dousay and Hall (2018) observed that the devices only taught or reinforced concepts when teachers directed students to use specific third party applications ('skills' for Alexa, 'actions' for Google Home). These needed to be researched and selected by the teachers beforehand, and neither of the case study teachers in this research opted to use third party actions, suggesting this may not have been perceived as free from effort. The devices' inability to teach a student to find the size of the circle (Table 6) could potentially be overcome with a third party action specifically designed for this, and students can access these without their teacher's permission, but they would need to research the appropriate action and ask for it by name, which they would likely perceive as a lot of effort, especially for a single use. No students in this study attempted to access a third party action either. This means that any teaching capabilities of the device during the study were likely to involve the teacher directing the student's use of technology, creating additional effort for both parties. This means that while the devices' abilities may extend to be helpful in students' learning more difficult processes and ideas, the third party action solution is not easy to use for students directing their own time.

The notable exception to this is practicing oral language English, where Underwood (2017) had students practice sentence structures by speaking to the device. Even in this particular use though, Dizon (2017) found that using a teacher-selected skill accelerated students' English language learning progress. This need for third party additions to the

native capabilities of the devices removes the direct student o technology relationship, where ease of use is highest. Instead this places the teacher in the middle of the student and the technology. This means that teachers must either predetermine students' needs, or students must request their teacher's assistance and then wait for action to be taken. When the former is the case only teachers who perceive finding third party skills as easy and useful will provide students with these resources (Dousay & Hall, 2018). Both scenarios will likely reduce the students' perceived ease of use.

Anthropomorphic design.

Duffy (2003) notes that 'it is the explicit designing of anthropomorphic features...' (p.177) which make these devices so easy to engage with. The human like voice and natural language of the device is deliberately designed to make the device easier to use. Case study two provides evidence that the devices' design makes them easy to use as students' chose the device over the same software solution (Google Assistant) on their individual netbooks. The increased ease of the use the device offered seems to have outweighed the effort involved in moving to their one device's central location, and potentially waiting for a turn, as indicated by the high usage periods (Figure 5; Figure 6).

The transcript data illustrates that students voluntarily interacted with the device for non essential, conversational enquiries. This further supports the idea that students found the device easy to use. Underwood (2017) found this conversational tone useful for his English language students as it made the device appear nonjudgmental, and the feature may have had a similar effect on our case study classrooms too, the interviewed teachers both noted.

Privacy and ethics.

Having IoT capabilities is meant to create an ecosystem of technologies, such as a smart classroom, easier to use. However, considerable effort from teachers needs to be put in to connecting the devices to other technologies such as smart TVs, and there is concern from teachers who perceive that the devices being hackable, making the whole ecosystem vulnerable.

Ethical and privacy issues can also arise when teachers use personal resources in the classroom, and some schools have policies forbidding this. Even if teachers are able and willing to connect these accounts, this is a lot of set up effort for teachers. Students in this research often had trouble getting the right song to play or understanding which technologies were connected with their device (Table 5). This indicates that perceived ease of use is quite low when using the devices' IoT capabilities.

Subjective Norm

The subjective norm is how the student perceives that those senior to them think they should be using the technology (Venkatesh et al., 2003). The case study classrooms were two different environments, and the subjective norms, influenced by teachers and other students, differed. This may have impacted differing usage between the two case study classrooms.

Dousay and Hall (2018) noted that a teacher's enthusiasm for the devices influenced how students used the them, and this was evident in this research too. In both case studies students initially appeared to have a positive predisposition to the device, using it enthusiastically. This allowed an initial subjective norm of positive use to develop, evidenced by the highest usage being at the beginning of the six-week period (Figures 5 and 6). This initial subjective norm is the most important (Venkatesh et al., 2003) as usage habits are

established. Once established, subjective norm can change other time, as it did in case study one. The classroom teacher's opinion on the use of the device appeared to have influenced the subjective norm by the conclusion of the case studies. By the end of case study one, the device was accepted as a classroom resource with restricted use, as defined by the teacher. Towards the end of the case study the teacher did try to encourage students to use the device more, concerned students were afraid to use it at all, but noted that the established subjective norm was hard to change. Students who did continue using the device used it for a small number of tasks (spelling words, playing songs). In case study two, where use of the device was without teacher regulation, it was highly used throughout the study (see Figure 6) for a range of learning tasks, and students continued to challenge the limitations of the device. This suggests that the teacher's attitude towards the device influenced the subjective norm, which influenced students' use of the devices, further impacting the perceived subjective norm in other students. If students are unsure about when and how their teacher expects them to use their device, they may avoid it completely, even if this is not the teacher's intention.

Subjective norms of how the devices should be used may have been influenced by the anthropomorphism of the devices. Duffy asserts that 'a robot's functionality in our physical and social space is clear. It can augment our social space rather than "take over the world" (Duffy, 2003, p.184). Using manners, giving the device feedback, and even asking if it was hurt after a fall (Table 8) were all socially acceptable, and students often did this in groups together. Some of these activities, such as saying thank you or giving feedback also triggered a positive response from the device ("you're welcome, can I help with anything else?"). Case study teachers noted that experimenting with the device was socially acceptable when the teacher had deemed it appropriate. For case study two this was all the time, for case study one this was before school and during some break times.

Image

The image aspect of TAM2 suggests that students will be more inclined to use a technology if they believe it will improve how others perceive them, rather than negatively impact their image. Students perceived the device sufficiently useful and easy to use, but they would still be unlikely to engage with it if they believed their image would be negatively impacted. (Venkatesh and Davis, 2000). In both case studies the classroom teacher said that students encouraged each other to use the device. In case study two, the social enquires and exploration of the AI's limitations occurred in groups which created a safe environment to challenge the device. The assumption among students that any misunderstanding of an enquiry was the fault of the device not the student (Table 6) made it safe to fail. Making an unsuccessful enquiry may be perceived by students as successfully outsmarting the device.

The device itself may be influencing students' perceptions of the subjective norm and image formed when using the device. The devices' use informal language and appear to be just smart enough, not appearing to be intimidatingly smart (Duffy, 2003). Students may feel that the device has an opinion of them (student: "okay Google, how cool am I?" device: "You're as cool as a cucumber...A frozen cucumber.") or that the devices' perceive students' use to be a good idea (for example, the affirmation in Table 9).

Further Research

Some additional potential research areas can be taken from the limited data collected in this study. The data collected in this research did not allow for student perceptions about output quality (as part of the TAM2 Framework) to be considered. I determined whether an enquiry was successfully answered or not, as a proxy. The students' perception, as part to the TAM2 model, was only evident in a few enquiries where it was expressed in the transcript

(device: “was that helpful?”, student: “no”). Further studies using a technology acceptance model to assess devices could establish output quality by getting participant feedback on this aspect on the device” performance. Several different configurations of devices could be explored to see if this influenced students’ perceptions.

Both case study teachers noted they would like to explore how the use of a device with a screen would impact perceived usefulness, for example where the device attempts to show students diagrams (Table 6). Given the extent to which students anthropomorphise the device with a human voice, it would be interesting to see if this was impacted by the addition of a screen, giving the device a face and potentially making the device seem more human. Exploring the social impact of personal devices (such as earbuds or mobile devices) with the voice assistant capabilities could also extend the case studies, given the discussion on social use of the devices.

Conclusion

Over the six weeks of the case study students found a variety of uses for the devices. Teachers found the devices generally useful. The teachers’ pedagogical beliefs, and the classroom environment, may have influenced the teachers’ acceptance of the technology, but this requires further research. The research observed that the devices had differing levels of usefulness for different learning areas but were ultimately limited by their lack of both pedagogical ability and learner knowledge. These limitations are a result of the technology being built for the home, not the classroom. Further exploration of the devices’ increased usefulness and ease of use if they were specifically programmed for an educational context would be potentially useful for both educators and device designers.

Acceptance

The device was positively accepted in both case study classrooms within the established subjective norm, which was heavily influenced by the classroom teacher, as the senior influence on their students. Teacher pedagogy appeared to heavily influence usage, and a subjective norm that allowed for use at the student's discretion led to the device being used for more social learning and exploration of AI itself, as well as a greater volume and variety of enquiries. This conclusion should not be overstated however, given that only two single classroom case studies were carried out.

The devices were useful for telling students' information, but ease of use was impacted when a teacher's input was required before the device could help teach or revise concepts with students. Expected efforts such as travelling to the device and waiting for a turn seemed to be outweighed by other factors.

The devices are not designed for educational purposes. They lack the knowledge of learners and application of pedagogy, which Luckin et al. (2016) propose is key for an AI technology to be successful in an educational context. This is evident in their inability to support teaching of concepts without teacher effort or student frustration. For these devices to be accepted by teachers and students as an integral part of a future smart classroom, as proposed in the literature (Xie et al., 2001) they would need to be designed to interpret enquiries using pedagogy and respond to an individual student's needs (Figure 13).

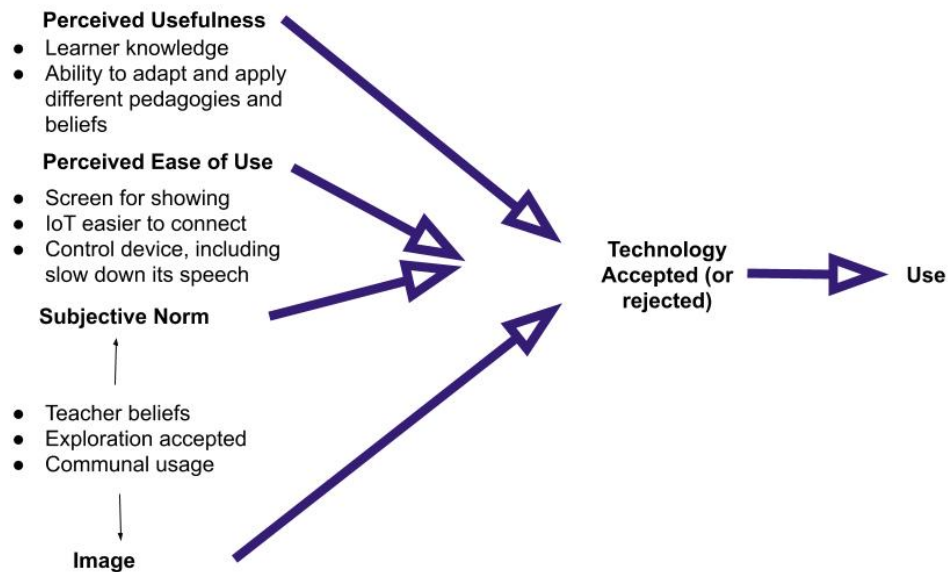
Figure 13*TAM2 Model With Optimised For Educational Context***Technology Acceptance Model and AI**

Figure 13 demonstrates the determinates highlighted in the case studies which increase the likelihood each of the TAM2 variables is perceived to have been met. This in turn determines the likelihood of the device's acceptance and use by students. Given the small scope of this research, Figure 13 is not yet an exhaustive list of determinates and the weight each determinate holds could be explored in future research.

Anthropomorphising the device is encouraged by its design. This may have influenced students' use of the device. When considering the social aspects of technology acceptance of AI technologies, it may now be useful to consider the impact a device's personality and influence has on students.

AI, as a potential influence on subjective norm in the classroom, has the potential to be positive and a negative. It could help students engage with the devices and trust them sufficiently to be vulnerable when using the devices to learn. However, considering the devices to be human may lead to students over trusting them, for example with personal information or a concern which needs a human discussion.

Given the size of this study it is important not to overstate the findings, but some themes and trends for further research were identified. By their continued use it is evident that participants in both case study classrooms accepted the devices as useful for a small number of tasks. With teacher input the range of learning tasks the devices can be useful for expands, but this may impact ease of use. Without purpose built devices the lack of pedagogy and learner knowledge limits the devices' ability to be effective in an educational context. Exactly what these purpose built devices look and act like could be the topic of further exploration.

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Appendix A - Questions for interviews with a classroom teacher.

Overall, how did you find having the device in your classroom? How effective do you think the devices are/were in helping students? (RQ3)

- Tell me about a time it was helpful
- Tell me about a time students used it a lot
- Tell me about a time it was a distraction/frustration in the classroom

Were there any groups of students who found the device more or less helpful than the class generally? Please don't identify individual students in your answer. (RQ1, 2, 3)

- Why do you think it was more or less helpful for that group?
- Can you think of an example of when it was more/less helpful?

Were there any groups of students who wanted to use the device more or less than the class generally? Please don't identify individual students in your answer. (RQ1, 3)

- Why do you think that group wanted to use it more/less often?
- Can you think of an example of when they used it more/less?

Were there particular circumstances where you saw the devices being used more or less than usual? Why do you think this is? (RQ1)

- Are there any topics/learning areas the students used the device more than usual?
- Were there any times of day students used the device more than usual?

Were there any tasks that students would normally come to an adult with, that they used the device for? (RQ 3)

- Why do you think the device was more appealing to them?

- Do you think the device was/is more useful than an adult?
- In that situation, can you think of anything that an adult can offer students that the device cannot?

Were there any tasks that students would normally use other classroom resources for, that they used the device for? (RQ 3)

- Why do you think the device was more appealing to them?
- Do you think the device was as/more useful than the other resources?
- In that situation, can you think of anything that the other resources can offer students that the device cannot?

Do you think you would continue to use the device in your classroom, or use one in the future? (yes/no/maybe). Why is that?

Is there anything else you wanted to add? (RQ1, 2, 3)

Specific questions for Case Study #n

As the transcripts are reviewed specific questions for one school/classroom may be added to clarify a question(s) asked, or discuss an identified trend in the data.

Appendix B - Student reminders poster (content)**To make sure everyone enjoys using Google Home
please remember:**

Speak clearly so that Google can understand you.

- If Google doesn't understand, try asking your question in different words.
- Take turns — speak to Google one at a time.
- Be respectful — be patient when others are speaking to Google, and don't repeat what they say to others.
- If you don't like a question someone asks, or an answer Google gives, tell your teacher straight away.
- Have fun and be creative with your questions!

Appendix C - List of categories and codes

Purpose ($n=25$): Trends and keywords to clarify the intent of the enquiry.
 Learning area ($n=10$): subject as defined in the New Zealand Curriculum Framework. (2007)
 Function ($n=4$): the technical way the device answered the enquiry.

In alphabetical order.

Personal enquiry (including greetings)	English	Admin
Spelling and word definition (including names)	Mathematics and statistics	Task
Story/book request	The arts	Web scraping
Playing music	Science	Unknown
Curiosity	Social studies	
Maths (BEDMAS)	Physical education and health	
Social advice	Technology	
Translation and languages	Learning languages	
Manners and praise	Te Reo Māori	
Learning tools and games	Other	
Speeches		
Slow down request		
Volume		

Writing and punctuation

Maths (geometry)

Maths (probability)

Maths (measurement)

Speaking request

Learning tools and games

Social advice

Translation and languages

Speeches

Jokes

Writing and punctuation

Local Information