How effective might tutorials designed around the major learning areas of the VARK framework be to teaching primary school students entry level programming and game design?

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Copyright Statement

Abstract

Computing and in particular, programming and video game development in UK primary schools are about to receive a big investment. And most primary school children have never been exposed to the many programming languages or what it takes to build a video game, therefore, this research investigates how schools might approach teaching children this area of computing. Also taking into account VARK's (1987) idea that everyone learns differently; how could schools effectively teach programming and game design to individuals? This was approached by using VARK (1987) heavily as a framework to develop tutorials and exposing them to a traditional classroom environment in primary schools. Observations and interviews with children and teachers suggests that these current forms of tutorials are somewhat effective in teaching the Scratch software package, the effectiveness though, depends on factors that are present in a traditional classroom environment. Refinement of the tutorials as well of more control over classroom factors might improve the effectiveness and reliability of these tutorials.

Contents

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1.0 Introduction

This thesis discusses the effectiveness of a technology-enhanced learning (TEL) intervention in a primary school setting. This will be done by taking a pre-existing software package designed to demonstrate basic video game design and programming principles into primary schools, this pre-existing software will be Scratch; a lightweight 2D Sprite based program. Pupils will be taught to use this software through the forms of different teaching approaches, and drawing on Fleming's VARK framework (1987), interventions will be designed and implemented which address three learning styles: visual, aural and reader/writer. As suggested in the VARK framework, pupils are individuals that learn differently from one another (VARK Learn Limited, 2016). Therefore, using Bolles' Sensory Learning Method (1997) an intervention will be designed that combines video and audio as it is suggested that it is more effective than either one on its own, this will be a series of video tutorials that demonstrate actions on screen whilst being narrated at the same time. Another intervention will be designed that incorporates a learning from reading approach, the intervention will involve text and images to teach the same material as the video and audio version. Research will be done into appropriate methods and theories to ensure the design of these interventions are effective in teaching children Scratch. The effectiveness of these interventions will be measured through two data collection cycles and comparisons and observations will then be made.

1.1 Context and Justification

The video game industry in the UK is projected to contribute £1.02 billion to the UK GDP (Gross Domestic Product) (Wilson, 2014) because of this, now is a beneficial opportunity to introduce the tools and knowledge to children. The learning programming landscape has changed a lot since the days of magazines like Input Magazine that readers used to input code into their Commodore 64s and BBC Micros in the 1980s. Now there is a lot more choice of software and better means of obtaining information with internet. Harms, Kerr, Ichinco, Santolucito, Chuck, Koscik, and Kelleher (2012) identify that two issues that surround programming in schools are that there is lack of time to place programming in the curriculum and that many teachers don't have a computing background. This research could help with these issues by providing a streamlined, effective method of teaching that both teachers and children can easily work with.

This investigation will introduce Scratch into primary schools and in particular small groups of children. Scratch was chosen because it is very visual based, which means the intimidating nature of programming with text isn't as present as using Turtle Academy's software, Scratch will help to teach children the concepts and principles of programming. Moreover, with Scratch there can be a more instant reward from the work the children will do which the article '*Recognition and Reward Guidance for Children and Young People*' suggests is good for encouraging learning and development of skills.

Programming in education is becoming increasingly popular due to the technology driven world we live in today. Because of this "G*overnment minister Michael Gove proposed promising changes to UK ICT education*" (Everitt, 2014). There are a lot of resources available outside of schools in

the form of online courses, magazines and books but now there are a lot of options that are exposing themselves to UK schools like ComputerXplorers that bring after school clubs to primary schools to teach children programs like KidPix 3D and games like Minecraft that are accompanied by lesson plans to guide the groups through team building exercises and game mechanics. Although these clubs only last for an hour per week the children are experiencing a different side to computing other than word processing and spreadsheet skills that are the subject of current school ICT courses.

This is a step into the right direction, although, there is room for improvement. This improvement will only happen when the barrier for entry to programming is brought down by making teaching programming less daunting to teachers and to streamline the learning process so that programming can be more suited to the curriculum.

There are an increasing number of opportunities for people of all ages to get into programming, these opportunities come in the form of software packages and after school/out of school clubs. However, there hasn't been a clear method of learning that has been defined; for example Gruenbaum (2014) talks about a new class at the University of Washington that aims to teach coding concepts using Scratch, which done in a workshop format therefore there would have been a lot of hands on experience with the software. Gruenbaum mentions how some students struggled to catch with **up** others which resulted in incomplete work, this might be because these particular students don't learn best with a hands-on or kinaesthetic approach. Therefore, there isn't much thought going into how children perceive and interact with the materials presented to them.

1.2 BBC Micro Bit

In 2015 the BBC plan to introduce primary school children in the UK to basic programming by giving every child in Year 7 a Micro Bit. A Micro Bit, as described by the BBC website is "*A pocket-sized codeable computer*" (bbc.co.uk, 2015), it bears a lot of resemblance to the BBC Micro computer that was introduced in the 1980s in the way that its aim is to provide that first step into the digital age and more specifically, into programming.

Key features of the Micro Bit include (Taken from BBC website):

- Programmable LED lights
- Two programmable buttons
- Motion detector or "accelerometer"
- Compass
- Bluetooth
- Five input and output rings

The BBC are obviously taking a different approach to teaching children programming by offering a piece of hardware that is programmable instead of purely software like Scratch and Game Maker. The Micro Bit will have children plugging the device into a computer, mobile phone or another device such as the Raspberry Pi and will have them using the accompanying software to communicate with the device. By programming two buttons and with use of the accelerometer the device could be used as a controller for a video game or to control other software (bbc.co.uk, 2015).

Sinead Rocks, The Head of BBC Learning says "*We happily give children paint brushes when they're young, with no experience - it should be exactly*

the same with technology" (bbc.co.uk, 2015). This reinforces the fore mentioned point about now being a beneficial time to introducing tools such as hardware and software to the new generation as well as doing research into how such tools should be taught to children.

Furthermore, it is great to see big companies like the BBC pushing this area of computing because it will allow easier and cheaper access to more resources therefore more children in primary education in the UK will be given more opportunities to get started in the digital world that surrounds us, as it is very important to offer these tools and opportunities now *"It is that if we don't act now we will be short-changing our children"* (J. Naughton, 2012) and to further this point *"But their world will be also shaped and configured by networked computing and if they don't have a deeper understanding of this stuff then they will effectively be intellectually crippled."* Therefore, the Micro Bit as long with the similar device the Raspberry Pi are giving children the chance to code using hardware and introduce them to the digital world at a young age.

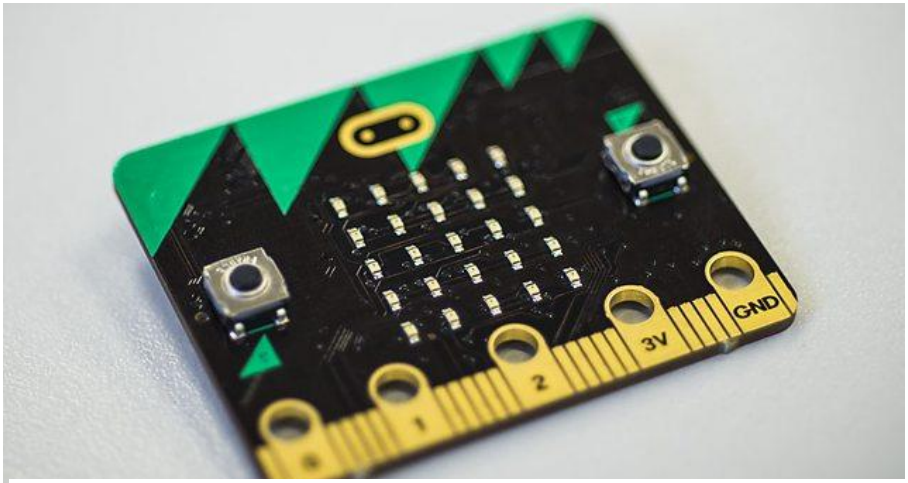

Figure 1: BBC Micro Bit

The BBC Micro Bit along with the government's new curriculum on programming is evidence that there is going to be a major push for computing in education in the UK in the next few years. Computing in schools in the UK will be a new area of education as Curtis (2013) says *"England will become the first country in the world to mandate computer programming in primary and secondary schools".* This is an appropriate time to perform research in this area and in particular research into effective ways to teach computing materials to primary schools pupils in the UK.

2.0 Literature Review

This section will briefly analyse existing research that is relevant to this project and it will show how it relates to this investigation. Firstly, this section will look into any theoretical theory that is relevant to the subject area for example how video has been used to enhance learning in schools as well as looking at how the other three learning preferences (Audio, reading and kinaesthetic) have been used to teach. Secondly, this section will look at physical/digital products that have been brought into learning environments. Although the focus of this project isn't the software that the children will be using it is important to see how software that is designed to teach is received and in what ways they can be effectively used. With these insights, it can be made clearer which software to choose to accompany this project's interventions.

2.1 Learning Related Literature

The following section will discuss literature and theories that relate to learning and teaching, the literature here will made up the building blocks of the interventions.

2.1.1 VARK

VARK is an acronym which stands for Visual, Aural, Read/write and Kinaesthetic, these are four modalities or learning styles that are described by Fleming and Mills (1992). They "*Suggested four modalities that seemed to reflect the experiences of the students and teachers*" although they also mention that there is some overlap with the styles. Fleming, being a learner and a teacher himself mentioned that his main research interest involved *"How people learn and how they use their modality preferences in their communication"* (VARK Learn Limited, 2016)

Firstly, the visual element of the learning style refers to a person's preference of information displayed in forms such as "*Maps, spider diagrams, charts, graphs, flow charts, labelled diagrams, and all the symbolic arrows, circles, hierarchies and other devices*" (VARK Learn Limited, 2016). The visual element of VARK, despite the name "visual" does not involve videos or anything of that nature. Another label for this modality could be "graphic".

Secondly, the aural/auditory element is described as information presented as being heard or spoken. The VARK website (2016) suggests that *"Learners who have this as their main preference report that they learn best from lectures, group discussion, radio, email, using mobile phones, speaking, web-chat and talking things through"*. This form of learning has a major emphasis on talking out loud, discussing ideas and information vocally to someone else or even just to themselves. Repeating what someone has already said or asking a previously answered question is all part of learning through the modality.

Next, the read/write learning preference related to information being displayed simply as words. This includes *"Reading and writing in all its forms but especially manuals, reports, essays and assignments"* (VARK Learn Limited, 2016). The internet is an excellent resource and tool for people who prefer using words to learn information, in particular sites like

Wikipedia are well suited to this style. Although, with the internet there is also a lot of imagery and even videos, therefore, there is some overlap here.

Lastly, Kinaesthetic (Or Kinesthetic in other parts of the world) this last modality refers to *"perceptual preference related to the use of experience and practice (simulated or real)"* (VARK Learn Limited, 2016) also, this style of learning could also be described as learning by doing, more simply. The VARK website also suggests the people with this particular learning preference value their own experiences of doing a certain task. In terms of computing, a student may not fully grasp a concept of programming until they have sat down at a computer themselves and attempted it. Moreover, this modality have the most overlap with the other learning styles than the rest, as taking part in a particular task could involve reading, listening or even looking at diagrams before they perform the task, or as they perform the task.

Therefore, Fleming (1992 onwards) designed sets of questions that became the VARK questionnaire which appears on the VARK Learn Limited website. This questionnaire consists of 16 questions that are multiple choice and the user can select as many choices as they feel applies to them. After a questionnaire is completed the user will be given four results, one for Visual, Aural, Read/write and Kinaesthetic. This questionnaire will be used in this project to gather information about student's learning preferences.

This project will be heavily based upon the works surrounding VARK by Fleming and Mills (1992) and in particular the four learning styles discussed in this section will be pillars on which the interventions for this project will be designed and developed.

Cassidy (2004) writes about the *"Fragment and disparate"* topic that is learning styles and the research behind it, this is because of the quantity of research around it. Cassidy (2004) attempts to explore *"learning-related concepts"* and while he mentions particularly ones that are the focus of attention he goes into detail of *"learning style"*. On the topic of learning style, he states that *"Learning style has been the focus of such a vast number of research and practitioner-based studies in the area, there exist a variety of definitions, theoretical positions, models, interpretations and measures of the construct"*. In this area of research, it can be difficult to define a path/approach to applying a learning style to a project such as this.

After looking into alternative styles of learning such as, Curry's Onion Model (1983, 1987) in that there are multiple layers to learning behaviour. And Riding and Cheema's Fundamental Dimensions (1991) in which how information is processed is split into two major areas/dimensions, it was decided that in the interest of time this project would benefit from an approach that I have tried before. During my undergraduate project VARK was one particular approach that was analysed and implemented. Some of the ground work was already done, therefore VARK would be used again in this project.

2.1.2 Cognitive Overload

Cognitive load is according to Mayer and Moreno (2003) the amount of information a person can process at one time. Their journal talks about how people process information using separate channels; pictorial and verbal and how the brain makes connections between these two channels to

improve learning. The studies they performed determined that the information people can process through these channels does have a limit and they state that “our analysis shows that cognitive load is a central consideration in the design of multimedia instruction” (2003). Moreover, Mayer and Moreno do offer theory based suggestions that they claim could reduce cognitive load all of which will be greatly considered when developing the interventions for this project.

The table in figure 2 briefly describes some overload scenarios that happened during Mayer’s and Moreno’s (2003) studies and methods that they came up with to reduce the load of information.

TABLE 3
Load-Reduction Methods for Five Overload Scenarios in Multimedia Instruction

Type of Overload Scenario	*Load-Reducing Method*	*Description of Research Effect*	*Effect Size*
Type 1: Essential processing in visual channel > cognitive capacity of visual channel			
Visual channel is overloaded by essential processing demands.	Off-loading: Move some essential processing from visual channel to auditory channel.	Modality effect: Better transfer when words are presented as narration rather than as on-screen text.	1.17 (6)
Type 2: Essential processing (in both channels) > cognitive capacity			
Both channels are overloaded by essential processing demands.	Segmenting: Allow time between successive bite-size segments.	Segmentation effect: Better transfer when lesson is presented in learner-controlled segments rather than as continuous unit.	1.36 (1)
	Pretraining: Provide pretraining in names and characteristics of components.	Pretraining effect: Better transfer when students know names and behaviors of system components.	1.00 (3)
Type 3: Essential processing + incidental processing (caused by extraneous material) > cognitive capacity			
One or both channels overloaded by essential and incidental processing (attributable to extraneous material).	Weeding: Eliminate interesting but extraneous material to reduce processing of extraneous material.	Coherence effect: Better transfer when extraneous material is excluded.	0.90 (5)
	Signaling: Provide cues for how to process the material to reduce processing of extraneous material.	Signaling effect: Better transfer when signals are included.	0.74 (1)
Type 4: Essential processing + incidental processing (caused by confusing presentation) > cognitive capacity			
One or both channels overloaded by essential and incidental processing (attributable to confusing presentation of essential material).	Aligning: Place printed words near corresponding parts of graphics to reduce need for visual scanning.	Spatial contiguity effect: Better transfer when printed words are placed near corresponding parts of graphics.	0.48 (1)
	Eliminating redundancy: Avoid presenting identical streams of printed and spoken words.	Redundancy effect: Better transfer when words are presented as narration rather narration and on-screen text.	0.69 (3)
Type 5: Essential processing + representational holding > cognitive capacity			
One or both channels overloaded by essential processing and representational holding.	Synchronizing: Present narration and corresponding animation simultaneously to minimize need to hold representations in memory.	Temporal contiguity effect: Better transfer when corresponding animation and narration are presented simultaneously rather than successively.	1.30 (8)
	Individualizing: Make sure learners possess skill at holding mental representations.	Spatial ability effect: High spatial learners benefit more from well-designed instruction than do low spatial learners.	1.13 (2)

Figure 2: Table to show Cognitive overload scenarios and solutions (Mayer & Moreno, 2003, p.46)

Type 1 – Off-Loading When One Channel is Overloaded is described as what Sweller (1991) calls the split-attention effect. The Mayer’s and Moreno’s journal (2003) suggests a situation where a student is watching animation with moving elements and on screen text that explains the content, this text is at the bottom of the screen, this means the student’s attention is split between the moving animation and the text that is displayed elsewhere. The solution they suggest is called off-loading; in regards to the same scenario they recommend the on screen text to be pushed to the audio channel in the form of narration

Type 2 – Essential processing in both channels is a scenario this research will probably encounter because of the nature of one of the interventions; the one that is built using visual and audio in mind. Therefore, it will be beneficial to expand on this certain scenario. Their journal (2003) talks about an example where a student is watching an animation that features pictures which will be processes by the student’s visual channel and is narrated which will be processes by the audio channel. The overloading of the channels can come from the animation being too rich in content and from playing too fast which results in the student not having enough time to process the content individually and to connect pictures and audio together “By the time the learner selects relevant words and pictures from one segment of the presentation, the next segment begins, thereby cutting short

the time needed for deeper processing". There are a couple of suggested solutions for this particular scenario but the Segmenting solution is most appropriate, this solution for one, simply involves breaking down the content into smaller chunks and allowing time between each chuck this will allow time for the student to process and link the content together. Furthermore, in the animation example a button could be implemented that allows the user to continue to the next section when they are ready. On the other hand, with anything other than an animation or similar intervention, for example a video, the length of each section would have to be considered. Mayer and Moreno (2003) back this point up by saying "When it is presented in learner-controlled segments rather than as a continuous presentation".

A detailed look into cognitive research in learning by Mayer, R.E. & Moreno, R. (2003) will be useful. This investigation's research will look into learning and teaching theories that have been used in the video game and interactive media for education spaces like the work the organisation Quest to Learn has done with their learning for complexity and, learning for design and innovation approaches (q2l.org, 2016) and how Repenning brought his Scalable Game Design software into American schools.

Also, Bolles' Sensory Learning Method (1997) which suggests learning through two sensory channels (visual and audio) is more efficient and Kolb's Experiential Learning Cycle (1984) that describes a cycle that increases learning will compliment VARKs (1987) work and help develop an effective way to teach Scratch.

As Peyton-Jones (2013) states "Computers are now part of everyday life. For most of us, technology is essential to our lives, at home and at work". He feels teaching children in primary schools programming and other similar computing skills will be important so they can "Participate effectively in this digital world". Peyton-Jones' organisation does an effective job of introducing the concepts, principles of computing and programming as well as using a range of different software and internet services just like the fore mentioned Quest to Learn does. Although because this area is still relatively new (these two organisations only appeared in the last couple of years) there is still work to be done to improve the effectiveness of the learning process. Although, according to Moody and Sindre (2003) "Currently, there is no standard instrument for evaluating learning effectiveness", that was until they conducted this study. Therefore, this process as well as Neil Fleming's VARK will be the pillars that this research will be built from.

2.1.3 Threshold Concept

Threshold concepts is an idea that came from a UK national research project about learning and teaching environments. Erik Meyer and Ray Land suggest that "*Certain concepts were held by economists to be central to the mastery of their subject*" (Cousin, 2006), to break down this quote; there are certain thresholds or milestones in a subject that once a student passed they will have this eureka moment that enables the student to progress through the subject onto more difficult material or into another area of the subject. These threshold concept essentially opens doors to the student that were previously closed, "*Maybe considered to be "akin to passing through a portal" or "Conceptual gateway" that opens up "Previously inaccessible way[s] of thinking about something*" Meyer and Land (2003).

Furthermore, it is said that there are eight features of a threshold concept; many of these features will be important and could help direct the design and development of this project's interventions therefore, these features will be listed and expanded upon below.

2.1.3.1 Transformative

A threshold concept at its core is; transformative this means that once a student has understood this concept of the subject it can change the way the student thinks about the subject and its material. In regards to this project for example, once the students grasp the different tools in the Sprite editor work then they can begin to create their own assets and therefore can make the game their own and unique. In other words, more doors have been opened and the student may think about creating the project in Scratch differently now, they no longer have to stick to the limited library built into Scratch.

2.1.3.2 Troublesome

Threshold concepts can be troublesome, the particular knowledge that needs to be grasped/mastered Meyer and Land (2005) say "*Knowledge may be troublesome because it has become ritualised, or inert, because it is conceptually difficult or alien*" a student might have their own understanding of an idea or concept that won't be correct and they might refuse to move from this way of thinking when exposed to a different, correct way. It might prove hard to move the student away from their way of thinking. For example, a student might have previous experience with a similar program to Scratch but has fundamental difference in the way the software is used. This student might have trouble adjusting to this different way if they are comfortable with the way they already understand.

2.1.3.3 Irreversible

This feature is self-explanatory; it is difficult to unlearn a threshold concept once it is learnt. The Academy of Art University (2015) uses the following example that is illustrated in figure 3:

"*Did you know that there is an arrow embedded in the FedEx logo? Maybe you did. If you didn't, look for it next time. Once you see it, you will never be able to look at the FedEx logo again without the arrow popping out at you. You will not understand how you ever missed it*"

Figure 3: FedEx Logo

Although this particular example is a very simple analogy the principle stays the same. Once that eureka moment has happened for a student it will be very difficult to take a step back and forget this threshold concept.

2.1.3.4 Integrative

Once a particular threshold concept has been overcome other similar concepts and ideas begin to easier to understand for the student, it may bring together other troublesome concepts. In reference to this project, say for example a student has overcome the concept of the IF function in Scratch then other similar functions such as FOREVER and IF can be understood more easily. But before one of these functions were understood the student had trouble with using of all these functions.

2.1.3.5 Bounded

Bounded can occur when an idea, concept or phrase/term etc. is confused with the same from another subject. The student is therefore bounded to this one particular understanding of this concept and will have trouble differentiating between the two ideas. Terminology may even be common in everyday usage which may confuse a student (Flanagan and Smith 2008). A good example of this is the fore mentioned IF and FOREVER functions in Scratch.

2.1.3.6 Discursive

Discursive is when a student places the threshold and develops an extended use of language and are more capable of simply understanding the concept, "*We have repeatedly seen students who have grasped a local threshold concept themselves enthusiastically and volubly attempt to lift their partners over the same threshold*" (Flanagan and Smith 2008).

2.1.3.7 Reconstitutive

This threshold concept feature is when a student passes a threshold which allows them to reconfigure an earlier conceptual stance. A previous understanding they had of a concept which is incorrect can now be altered because the student has passed an important threshold concept.

2.1.3.8 Liminality

Liminality is the term given to the 'rite of passage' a student takes when they understand a threshold concept. Cousin (2006) suggests that "*In short, there is no simple passage in learning from 'easy' to 'difficult'; mastery of a threshold concept often involves messy journeys back, forth and across conceptual terrain*".

Therefore, the curriculum that will be designed for this project needs to integrate this theory and to do this there are three key design suggestions that Cousin (2006) talks about in his article. The first of which is known as jewels in curriculum; this is where the key points or powerful transformative point are identified. To elaborate, there will be great care put into each individual lesson plan so that threshold concepts are placed appropriately. Therefore, the participating students should encounter these concepts at the right time and should have no trouble overcoming them and so that the next lessons are not a problem.

The next suggestion is called listening for understanding; this step can only take place during the actual run of the lessons instead of the design and modifications of the lessons plans. Whilst the lessons are taking place there will be observations on how well the students are doing i.e. how fast they are getting through the material and which materials they are using most (The video tutorials or the written guides). If any student is having any problems with any part (in particular the threshold concepts) they will be spoken to, to try and get an understanding of the problem. Is it just this student or are more having the same problem at the same place? Once these situations are noted the lesson plans can be adjusted and optimised this should lead to the more effective lesson next time round.

Lastly, a holding environment, which can be linked to listening for understanding is where a student is struggling with something but fears they are the only one. This may lead to them suffering in silence and therefore, won't seek help. Students that are stuck for too long may resort to mimicry or plagiarism. So looking for this during the lessons is very important not only because it is suggesting the lesson might be too difficult but obvious for the student as well, it would be unfortunate for a student to be cheated out of learning. Furthermore, "*students expressed the fear they were the only ones among their peers who did not comprehend difficult concepts. While it became a source of huge relief to discover eventually that other students were similarly confused, this awareness needed to be shared early on in the course*" (Cousin 2006) it is also important to catch this sort of situation early on so the student can be reassured and helped along, communication is paramount to understanding how effective or ineffective the lesson plans are.

2.1.4 Multisensory Teaching Techniques

Praveen (2015) sums up multisensory teaching techniques in saying "*If a child is not learning in the way you teach, change your teaching strategy and teach the child in the way he learns!*" Praveen goes on discuss studies that suggest that children who have difficulty learning to read can be helped via a multisensory teaching method, the same could be assumed for children that struggle to learn via visual and audio materials. Therefore, MTT (Multisensory Teaching Techniques) are designed to use these different sensors together instead of focusing on just one "*Multisensory teaching techniques and strategies stimulate learning by engaging students on*

multiple levels". To elaborate on this, a child's vision may be affected by injury or simply isn't as developed as others and on the other hand, another child's hearing may have similar problems, MTT is built around offering something for everybody.

Also, children are less likely to struggle with the material because they are able to use their personal areas of strength be it looking, listening, reading or even doing. Studies have suggested that children do learn at a faster pace, learn more easily and develop a better understand of concepts when exposed to MTT (Praveen 2015). Moreover, teaching materials that integrate more than one sense encourages children to develop their lesser senses utilising more of them, children may "*Tap into nonverbal reasoning skills*" or "*Link information to ideas they already know and understand*".

Praveen's (2015) article also provides some bullet points that advise on what to include when designing materials based on visual and auditory learning that could be useful when developing materials for this project:

To stimulate visual reasoning and learning

- Text and/or pictures on paper, posters, models, projection screens, computers or flash cards
- Use of colour for highlighting, organizing information or imagery
- Graphic organizers, outlining passages
- Student created art, images, text, pictures and video

Auditory techniques

- Books on tape, peer assisted reading, paired reading and computerized text readers
- Video or film with accompanying audio
- Music, song, instruments, speaking, rhymes, chants and language games

As already stated the nature of this project is to develop two separate lesson plans/materials one focused on video and audio and the other focused on text/reading and screenshots therefore, this multisensory teaching theory (Praveen 2015) suggests that in practice the children should use both these materials together to gather information and to progress through the lesson instead of favouring one particular option.

On the other hand, the VARK (1987) theory based on its principles may suggest the opposite so that a child knowing that their learning preference is audio for example, will choose the video tutorials most of the time if not all the time instead of using both together.

2.2 Discussion of Programming Environments

Discussion and comparisons of potential programming applications will take place here, one was then chosen to be incorporated into the project. Programming environments are computer applications that act as a set of tools or an editor for the user to create code, this code could eventually be another computer application or a video game etc. There are different types of environments, for example, visual based ones and text based ones.

2.2.1 Scratch

Scratch is a computer application that allows users to create simple games and to develop a basic understanding of design and programming concepts and ideas. A user can use its tools to mix art, music and logic to achieve different results. The program was developed by MIT (Massachusetts Institute of Technology) Media Lab in 2006 and has received regular updates since then.

Scratch is the go to choice of software for this project because firstly, it is a free application that is easily accessible online and is downloadable to be used on the desktop/offline, therefore, there will be no issue getting hold of the software. Secondly, programming and the concepts/principles that come with it can be difficult for some students to understand (Kerki, 2008) so Scratch was used to “Smooth the initial relationship with programming”. This is important because the intended audience this project is going to study is primary school pupils whom will most certainly have no programming or game design experience prior to this. The case studies Kerki conducted resulted in some positive feedback. Kerki found that Scratch to promote high levels of motivation is the pupils providing a “positive perception of learning programming”, so Scratch is a good first step to introducing pupils into programming. On the other hand, the same case study discovered that there wasn’t as big an improvement is skills of pupils that have already used Scratch before.

Moreover, Scratch is Sprite and Script based; although the systems in Scratch are very simple compared to a lot of other video game engines and development environments they are simple enough and appropriate for an introductory step into programming and game design. Firstly, according to TechTerms (2012) a Sprite is a *“Bitmap graphics that is designed to be part of a larger scene. It can either be a static image or an animated graphic. Examples of sprites include objects in 2D video games, icons that are part of an application user interface, and small images published on websites”.* Sprites were extremely popular in video game development during the 1980s and 1990s before technology that was powerful enough for 3D rendering was developed. Sprites in video games are still used now, they are mostly seen in a lot of independently developed titles because they are cheaper and easier to create, as well as for the nostalgic aspect, as a way to remember the older generations of video games. As sprites were used to create the protagonists and enemies of video games as well as power ups and other objects, this meant they were important therefore, it is important to introduce and teach this element of video game design. In Scratch the user has the ability to import already made sprites from various resources such as websites or create their own. The software also has a feature called

Costumes which can be used to alter the appearance of a sprite and cycle through them, effectively creating an animation.

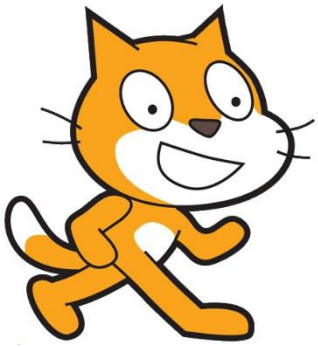

Figure 4: Scratch's cat mascot, used as the default sprite when starting a new project

Secondly, Scratch features a Scripting system that is visual based instead of an actual programming language which is text based, for example, C# or Java. Script in Scratch requires the user to drag a block of Script from the library and drop it on the blank Script canvas. The Script system features many of the concepts and phrases you expect to come across in any programming language such as Java and C#. Phrases that the user will come across are, for example, an IF statement; which is a block of code that tells the program to execute something only if a certain condition has been reached. This block of code in Java could amount from 5 to 15 or even 50 lines of text, which could get very confusing to a beginner student. In Scratch, a simple IF statement can be 3 or 4 blocks of Script, as illustrated in figure 5:

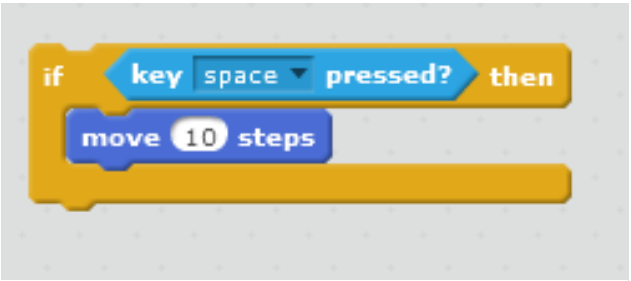

Figure 5: IF statement in Scratch, consisting of 3 blocks

This simplified version of basic programming concepts, similar to the sprites, will be a good introductory step for students in primary schools for the understanding such concepts.

2.2.2 GameMaker

GameMaker is another computer application that provides users with a game creation system. Similarly to Scratch a lot of the interface is “drag and drop” and it features a scripting language known as Game Maker Language. GameMaker first appeared in 1999 and is still supported today, appearing vastly different to its initial release, it is developed by YoYo Games. The software is a lot more advanced than Scratch because of its more complex

scripting options and its ability to export its projects to various devices like Android and iOS phones and tablets. This results in a more powerful toolset that might prove to be too advanced for primary school pupils. In addition, GameMaker isn't available for free it is priced at $49.99 for the professional version (yoyogames.com, 2015). Software like GameMaker would be an effective tool for pupils who have already had an introduction into programming and game design. This is where Fleming's VARK theory can be used to develop a unique learning experience to the pupil, one that can be more effective to the individual, from this the research question emerges: *what influence can VARK-inspired interventions have on a children's learning experience in programming?*

2.3 Discussion of Teaching and Learning with Video and Other Mediums

This section will discuss appropriate techniques that comes with teaching through and with interactive mediums and in particular video. Moreover, what effective methods can be employed when teaching a video game and video game creation to a class, is this something traditional teaching methods can handle or is there a different approach? Also, are there certain elements to consider when dealing with video content?

2.3.1 Teaching with Interactive Media

Shaughnessy and Fulgham (2011) use an old Chinese quote to describe the traditional way of teaching "*Teachers open the door; you enter by yourself*". What they are saying here is that traditionally a teacher is always present to help you through this door of learning but now with online learning in the form of video tutorials, guides and software with built in help and tutorials this quote isn't as true anymore. The user/student is now more in charge of their learning without the presence of a teacher therefore it is up to the online material to be effective, informative and accessible.

Furthermore, it is said that "*The instructional environment should be viewed as a system, a relationship among and between all the components of that system — the instructor, the learners, the material, and the technology"* (Shaughnessy & Fulgham, 2011). The instructional environment sometimes has to work without the instructor present, as instances like online tutorials. Therefore, the instructor must make prepare everything a head of time to ensure the environment works properly without his input, if it can be avoided. Although this is the ideal situation, the instructor can and should provide his help and input to the leaners whenever they need it. In relation to this project; the sessions that are going to take place will take this form that is described in the instructional environment. This effectively means that, the students will be given the tutorials and will be asked to follow them to the best of their ability with an instructor being present as an additional resource. Therefore, a lot of care and planning will go into the design and development of the lesson plans as well as looking into an effective way to present and structure the lessons. Because, as suggested by Moore and Kearsley (1996) the relationship between all these components of this

system are important and *"That adapting a systems approach is the secret of successful practice"* (1996), so that adapting a system similar to the one posed by Moorse and Kearsley may be an effective way to approach this project's objectives. On the other hand, because the sessions that this project will provide won't be over a long distance and will instead be local to primary schools in the area, a teacher will be present in the classroom to engage with the students to help them understand the content of the tutorials. Although, one goal for the teaching materials is to be informative and effective enough so that they can stand on their own, therefore, students can progress through the tutorials unaided and at their own pace. Additionally, the tutorials, following Moore and Kearsley distance education system could be made available online for users to follow in their own time outside of school.

Additionally, there is a model for course design called Unit Module Topic model (UMT Model) that is based around the best practices for developing courses/lessons and for fast delivery. This model considers "*The content, the nature of the learner, the process by which the learning will take place (methodology) and the means for assessing the learning experience*" (Shaughnessy & Fulgham , 2011). These points will be very important and will be taken into account during the development of this project's lesson plans.

To expand on the point about the nature of the learner Willis (1994) suggests some questions that could be asked before the lessons take place to help understand this particular audience of students:

What are the students' age, cultural backgrounds, interests, and educational levels?

What is the level of familiarity of the students with the instructional methods and technological delivery systems under consideration?

How will the students apply the knowledge gained in the course, and how is this course sequenced with other courses?

Can the class be categorized into several broad subgroups, each with different characteristics?

2.3.2 Teaching with Video

Teaching with the use of video has changed a lot over the years due to the growth of the internet and in particular websites like YouTube, which theses now feature hundreds or even thousands of tutorials and instructional videos for a number of subjects and topics. Bull and Bell (2010) compares the traditional way of teaching with video to what is common is classrooms now. The old way consisted of turning on a film projector or VHS/DVD player and stepping out of the role of teaching whilst the video played, these videos could be 30 to 60 minutes long. Nowadays teachers are going to YouTube and similar sites to aid in delivering information to their students, these videos are generally a lot shorter for example 30 to 60 seconds or even a couple of minutes long. Because of these shorter videos the teacher can use these to "*Pinpoint the most relevant information and play an active role in the instructional process*" (Bull & Bell, 2010). As the authors explain,

videos are generally very easy to find online and a number of videos can be used together in a sort of playlist to help students develop an understanding of a concept and to provide new information that would otherwise be difficult to acquire. Therefore, it would be beneficial to follow the structure of online tutorials in creation of the tutorials for this project, that is, to make the videos relevantly short and in parts. Each video will demonstrate one or more steps of the whole process, this way the student can have time to evaluate the information in between videos. Furthermore, because of the length of the videos they can easily be replayed and skipped to a certain point which will aid in the learning process.

On the other hand, there are disadvantages that come with learning with video for example, "D*ifference between watching as a casual consumer and watching as a learner*" (Bull & Bell, 2010). Watching a video for the purpose of instruction/learning requires the viewer to have a form of critical thinking whilst watching instead of just watching something like somebody would for entertainment purposes. The authors suggest two forms of awareness a student must have when watching as a learner; the first one is they must be aware of the context the video, questions like who made the video, when was it make and why was it made need to be answered for the student.

Furthermore questions like how was it made might be important to this area of research, for example, the videos being made for this project will be made using Camtasia video recording software and the software being used in the videos will be exactly the same version as the students will use in the sessions. Therefore, things such as the videos' intent, i.e. information, persuasion, entertainment etc. needs to be explained to the students beforehand so they know what to expect and what form of critical thinking will need to be involved whilst watching.

Moreover, the second form of awareness is self-awareness "*As viewers watch the presentation, how does information being viewed fit within each person's existing ways of knowing and understanding?" (*Bull & Bell, 2010*).* The information/demonstration in the video might conflict with a student's previous knowledge and/or experience, a student might be left confused and may be left with questions after the videos so it is a good idea to get an understanding of the student's position in terms of their knowledge and previous experience before introducing them to the learning materials and the software. Getting this information prior to the sessions be would of greater benefit because adjustments can be made to the learning materials before they even get to the classroom therefore, they will be tailored more to this group of students and should be more effective.

Another important point, it is suggested to encourage critical viewing with videos, that is, to have the viewer challenge and engage with the video instead of simply watching the video as you would for entertainment. This can be used to make sure the students are being involved and are understanding the content as it's being delivered "*As with critical reading, critical viewing is mentally active and requires the viewer to be in dialogue with the material*" (Bull & Bell, 2010). This can be done by asking specific questions before the videos and then asking for the answers at the end.

To elaborate on the earlier point about the length of the videos, because the videos that are going to be created for this project are going to be screencasts (A recording of a computer screen) it is a "*Pre-recorded event can be viewed multiple times and sped up or slowed down for analysis*" (Bull & Bell, 2010) this will help in case a student does not understand something first time so therefore, can repeat the video and the action themselves until

they understand it, this relates to the repetition learning theory by Wogan and Waters (1959). Also, because the videos can be stopped at any time there is the chance to pin point important information and even highlight the aforementioned threshold concepts so the students understand where the milestones are and furthermore, what can be achieved after these milestones are completed.

3.0 Research Question, Methods and Methodology

Upon preliminary research into the VARK framework in which every user comes out at the end of the VARK questionnaire with a different score, leading to the idea that every person learns differently from one another. As well as looking into multisensory teaching techniques through the uses of interactive media such as videos and online tutorials discussed in Chapter 2, a primary research question (PRQ) arose:

How effective might tutorials designed around the major learning areas of the VARK framework be to teaching primary school students entry level programming and game design?

Moreover, with underlying research into teaching related theories such as threshold concepts and cognitive load clear project objectives were presented:

- To investigate the experience of a student using a tutorial tailored towards their learning preference.
- To explore the advantages and disadvantages of such tailored tutorials against traditional methods of teaching in class rooms.

3.1 Methodology

This section will discuss and compare different methods and methodologies before ultimately choosing the most appropriate one for this type of project; the methods chosen here will decide how the project moves forward, in particular how the sessions in primary schools will take shape as well as how the data will be collected. The primary and second research questions that were outlined in section 3.0 will be the primary consideration when choosing an appropriate research approach.

3.1.1 Discussion of case-study as a research methodology

The case study method of approaching research is described as investigating a case or multiple cases; a case could be *"A class, or an office, or a hospital ward; it can be an institution"* (Bill, 2010, p.1). Which, to begin, could appear to this project as the case would be the group of students in a primary school that used the tutorials. Bill (2010) goes on to mention that "*Not one kind or source of evidence is likely to be sufficient (or sufficiently valid) on its own*". Therefore, instead, having multiple sources of evidences is a key feature of a case study, this would be beneficial to the validity of the data that would be presented from this project.

On the other hand, Bill (2010) discusses that the nature of case studies are *"scientific"* and that the ones preforming the experiments often have the ability to control all the variables, for example, the environment, the length of the experiments etc. Unfortunately, as the resources available to this project are limited and therefore, being invited into local schools and using

their resources on their terms is the most viable option all the variables can't be controlled. Consequently, the case study approached was rejected as a primary methodology for this investigation although the key feature of multiples sources of evidences would add to the authenticity of the data and therefore, will be incorporated.

3.2.2 Discussion of Action Based Research as a Research Methodology

Many sources credit Lewin (1980-1947) with coining the term Action based research (ABR) (Berg, 2004), since then the method has been a common practice in the area of educational research (See, for example, Anderson, Herr and Nihlen, 1994; Kemmis & McTaggart, 1988). And although it has appeared in many different other areas, for example, social sciences it is common *"Especially among those researcher interested in classroom teaching practices"* (Berg, 2004). Consequently, this method of approach would suit the environment this project intended to be involved in and would be a good fit to the literature that was discussed earlier in Chapter 2.

On the other hand, ABR can be compared to a design based research approach which result in a lot of similarities. In particular, the underlying process of action based approach as described by Sagor (2000) are:

- Selecting a focus
- Clarifying theories
- Identifying research questions
- Collecting data
- Analysing data
- Reporting results
- Taking informed action

Many phrases here in this process can be shared with those in the process of design based research that is discussed later on in this chapter.

3.2.3 Discussion of Design Based Research as a Research Methodology

According to Anderson and Shattuck (2012) Design based research (DBR) also known as design-research and development research is defined firstly through, *"Being situated in a real educational context"* (p.61) which, in this case a primary school in the north of England. Because of this fact, this research would be used to *"Assess, inform and improve practice"* (2012) in similar contexts like other projects taking place in schools and other educational establishments. Moreover, Brown (1992) who is credited with first developing the method of research, suggests that the focus on the design and testing for the intervention is an important aspect of DBR. To elaborate, the selection and creation of the intervention should be supported by relevant theories and literature *and "is designed specifically to overcome some problem or create an improvement in local practice"* (Anderson & Shattuck, 2012). The development of an intervention to aid the process of DBR is unique and in which the design part of the research method comes into play so therefore, won't be part of the process in another method of research, such as Action based research.

Furthermore, DBR has flourished over the last decade because of the *"Rapid development of new technologies (e.g., computers, wide-area Internet, and PDAs)"* (Wang & Hannafin, 2005) which would further put these approach in line with the objectives set out by this project as well as the context, background and justification discussed in section 1.1. And to the same effect, Wang and Hannafin suggests that one benefit of DBR is that it actively involves areas of learning and teaching as well as scientific procedures, the same cannot be said for the scientific-orientated ABR.

3.2.4 Design Based Research as a Chosen Research Methodology

Upon discussion and consideration of different approaches to research it became clear the design based research would be most appropriate, as development of interventions is an important factor to answering the project's primary and secondary research questions as well *"Design of these interventions is a key feature of the quality and results of the research project"* (Anderson and Shattuck, 2012).

Anderson & Shattuck (2012) stated that "*DBR is a methodology designed by and for educators that seeks to increase the impact, transfer, and translation of education research into improved practice"*. Furthermore, they highlight that DBR is growing in popularity in the education research space and that a number of respected researchers in the space have celebrated the potential of this approach. For instance, Brown (1992) noted that *"an effective intervention should be able to migrate from our experimental classroom to average classrooms operated by and for average students and teachers, supported by realistic technological and personal support"*. This justifies the choice of methodology for this type of project.

The intervention that will be created for this project will be designed with the theories for VARK (Neil Fleming, 1987), Bolles' Sensory Learning (1997) and Kolb's Experiential Learning Cycle (1984) as well as Moody and Sindre (2003) investigation evaluating the effectiveness of learning interventions. To analysis these theories as well as other appropriate research a literature review will take place. Although according to Phung (2012) "*due to the wide variety of DBR theoretical modelling and case studies deployed, it can be challenging to locate an over-riding theoretical framework to cross compare available DBR experimentations*" so Phung (2012) suggests a trio of acts in the article Design Based Research as Stories of Discovery and Invention that should be followed if conducting a design based research approach. These three acts mentioned by Phung (p.4) are as followed:

Act 1: Set-up of problems-questions in pre-experimental phase of analysis and exploration.

Act 2: Confrontation of problems through series of actions in experimental phase of design and construction.

Act 3: Search of solutions-answers in post-experimental phase of evaluation and reflection.

On the other hand, there are disadvantages that accompany this type of methodology. For example, although design research is a powerful tool there are some challenges that comes from this approach, some in particular are as followed, which are taken from Design Research:

Theoretical and Methodological Issues (Collins, Joseph, Bielaczyc, p.16, 2004):

• Difficulties arising from the complexity of real-world situations and their resistance to experimental control.

• Large amounts of data arising from a need to combine ethnographic and quantitative analysis.

• Comparing across designs.

Therefore, because these experiments will take place in a primary school setting, which is a real-world situation that is attended by school pupils of different backgrounds as well as ranging skills, in particular computing skills, the ability to control all aspects like behaviour might be troublesome. This is the scientific side of the research method which isn't the focus of this project; instead, the focus is the educational side, in which to better answer the project's research questions will take the interventions into a real world primary school class room with a range of students. Furthermore, the analysis from combine ethnographic data, which is a study of social interactions, behaviours and perceptions (Reeves, Kuper, Hodges, 2008) and quantitative data; that is information about qualities, *"In which the investigator compares two or more groups in terms of cause"* (Creswell, 2013)

Consequently, with the benefit of hindsight, certain difficulties associated with this approach could have been foreseen and therefore, planned for. Planning for these real-world situations more effectively is one area of improvement if a similar project were to take place in the future.

A design based research approach would be appropriate for this project because the authors from the Design-Based Research Collective argue that it is *"An important methodology for understanding how, when, and why educational innovations work in practice"* (The Design-Based Research Collective, 2002).

3.2.5 Discussion of Qualitative data vs Quantitative

Firstly, a qualitative approach to data collection is, as described by the Lewins, Taylor and Gibbs (2012) *"Forms of information gather in a nonnumeric form".* They give a list of common examples of such data:

- Interview transcript
- Field notes (notes taken in the field being studied)
- Video
- Audio recordings
- Images
- Documents (reports, meeting minutes, e-mails)

Lewins, Taylor and Gibbs continue to say that qualitative data *"Usually involves people and their activities…The most common forms of qualitative data are what people have said or done"* (2012). Consequently, data gathered from this method appear more texted based then that from qualitative. It requires looking at the data that was acquired from those listed above and making sense of them and picking out themes from the

information, this information can then be used to better answer the research question.

In comparison, quantitative data is described as requiring large amounts of data in order to be significant (Rasinger, 2013) whereas, qualitative often deals with small amounts of data *"The main characteristics of quantitative data is that it consists of information that is, in some way or other, quantifiably"* (2013, p.10). Furthermore, Rasinger (2013, p.10) goes on to mention examples of quantitative;

- People's age
- People's weight
- People's sex

From these examples here, two of them are numbers and the other one could be listed as a one letter label. Rasinger (2013) mentions that quantitative data usually deals with numeric data as opposed to qualitative data which, *"On the other hand, deals with the questions of how something is, as opposed to how much/many"* (2013, p.10).

Consequently, quantitative data would require going into multiple schools and gaining feedback on many students whereas, with qualitative only a smaller sample of data is required, therefore, only a couple of schools would bring in significant data. With time being a restraint because of the school year and its term times it was only possible to visit two schools anyway. Furthermore, the nature of the research question means that it doesn't require a numeric answer, instead the opinionated nature of qualitative data through the means of such research methods like interviews were more beneficial in answering the primary research question. To conclude, a qualitative approach to data collection made sense for the type of project and the time scale.

4.0 Discussion of Research Methods

This section will be a discussion of research methods that could be used in this research to aid in gathering data. Methods will be discussed and compared then one or more methods will be decided on. The methods discussed here will be appropriate to the project and when deciding on one to use the primary and secondary research questions were considered.

4.1 Interviews

One of the methods of gathering results that was incorporated into this research was interviews. Interviews were carried out with primary school pupils, they were conducted before and after the tutorial sessions. The aim of these interviews before the sessions were to retrieve a little background information about the pupil in reference to using computers and coding experience, this is drawing from Willis' (1994) theory about understanding the abilities of the audience of students that will be taking part in the sessions. Moreover, the interviews after the tutorial sessions were used to gain valuable feedback from the students about the video and reading tutorials, as well as the way the sessions were ran and structured.

Consequently, when conducting interviews with children, a number of ethical considerations had to be made. First and foremost, the safety of the children is important, as well as making sure the children will comfortable in an interview setting and answering questions given to them, as suggested by Esomar World's Research Codes and Guidelines (2016) *"They must not be disturbed or harmed by the experience of being interviewed"*. Furthermore, the Research Codes and Guidelines (2016, p.2) mentions a few more points to consider when interview children and young people, they are as follows:

• The parents or anyone acting as the guardian of any child or young person taking part in a research project must be confident that the latter's safety, rights and interests are being fully safeguarded.

• The interviewers and other researchers involved in the project must be protected against any misunderstandings or possible allegations of misconduct arising from their dealings with the children or young people taking part in that project.

• The authorities, and the public generally, must be confident that all research carried out with children and young people is conducted to the highest ethical standards and that there can be no question of any possible abuse of the children or young people involved.

In reference to the first point above; I (The one conducting the sessions and the interviews, therefore, the one going into school) has a required DBS (Disclosure and Barring Service) check that is needed to work and volunteer in schools and in other situations when dealing with children. This document has been requested and approved by the local school that the tutorial sessions took place in.

In addition, in reference to the other points above; a document was designed as a consent form that detailed the nature of the research, what

exactly the sessions during school time will feature and what exactly would be asked of the children. Also, the document made sure to highlight the fact that the children that chose to take part in this research are volunteers and are able to leave at any point with data that was collectioned in association with them being deleted if they so wish. This document will appear in the appendix.

Moreover, the Research Codes and Guidelines (p.3) suggest further points that should be considered when conducting interviews and testing products on children under age 14. The points that follow are taken from the document that only apply to the tutorial sessions:

Where a survey is being carried out within a "protected environment" - i.e. a location such as a school or leisure centre where some person in authority has overall responsibility for the protection of the child - then the permission of the relevant adult overseeing that location (such as a teacher) must be obtained before conducting any interview.

When requesting permission to carry out an interview, sufficient information must be given to the person responsible for the child for him or her to reach an adequately considered decision about giving such permission. Where it is not practicable for that person to see or hear the actual questions to be asked, the subject and general nature of the interview must be explained, together with an explanation of any potentially sensitive or embarrassing questions etc. The identity of the person giving the permission for the interview should be noted but it is normally unnecessary for the permission to be obtained in writing.

If the child is to be asked to test any product, the responsible person must be allowed to see this and (if they wish) to try it themselves.

4.1.1 Un-Structured Interviews

There are different formats interviews can take, depending on what the objective is, one of these formats is un-structured; this format involves the interviewer choosing a number of questions that they will ask the interviewee, this format of interviews *"Are based on a clear plan that you keep constantly in mind, but are also characterized by a minimum of control over the people's responses"* (Bernard, 2011, p.211). This type of interview prompts the interviewee to open up on the topic and express themselves instead of the interviewer asking specific questions. Although, because the intended audience of the interviews are children, asking them to express their honest and detailed opinions on a particular question or subject might be difficult.

Moreover, interviews can be time consuming depending on the number of people that need to be interviewed, besides this, Bernard (2011, p.212) also suggests that this format is beneficial when there is a lot of time to spend on interviews and have the opportunity to interview the people on many occasions, which isn't the case for this project because the primary school gave limited time for the sessions due to their time table.

4.1.2 Structured Interviewing

On the other hand, Bernard (2011) suggests another type of interviewing format named structured interview, Bernard describes this as when *"People ask asked to respond to as nearly identical a set of stimuli as possible"* (2011, p.212). Moreover, this format involves use of an interview schedule, which is a set of instructions to interviewers, the example Bernard uses in this case is *"Instructions might read: ''If the informant says that she or he has at least one daughter over 10 years of age, then ask questions 26b and 26c. Otherwise, go on to question 27"* (2011, p.212). The format of the questionnaire shown in this example is basic and would work well with children.

Furthermore, collecting data could be easily compared with that of other children in the same group/class and with that of data from other groups/classes, because of this, this format of interview would be useful in this situation. Also, because of the way questionnaires (written down or orally) are set up, the interviewee's responses can be controlled (2011), this would make comparing the data easier. Lastly, because every interviewee would have the same questions in the same format, this would also make comparing their responses more effective.

4.1.3 Selecting an Interview Format

Both un-structured and structured interviews have their advantages and disadvantages when it comes to including them in a research project such as this. Consequently, as the target audience for their interviews will be primary school children the format and features the structured interview brings would be more beneficial. For example, although an un-structured interview would lead to a more natural interview because the interviewer doesn't need to stick to pre-defined questions and instead can divert to other topics and questions based on what the interviewee has said, the children might not be comfortable with this type of approach.

Therefore, pre-defined questions decided before the interview will be set up for their primary school sessions. On the other hand, the natural interview process of the un-structured interviews will help outline a teacher's opinion about programming in primary schools. Therefore, this format will be incorporated to separate interviews held with the teachers and the head teacher of the school. The interviewer can prompt the teacher to elaborate on points if the interviewee isn't providing enough information to answer the question and can have a more active conversation with them instead of a question and answer format. Also, more time can be spent with the teachers and head teachers because these interviews will be held at separate times to the children and therefore, won't be constraint to the hour sessions. This is further benefit to the un-structured format as discussed in section 4.1.1.

In conclusion, the interviews held to answer the research questions outlined in section 3.0 will feature a mixture of the structured and un-structured formats as described by Bernard (2011) depending on who needs to be interviewed.

4.2 Structure of the Data Collections

For the first iteration of data collection three tutorials have been developed **and both tutorials** has a reading element and video element to them. These tutorials were designed using what was appropriate learning theories and good interactive media development practices that were discussed in Chapter 2.

4.2.1 Discussion of Contacting Schools and Structure of the Lessons

When contacting the local schools to set up these after school lessons certain issues, for example, lesson length was discussed. This is because the lessons are going to be completely voluntary and the children can drop out at any time and also the school will have to consider their already established day schedule. But various issues could arise, for example the children that will be partaking in these sessions may not have used the Scratch software before and may have limited experience with a computer and furthermore, may have difficulty using the mouse and keyboard. Therefore, the time for the sessions may have to be extended longer than the estimated completion time for the lessons. On the other hand, if, for whatever reason the parents or the schools are having issues with the length of these lessons the videos and written guides can be altered in length or even split down so there will be more but shorter lessons.

Regarding the number of lessons, as there were three tutorials designed there needed to be at least three lessons that would focus on one tutorial each, as agreed to the school these lessons would happen once a week during the children's last lesson that day. Moreover, there would also have to be an additional lesson dedicated to the interviews and feedback and also to any technical or non-technical issues that could have arisen, thankfully though, the school allowed the sessions to be very flexible.

Furthermore, to collect enough comparable data, it was beneficial to go into two or three schools, this could have been done A schedule like this should provide useful data that features children with different technical abilities which will aid in improving the lesson materials so that more effective sessions can take place at the second stage of testing. Furthermore, the initial set of lessons will also help streamline the whole process for next time, any issues or problems can might be encounter can be learnt from.

Local primary schools were be contacted via email, this email will inform the school about the nature of this research project; what it will involve, how long it will take, what resources (i.e. PCs, installation of software) will be needed etc. This email will also offer to meet with the head teachers to further discuss the process and time and days. Next, once a school has agreed to participate in this project content forms will be then available for the year 6 classes (Aged 10), the children can take these forms away to their parents who will have to sign the form. These forms will contain information about the project and what exactly the children will be doing and what data will be collected from these sessions, these forms will also contain such information as the dates and times of the sessions. Lastly, this form will feature general questions that will attempt to gauge the technical experience of the child. This information will be useful because a mixture of children that possess different technical ability can be chosen to partake in

the lessons therefore, the information could indicate a level of effectiveness in the lesson materials.

Next, during the first session the children will be invited to take the VARK (1987) questionnaire online that will provide them with a score that represents their learning preference, there will be four separate scores in visual, aural, read/write and kinaesthetic. These results will be recorded. Now, the children will interact with the lesson materials, every child will be given the first lesson's written guide with accompanying images and the video tutorials. The children will be told to follow both learning materials and to complete the lesson, they will be shown the finished product so they have an idea of what they are working towards.

Moreover, the idea of this structure of lesson is to give the child the tools they need and/or prefer so that they can learn better than traditional methods. Although, a teacher will be present to help with any problems the children might encounter it will be preferable that the children have the right materials provided so that teacher intervention is not needed. On the other hand, a teacher being present and involved is still important to the children's learning as according to Shaughnessy and Fulgham (2011), all this will be observed and recorded because if a teacher is needed and gets involved too often then the lesson materials are not working as effective as they could be.

Furthermore, during the actual lesson, observations will be the primary method of data collection, observations will look into which form of learning material the children using most, if any, or is one form dominating over the other? Are children looking back to previous pages of the written guides or/and rewinding the video to look over something? Also, how long is it taking this group to get through the lesson? And is this because the lesson is too easy or are the lesson materials doing a good job of teaching them to use Scratch. These observations were made by the teacher (I) as they made their way around the classroom as the students were following the tutorials. The teacher could track the student's progress by looking at their computer screens as they walked by. From this the teacher could take note of any particular sections that the students got stuck on or found too difficult or completely ignored. Moreover, the classroom observations also helped to determine how often the student's switched back and forth between the Scratch application and the tutorials; and in particular, how often a student would replay a section of the video tutorial or replay the whole thing. Observations like these helped in answering the primary and secondary research questions outlined in Chapter 3.

In addition, at the end of each session their progress can be saved and compared to the other school's groups, actually seeing and comparing their pieces of work can help determine how clear the lesson materials are and if, for example children are getting stuck at the same points or is anybody skipping certain sections. Also, their work can also be linked to their previous programming backgrounds, it is expected that those with programming experience will have less difficulty and may even finish faster than those without. This could be because words, phrases and even features of the Scratch program might be familiar with them therefore, less time will be taken to understand these.

Lastly, at the end of all these sessions the children will be invited to answer a few questions that will try to illustrate their experiences with the two forms of learning materials. This post-lesson questionnaire is drawn from the Willis' (1994) work about understanding your audience, as well as this

questionnaire more direct one on one interviews may be held after the sessions this will help provide a better understanding of the child's experience learning Scratch among other advantages Willis (1994) mentions. The decision on interviews will be made after discussion with the schools are made where agreements on time and dates can be done.

Furthermore, the answers and information gained from these questionnaires and interviews can be compared to the VARK data obtained at the beginning to see if there is any correlation between the children's score and their opinion of a particular lesson material as well as their overall progress they made. This will be an opportunity to better answer questions such as are these video tutorials effective at teaching children with a visual and aural learning preferences? And are written guides effective at teaching children that prefer to read information? In addition, all the data and feedback obtained from these sessions will also go towards enhancing and improving the lesson materials as well as the entire process for the second iteration.

5.0 First DBR Cycle

This chapter will look into developing the first iteration of the lesson materials, namely, the video tutorials and the written guides without any previous feedback. These first versions will incorporate some learning and teaching theories that have been discussed in the literature review earlier in this thesis. These lesson materials will be taken into schools and will be tested, then from the feedback from these sessions the interventions will be improved and furthermore, from the second iteration the phase will be repeated which will result in a third and final iteration that will aim to answer this project's research questions.

5.1 Research

To create the first iterations of the tutorials, they need to be designed around the previous research, in other words, the tutorials need to incorporate the idea of threshold concepts, ways to reduce cognitive overload, pull from multisensory theory and introduce a modern, non-traditional way of teaching.

To start, as this project is highly based around the idea of VARK it is important to mention it first. As mentioned in the literature review VARK stands for Visual, Aural, Read/write and Kinaesthetic. These are the four modalities or learning styles Fleming and Mills (1992) suggested *"Seemed to reflect the experiences of the students and teachers"* although they mention that there is some overlap. The tutorials in this project will be heavily influenced by VARK, this will done by creating interventions based around the four modalities.

Next, as described above is the idea of "gateways" that relate to features/ideas or use of tools in the subject by Erik Meyer and Ray Land (Cousin, 2006); in this case, it relates to Scratch. Before creating the tutorials important threshold concepts will need to be identified, these sections are fundamental in ushering the users through to completion of the tutorials as well as effective understanding of the software.

After looking through online Scratch tutorials, the website eastonhome.co.uk (2015) had suitable tutorials for this project. Certain skills that were required to use Scratch effectively became visible so therefore will be incorporated into the design of the tutorials. These skills include Sprite management; the Scratch software is heavy based around sprites and furthermore, sprites are a common element in development of 2D based video games therefore it is important of users to understand the creation and management of sprites.

Secondly, Scripts as also a big part of the software, the use of this feature will make the user's games interactive and actually playable instead of their games being static. Moreover, Scripts in Scratch is quite a powerful tool and there is a lot to it, especially for a user that is completely new to game design therefore, careful consideration will be given to this particularly threshold concept. On the other hand, once the user understands the basics of Script it will result in them having the ability to create more complex games. Furthermore, Scripts in Scratch are visual based instead of being text based which is what actual programming languages consist of, Scratch

Scripts are a great place to start for giving users an understanding of programming concepts.

Third and finally, the drawing tools built into Scratch will be important to the user as a good understanding and experience with them will make the difference between a basic background and Sprite and a complex, detailed background or Sprite. This will also allow the user to give their game a unique and personal art style. Moreover, the user could go through the tutorials without using these tools at all because there is a library that contains premade Sprites to use but the option to create something they can call their own will give their game personality.

Another theory the tutorials will need to draw on is the multisensory theory by Praveen (2015). This is the idea of the effectiveness of teaching and learning are increased when the user is exposed to materials that stimulate more than one human sense, for example, instead of just the video tutorials being purely a screen capture of Scratch it would be accompanied by an audio narrative of what is happening on screen. By the nature of the video tutorials that users can find online on sites like YouTube, this particular theory will be easy to implement. On the other hand, the reading tutorials will stimulate the user's visual sense through the screenshots featured on the page but the text that accompanies the images will also be visually. Because of this I am going to make the assumption the video tutorials are going to perform better in the hands of primary school children, this might be reflected in the children's feedback comments at the end.

Next, these tutorials will be designed in a way that's driven by the user instead of the teacher, which is the more traditional way of delivering a lesson. Shaughnessy and Fulgham (2011) use an old Chinese quote to describe the traditional way of teaching "*Teachers open the door; you enter by yourself*". The traditional way involves a teaching in front of the classroom and they deliver the lesson to the class of pupils in a way they were taught to do and also by what they have found to work in the past experience. The way these tutorials will be designed in to put the pupil in control, with the video tutorial the pupil is able to put headphones on and watch the video and be in their own personal isolated lesson. Then they are able to stop, rewind and play the video again as many times as they need until they are comfortable and are ready to move on. The same can be said with the reading tutorials, the pupil can go through the pages at their own pace which should improve learning as teachers have to go at the pace of the whole class instead of individually. Moreover, the pupils can still talk to each other and help each other like the traditional method because they are still in the classroom, therefore this new way has the advantages of the old method but features modern ways of doing things "*Who are in the process of discovering knowledge, yet work collaboratively within this virtual room whose door has been virtually swung open*".

Moreover, cognitive overload is an important theory to consider when dealing with teaching new skills to pupils. As mentioned earlier in this paper Cognitive load is according to Mayer and Moreno (2003) the amount of information a person can process at one time. Mayer and Moreno suggest several methods to reduce the load in pupils. Some, but not all will apply to the design of these tutorials.

One of these overloading problems is called Type 2, "*This is when both channels are overloaded with essential processing demands*"; this could happen in a number of scenarios, for example, there is a narrated animation that simply features too much visual and auditory information. Furthermore,

the pace of the narration might be too fast for the user to process or words etc. might not appear on screen for long enough. To overcome this problem, Shaughnessy and Fulgham (2011) suggests two solutions. One solution is called Segmenting, "*A potential solution to this problem is to allow sometime between successive segments of the presentation*" (2011). It is important to separate both the video and reading tutorials into sections where it makes sense to avoid overload.

Pretraining is the other suggested solution, "*An alternative technique for reducing cognitive load when both channels are overloaded with essential processing demands is pretraining, in which learners receive prior instruction concerning the components in the to-be-learned system*" (2011). An example of this would be to display and teach important key terms and phrases the user is going to come across in the follow tutorials, if you give the user this information beforehand then they will be more familiar with them when the terms and phrases then mentioned in the actual tutorials. On the other hand, if the first exposure to a term or phrase is during the tutorial then overload can happen when the user tries to process the meaning of the word as well as remembering the word, as is also as well as attempting to follow the action on the screen.

Another one of the problems is called Type 3, this is when the "*System is overloaded by incidental processing demands due to extraneous material*". Incidental processing refers to information that can be deemed interesting but not essential to the learning (Wikiversity, 2012). The solution is called Weeding which is done by determining what information is essential and what is extra information that could confuse and distract the user. In other words, make the information and tutorial "*As concise and coherent as possible, so the learner will not be primed to engage in incidental processing"* Shaughnessy and Fulgham (2011). One example of this is added background music to a narrated animation that could potentially distract the users by overloading the auditory channel.

Furthermore, another solution that is suggested is Signalling. The authors mention that when information is not feasible to be removed then a different approach much be taken. *"Cognitive load can be reduced by providing cues to the learner about how to select and organize the material"* (Lorch, 1989; Meyer, 1975). In the example they use, there is a 4 minute animation that features incidental information but instead of getting rid of it the information in colour coded with the important, extraneous information being one colour and the interesting but non-important information being another. Other cues could include use of headers, underlining, arrows pointing to information etc. In the scenario Lorch and Meyer set up there was a signalled and a non-signalled version that was given to users, they reported that users with the signalled version performed better on the subsequent test.

5.2 Design

This section will discuss and outline the actual design of the video and reading tutorials as well as the other elements that will feature in the school sessions, for example, the interviews. The design decisions in this section will be linked back to the learning theories and development practices that were discussed back in Chapter 2.

5.2.1 Reading Tutorials

The reading tutorials that include accompanying images will deliver the reading and writing learning style of the research mentioned in the VARK framework (1992). The children will be given printed tutorials that they can read through at their own pace and the images, although there are a visual element there are important because it would be more difficult to learn Scratch without them. Furthermore, children will be encouraged to write notes on their pieces of paper, this will cover the writing part of the style. The children will understand information better if they can place it into their own words, evidence of this is shown in an experiment that was conducted with children on their ability to learn names for objects (Zosh, 2013). The experiment suggests that *"People tend to think that parents must directly instruct their children by telling them the labels of the objects that surround them, but this research tells us that children are even better word learners when we ask them to figure things out for themselves"* therefore the children will make the tutorials easier for themselves if they can describe things in their own way.

The format of the reading tutorials came from breaking down the video tutorials from the Easton Home website (eatonhome.co.uk, 2015). This format consists of small, focused videos that take the viewer through small steps that eventually arrives at a simple game or project. These simple projects feature one or two mechanics that are suitable for a beginner to the software and indeed, to children in a Year 6 primary school class.

On the other hand, although the tutorials were entry level the videos went straight into showing the user how to make the game without much explanation as to what certain features did or what each part of the software was exactly. This series of videos assumes the user isn't new to using software like this. This assumption shouldn't be made when the intended audience is primary school children that might have limited experience with computers and software. Therefore, when designing the written tutorials for this project it was important to dedicate the first lesson to 'the basics'. This first lesson would introduce and explain the different sections of the software interface and furthermore, a page will be included that explained common terms that the user will encounter in the lessons. This decision also comes from the general layout and design that programming books take, as well as other similar books that include a lot of technical phrases. These books tend to include a page dedicated to such words and phrases so the reader can keep referring to them.

The reading tutorials in this format will be taken to the first round of data collection and from the feedback and observations that will be received there the tutorials will be improved in format and in content. These tutorials will be printed out and given to the students, with their own copy the children will be give the freedom to go at their own pace and go back and forth between the pages to remind themselves of information or to compare the screenshots if they went wrong somewhere etc. This feature comes from practices that are being performed by Summit Public Schools in the US. These practices involve software that helps children through the syllabus which the children control "*The idea is that children work best when setting their own goals and moving at a pace that suits them. Evidence from early pilot studies shows that pupils learn more effectively this way than with traditional teaching*" (Hodson, 2015).

5.2.2 Video Tutorials

The video tutorials initially took inspiration from the website eastonhome.co.uk (2015). On this website there is a series of seven video tutorials that tasks the user with creating various arcade games. These videos are of good quality and are split into short parts. On the other hand, the videos introduced and show the user different features and ideas in no apparent order, if might be less of a problem if a user was to watch and follow these videos in their spare time but for an after school class that will have a time slot of about a hour the format these videos follow aren't appropriate.

To begin developing video tutorials for a school environment it was important to look at the bigger features and mechanics of Scratch and plan separate lessons to teach these features; these main features can also be called threshold concepts (Meyer and Land, 2003). These thresholds concepts, as discussed before as important milestones that when a user overcomes can open gateways to further understanding of tools and concepts etc. of the software. Therefore, to define these concepts will be the first step into developing each lesson.

In that case, after looking at numerous video tutorials online and using Scratch's tools some threshold concepts became apparent; moving a Sprite around the screen using Script is a very important but basic skill that can be included in any game or project, also the tools that make up the Sprite Editor, if users can grasp this feature then they can create different characters or objects to use in their games. Also, basic programming logic like Forever loops, IF and ELSE statements will allow their games to be intelligent and interactive. Lastly, using the Broadcast Script, this will allow the user to have different objects and Sprites communicate with each other, for example, when a player picks up a key then they can tell a door to play an opening animation. Once these concepts are clear, there needs to a fun game or project that has the user interested and that involves these features and at the same time increasing in difficulty as the lessons go on because it is important for the user to have a challenge and to feel satisfied at the end when they have their finished game working properly.

Furthermore, it was clear that these video tutorials had to be split up into short videos because of a study that was done about optimal video length when it comes to student engagement. The study features a graph that shows median time spent watching a video in minutes against the videos grouped by length (Guo, 2013).

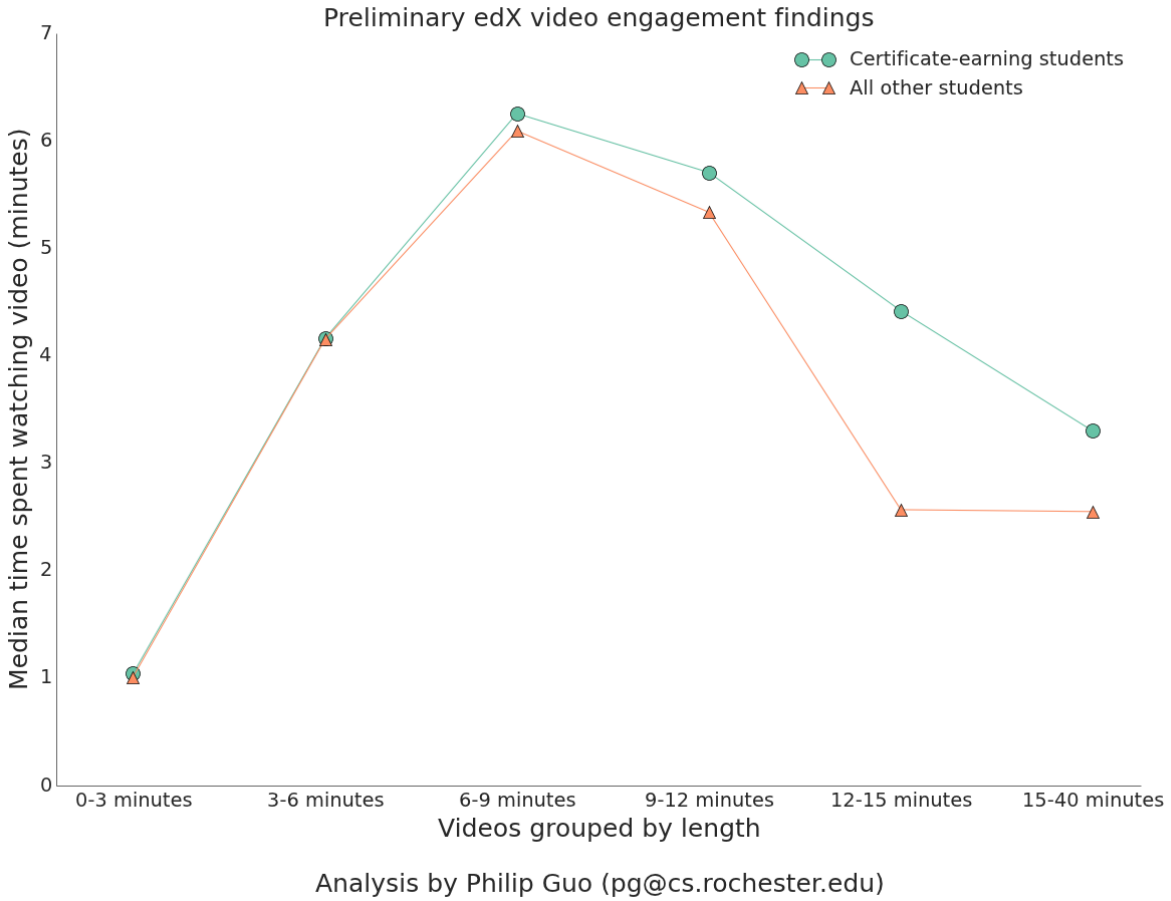

Figure 6: Graph of Preliminary edX video engagement findings by Philip Guo retrieved from http://blog.edx.org/optimal-video-length-student-engagement

The graph in figure 6 shows an increase in time watching a particular video until it reaches its peak at the 6-9 minutes group then it falls slowly until the 9-12 minutes group then it falls more dramatically. It is also important to mention that the graph shows data on two groups of people; one being Certificate-earning students and the other all other students. The study mentions that certificate-earning students engaged more with video *"Presumably because they had greater motivation to learn the material" (*Guo, 2013*)* than the all other students group. As a result of that, the results that will be retrieved from this project may see similar data from that of the all other students group because the class of students that will be exposed to these tutorials are being volunteered by the head teacher and not be themselves, therefore, there might be less motivation in wanting to learn the material.

Furthermore, the study sums up the graph by saying that *"The optimal video length is 6 minutes or shorter — students watched most of the way through these short videos" and that the "Average engagement time of any video*

maxes out at 6 minutes, regardless of its length". Therefore, it will be beneficial to design the video tutorials to be under 6 minutes to ensure students stay engaged.

5.2.3 Designing the interview

Drawing on Bernard's (2011) description of structured and non-structured interviews will constructed with the purpose of gathering simple data from the children and teachers that was used to firstly, gather feedback on the tutorials as well as the structure of the sessions to then improve them for the second data collection cycle. And secondly, to gather personal feedback from children to outline which tutorial they preferred and why, this information then can be compared with their VARK scores to better answer the primary and secondary research questions.

There were four separate instances of interviews, the first instance was a set of questions that took place in the first session with the aim of better understanding the children's technical experience and background, this information was then used to measure how difficult the tutorials were for children with little to no programming experience compared to children with more experience.

The second instance was the VARK questionnaire that is already constructed and is available online. From this questionnaire the children will receive scores based on visual, aural, read/write and kinaesthetic. These scores were recorded and then later compared after the sessions.

The third set of interviews was also a set of questions that took place on the last session. These questions were again aimed at the children and asked basic questions, for example, "Which tutorial did you prefer?" why they chose that answer. With the information gathered from these questionnaires, it was used to improve on tutorials for the second cycle of data collecting. This questions helped optimise the tutorials, which in hand aided in answering the primary and secondary research questions discussed in section 3.0. Furthermore, this information was also compared to the VARK questionnaire that the children took in the first session, from these comparisons it was clear if there only any links between a child's VARK score and their preferred choice of tutorial.

The fourth set of interviews will involve the teachers and the head teacher of the primary school, it was important to discover what they thought about programming and computing in primary schools in general as well as their thoughts on the video and reading tutorials.

Also, the first set of interviews determined whom (if anyone) had previous coding experience or is more knowledgeable with computers and software than others this information can be brought over to the last set of interviews therefore, more time can be spent using these individuals which will provide more valuable feedback.

Although the sessions that will be held for the purposes of this project will only consist of groups of around 10 to 12 children. Therefore, this method of

interviewing won't take much time and will result in valuable feedback because of the low number of children that need to be interviewed.

5.3 Implementation

This section will demonstrate the implementation of the theories and ideas that were discussed in the previous section, (section 5.2) into the reading and video tutorials that will be given to the students to follow. This is the first version of said tutorials, these are designed about the above theories and suggestions without being exposed to students. The initial versions of the tutorials feature three different lessons inspired by eastonhome.co.uk (2015), the three tutorials are being called The Basics, Cat and Dog, and The Tank Game.

Taken from the work by Guo (2013) on video length the three tutorials were designed so that they shouldn't take longer than one hour maximum to complete. This time involves everything from logging onto the computers, accessing the session materials; be it the video or reading tutorial depending on what group the student is in. Furthermore, this time also involves an initial look at the tutorials and then actively doing following the tutorials (With the video tutorials being under 6 minutes in length as suggested by Guo (2013)).

Figure 7 displays the questionnaire on the VARK website that the students will be asked to take on the first week. This questionnaire featured sixteen random, simple questions which usually explains a scenario and the user is give four options to choose them, they may choose as well options that apply to them. For example, "*You are using a book, CD or website to learn how to take photos with your new digital camera. You would like to have*" (VARK Learn Limited, 2016). The options are such things as written instructions, photos, diagrams or/and ask questions. At the end of the questionnaire the students will receive four scores based on the four areas of learning; visual, aural, read/write and kinaesthetic.

Figure 7: VARK website, displaying the questionnaire (VARK Learn Limited, 2016)

A person could come out with an combination of scores, one person may have chosen a lot of visual based answers and come out with a high visual score with the rest of the scores being very low, therefore, it is expected that videos would appeal and be more effective is teaching this particular person. On the other hand, another person might come out with really similar scores across the board. They could mean that they are adaptable when it comes to learning or it could mean the options given to them on the questionnaire didn't appeal to them. It will be interesting to see which tutorial the students prefer against what their VARK scores are.

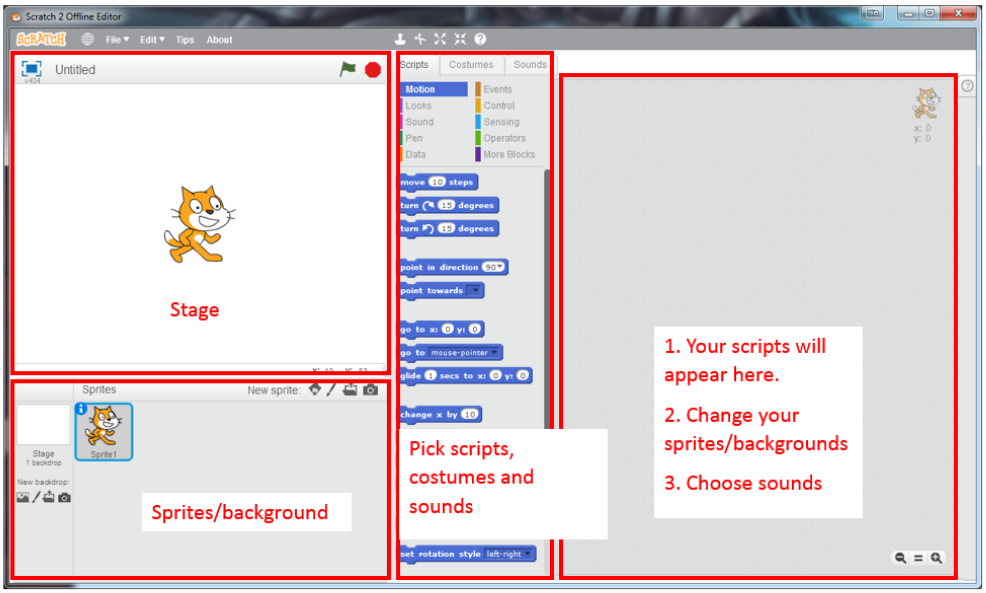

Figure 8: A page of the written tutorials

Figure 7 shows the main window of Scratch with accompanying labels that describe the different sections of the software interface. This was the first page in the reading tutorials. As well as this image appearing in the Basics tutorial the decision was made to include it in every reading tutorial as a reminder to the user as each lesson might be weeks apart, this is enough time for someone to forget some parts of the software.

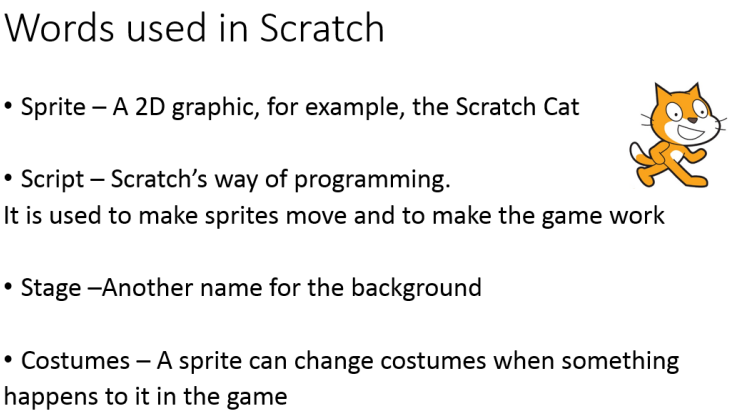

Figure 9: Another page featured in the reading tutorials

Figure 9 shows another page that was important to the reading tutorials. It consists of a list of common phrases used in Scratch, phrases a child in Year 6 might not have come across before. As mentioned earlier information featured in Figures 8 do not appear in the eastonhome.co.uk (2015) tutorials but it is critical information that should be presented to children. This will also act as the glossary page featured in a lot of paper based tutorial books.

To further emulate Easton Home's videos, the typical format of the reading tutorials consisted of each page being a 'step' just like each video covered a small piece of the whole game. Each page has a step number along with a title to indicate what the step would involve, next a text box will be on the left of the page that describes the step in short sentences and a screenshot will take up the right hand side of the page that will show exactly what the text has described. Moreover, there are blank spaces around the page where children will be encouraged to write and draw, this feature links back to teaching experiments by Zosh (2013).

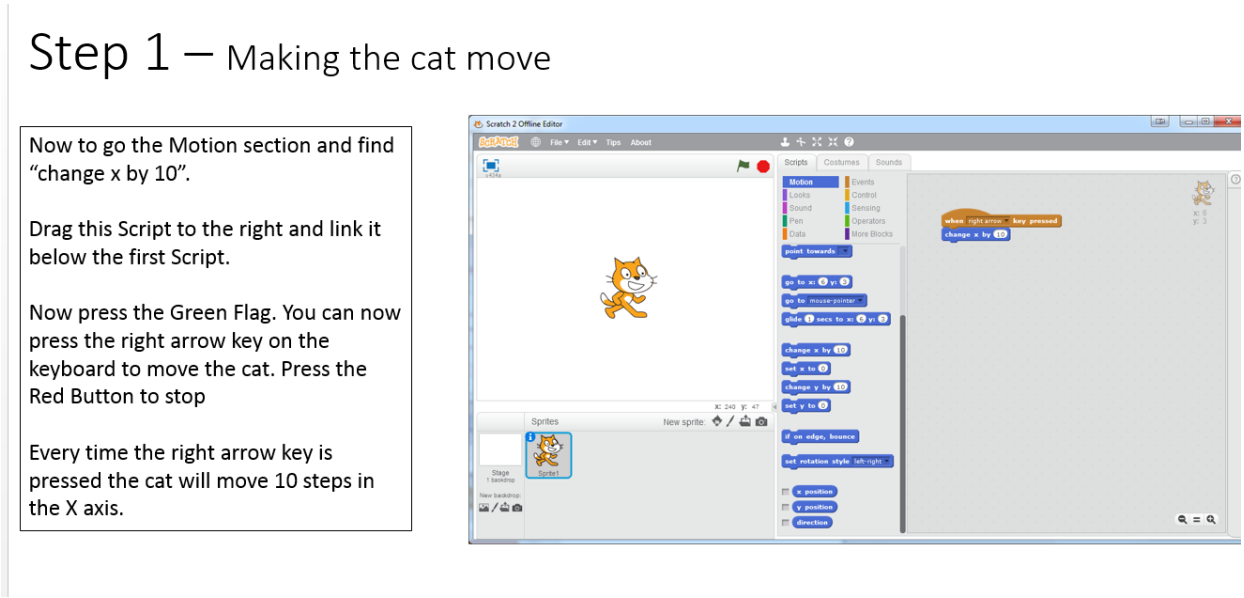

Figure 10: A typical Step in the written tutorials

Figure 10 shows the first page in the The Basics reading tutorial that asks the user to preform actions in Scratch. To bring in the VARK (1987) theories these reading tutorials have to feature writing and imagery therefore, as the screenshot shows the written instructions will always appear on the left hand side and a screenshot of Scratch will appear on the right. This will be the case as long as the size of the screenshot allows. Sometimes the whole Window **will not** need to be shown therefore, there might be more space for text to appear elsewhere. Furthermore, it is important that there is correlation between the text and the image according to multisensory theory by Praveen (2015). Therefore, text that **features** important details like Scripts and common phrases must be written exactly as they appear in Scratch, otherwise the readers will get confused, especially if there is similar looking phrases or options. Moreover, the design of the pages in this tutorial are simplistic and basic, there aren't any effects or colours to distract the reader.

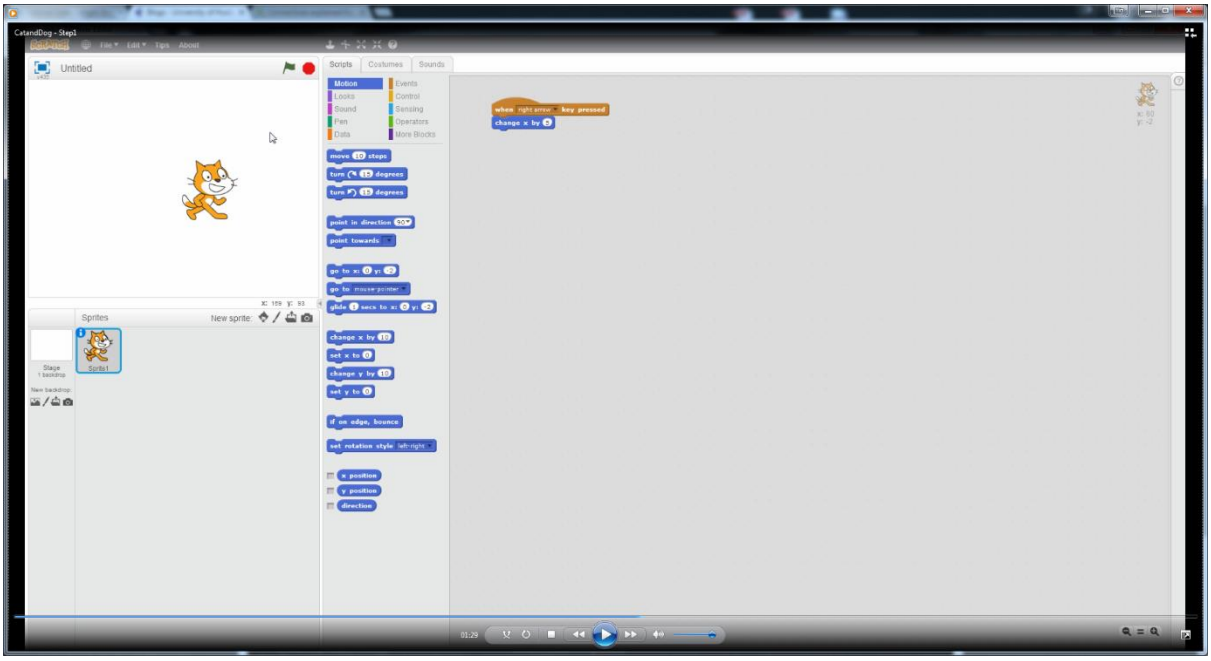

Figure 11: A screenshot of the The Basics tutorial in video form.

Figure 11 shows a frame from the first video tutorial, this is about half way through the video. The video follows the same actions and options as the reading tutorial which results in the same project at the end. Similarly to the reading tutorials, the video tutorials bring in the VARK (1987) theories by including a primarily video element and a secondary audio element, as the teacher is recording their actions in Scratch they are narrating exactly what is happening on screen.

As you can see from the video controls at the bottom of the screen this particular video is just short of 3 minutes long which is in the optimal video length suggested by Guo (2013). The majority of the videos in all three separate tutorials average a length of 2-4 minutes with the exception of the last video in the The Basics which is over 7 minutes long, this is because this particular video demonstrates some advanced Script that requires more time.

6.0 Discussion of First Data Collection Cycle

After contacting a number of primary schools in the local area one school replied and was willing to partake in this project. After an initial meeting with the head of the school to discuss details and when all the necessary DBS (Disclosure and Barring Service) check was received then the first versions of the written and video tutorials can be taken into sessions of year 6 pupils (Aged 10 and 11) of various experiences of computer use and programming. The first version of the data collection will be held in local primary school England's Lane Academy with a group of 16 pupils in year 6.

6.1 First Session

The plan for the first lesson was to have the children take the online VARK questionnaire and retrieve their VARK scores so that they can be compared with how they performed in the tutorials as well as their personal opinions of the tutorials at the end of the sessions. As well as have the children do the first tutorial which featured an introduction into Scratch. Unfortunately, time became an issue and a few problems arisen such as some videos not working on some machines, some pupils not being able to edit the VARK scores document that was prepared for them as well as the machines being preinstalled with an older version of Scratch. Therefore, the decision was made to just dedicate the first session to the VARK questionnaire and to make sure everything was accessible to everyone. Furthermore, this session helped discover that the Windows 8 notebooks the school possessed were not up to the task for this project due to the confusing nature some pupils found in its interface and navigation. On the other hand, some pupils did get a chance to load up the written tutorials and had a short amount of time to look through it, this should help them when they actually come to follow the tutorial in the following week.

Moreover, the first session was successful in retrieving the children's VARK scores and now that they have been recorded they don't need to return to this so the following weeks can be focused on following the tutorials and observations made to their performances.

6.2 Second Session

The second session as mentioned above, involved the pupils doing the first tutorial which featured using basic Script to have the Scratch mascot (A cat) to move based on user input and to have a dog catching the cat (Script controlled). This tutorial also included a few extra steps at the end to enhance the game if any pupils managed to finish the basic tutorial.

The first part of the session involved splitting the room into two halves, one half would follow the written tutorial in the form of a PowerPoint Presentation online therefore this would require them switching between the tutorial Window and the Scratch Window. Originally, the plan was to print off the written tutorials for easy access so they wouldn't have to switch Windows but because the class included 16 pupils instead of the planned 10 – 12 it would require printing off over 300 pages so everyone would have a copy, this wouldn't be cheap or feasible. Moreover, the other half of the room would be given headphones and would be required to follow the video

tutorial that is broken into steps (Four in total, for this tutorial). Again, the pupils would have to switch between the Scratch Window and the video player Window.

Consequently, some issues arose from this set up. Firstly, as mentioned above, some laptops had problems running the videos so the pupils using these laptops had to resort to using the written tutorials, therefore, there were more pupils doing the written tutorials in this week. Secondly, there were not enough laptops for every pupil this week because another class were also using them so some pupils had to share which proved to be difficult when it came to the video tutorials because only one pupil could have the headphones on. This is an example of how educational research conducted in laboratories doesn't match the 'messy conditions' (Brown, 1992) of the classroom.

Furthermore, some pupils had great difficulty actually performing the task issued by the tutorials. They didn't seem to understand what the tutorials were asking them to do and some even seemed confused at the concept of a tutorial as a number of the class simply read the written tutorials and thought they had finished. This issue leads to believe this group of children and maybe even the school has a whole does not perform a lot, if any, lessons using the laptops and therefore aren't familiar with this format of learning. The assumption was made that children and teachers more so these days would have been exposed to Youtube videos as Bull and Bell (2010) suggest, therefore, the pupils would be familiar with at least the video tutorials. This point did suggest to be somewhat true because the half of the group that did the video tutorials progressed further in the tutorial than the other half of the group. More evidence can be provided on this point by switching the groups in the next session so the video tutorial group will do the written tutorials and vice versa.

Moreover, on the subject of the written tutorials, a majority of the pupils once they understood that they had to follow the tutorials themselves in Scratch tend to skip the beginning steps and would perform some of the tasks later on this would obviously result in an incomplete Scratch project. More so on that point, no pupil finished the tutorial and majority produced similar projects. The assumption to be made here is that maybe the pupils were finding their footing to a new format of learning and to a brand new computer program and specifically, an area, that being programming/game design.

On the other hand, after speaking to a few individuals about the tutorials and Scratch, they shown understanding of what they had done. For example, one pair followed the tutorial somewhat and placed some Script that had the dog Sprite look at the cat Sprite but they didn't at first understand why the dog Sprite wasn't moving towards the cat Sprite. This was because they hadn't included a "Move X steps" Script to the dog. Once they were pointed to the first step of the tutorial (Which the majority missed out) the pair understood what the problem was straight away.

6.3 Third Session

On the third session the group was instructed to follow the racing game tutorial, the two halves of the group were flipped this time round so that the half that did the video tutorial would do the reading tutorial this week and vice versa. This tutorial was a step up from the basic tutorial from last week therefore, the assumption was made that the students were encounter more

problems this time round and no one would even finish the tutorial. Both these assumptions were true.

Majority of the pupils in both groups got to the same stage of the tutorial which was drawing a background that featured a track and a separate car sprite that would move follow and can be manoeuvred left and right using the arrow keys. This was around a third of the whole tutorial.

Some of the problems the students ran into included sprite management, for example, some of the students were drawing their car design onto the background therefore were not able to manipulate the car separately. This might be a common mistake that people new to sprite based game design do or it might be an issue with the tutorials not conveying the information effectively.

Furthermore, other students spent too long actually designing their car sprites which led to them not progressing to the technical section of the tutorial. This might be because the students did not fully understand how to use the build in drawing tools therefore ended up making mistakes. To counter this issue in further sessions there could be a simpler way of designing the sprite or the students could be given a premade for them to import and use, this would then give them experience with importing items into Scratch but on the other hand, less experience with the drawing tools within the program.

Other than these issues, this particular group showed little signs of progression and learning of Scratch, this is due to the lack of computer and Scratch experiences of the pupils in this school and due to the lack of interest in doing this activity.

6.4 Fourth Session

First thing to note about this particular session was that the group was remarkably smaller than the other sessions because of an intervention session some of the pupils were involved in, that happened at the same time as this one. Instead of having 16 students, this fourth week there were only 8. Consequently, this made managing the session as a whole a lot easier to handle, for instance, there was more time that could be spent with each individual student. Furthermore, it was also easier as well to slip the group into video tutorial and reading tutorial, because of these two reasons there should be a clearer observation of progression in this session.

Moreover, because there were missing members of the group the decision was made to have the remainder of the group do the racing game tutorial again. The group should be familiar with the first third of this tutorial and should progress further than last session. Unfortunately, this **is not** the case, few students in this smaller group got to the same stage they did last time and this might be because the idea of starting a clean slate, so to speak, wasn't appealing. On the other hand, if their work from last session was saved and they were able to continue from that point then the students would progress further and by result, be exposed to more of Scratch, including script and more sprite management.

6.5 First Cycle Evaluation

The first data collection was helpful in making clear what improvements could be done to the reading and video tutorials to make the second run more effective in teaching the material. One improvement that could be made is the length of each tutorial as well as the actual nature of the material in the tutorial. It came to light that no student finished any of the three tutorials over the four weeks that they had. This might be for a number of reasons, firstly, this particular class had not had a lot of previous programming/game design experience therefore, everything presented to them in the four weeks was new and unfamiliar to them. Secondly, there is a possibility the tutorials were too long in general, with time in these sessions being dedicated to setting up and logging into laptops, as well as technical issues that did arise there wasn't the time being spent on the actual tutorial as previously thought. Therefore, the tutorials could be redesigned to be shorter but still being taught over the same amount of weeks, so the students will have more time on the same tutorial.

On the point of previous experience, the three tutorials might be too complex for these students because the school does not provide any programming/game design materials or teaching. Consequently, for the second run of data collection the tutorials could be designed to create one project over four weeks instead of each week being a different project. The decision of the different projects came from the theory of threshold concepts, each week the students would learn one of these milestones but there is no reason why the same threshold concepts could not be implemented into one bigger project.

Moreover, these four weeks involved a few technical difficulties, some that were easily resolved but others not so. In particular, there were problems with accessing the files for the tutorials because the teacher that ran the sessions had limited access to the school's system. Therefore, for the next set of sessions the video and PDF (Portable Document Format) files that contain the tutorials could be uploaded online to a file sharing site so that the student's or the teacher will not need to access the school's system instead all they need is internet access. The PDF files would either be opened inside the web browser itself or through Adobe Reader, which is a free to download application that is designed to read PDF files.

Lastly, the first session was dedicated to retrieving a VARK score from each of the students so that they could be compared with the feedback and observations made at the end and throughout the sessions, although some issues occurred such as the documents containing these scores weren't saved and some feedback documents at the end were not being filled in properly, this lead to incomplete data, therefore accurate observations couldn't be pulled from them. For the second cycle, extra care will be taken to ensure these scores and data are recorded.

This table shows five student's VARK scores and their preferred choice of tutorial between reading and video.

Student's VARK scores against their preferred choice of tutorials

	Student 1	Student 2	Student 3	Student 4	Student 5
Reading	X	X			X
Video			X	X	
Students' VARK Scores	V:7 A:8 R:6 K:5	V:7 A:8 R:8 K:10	V:3 A:10 R:12 K:4	V:6 A:10 R:12 K:7	V:16 A:15 R:15 K:16

Figure 12 Table showing VARK scores and preferred choice of tutorials of five students.

V = Video, A = Aural, R = Reading/write, K = Kinaesthetic

This table in figure 12 features a sample of the class that took part in the first cycle of data collection. This sample was chosen because they are the most complete data that was retrieved from the first cycle. The first thing to notice is the two students that chose the video tutorials as their preferred tutorial didn't have a their visual VARK score as their highest score, the predict that was made before this first cycle was that if a student's visual VARK score was their highest then this student would prefer video and therefore, would learn Scratch more effectively from the videos. Although some of the data did back up that prediction, it isn't true for every student. On the other hand, both students that chose video in this table had high aural scores therefore, there is evidence of a correlation between a high aural score and the audio narration in the video tutorials.

Moreover, the last student on the table shows a high score on all four areas, despite this the student preferred the reading tutorial. This could be for a number of reasons, perhaps the ease of going back and forward through the pages made it easier for the student to find information or the technical difficulties of the video tutorials might have been a deciding factor.

Additionally, majority of the comments left by the students at the end of the sessions related to the video tutorials, there were complaints about low volume on the videos and from observing the students during the sessions some did have trouble with the video player controls, in particular moving forward and back to the point in the video that they needed. Therefore, an obvious improvement to the video tutorials would be to increase the volume of the narration as well as educating the students briefly on the video controls of the player.

Also, one of the questions the students were asked at the end of the sessions was on a scale of 1 to 10 how comfortable were they using Scratch after these tutorials (1 being not comfortable and 10 being very comfortable), majority of the students put between 4 – 6 on the scale. This is interesting as none of the students have had previous experience with this sort of material (programming/game design) though it is a good sign that the tutorials are doing a somewhat good job of giving the students the information they need to use Scratch.

Another question the students were asked on the questionnaire was "Which lesson was your favourite and why?" with the two tutorials (Cat and Dog and Racing game) being the options, because of technical issues the third

tutorial, the Tank game never happened. Out of the same five students that appear in figure 9 four of them chose the second tutorial, the Racing game and one student choice the first tutorial, the Cat and Dog. The of the reasons a student gave for this was *"Because we experienced the thrill of learning new features, which are more advanced and technical"* and another said *"We liked the racing one better than the basics one because its more advanced than the basics and they are more fun".* These two comments are similar, they are both saying they liked the challenge and the features the second tutorial introduced to them. This could suggest that the first tutorial was either too easy and/or uninteresting. Furthermore, when it comes to designing the second version of these tutorials it will be beneficial to look closely at the content and difficulty presented in the Racing Game tutorial and then use this to improve the next set of tutorials.

In additional, the students were also asked a number of questions about specifics of the reading and video tutorials, such questions were for example, was reading/video tutorial clear? And did the reading/video tutorial give you enough information etc. Firstly, the reason behind such questions is because if the students were given a general question asking for their opinions followed by a text box, many would have been put off by it. This is because of their age and the assumption that they haven't filled out a questionnaire of this nature before. Also, it was important to retrieve feedback of specific elements of the tutorials, like length and if they were clear enough.

6.6 Head Teacher Interview

As mentioned in section 5.2.3, a set of interviews were planned to be held with the teachers and head teacher. Unfortunately, due to time restraints on the teacher's end they weren't available for any interviews. Although, the head teacher was available to conduct one interview post the tutorial sessions. It was beneficial to find out what computer related skills and experience the teachers processed, because as discussed in section 1.1 the UK government is looking to introduce IT and computing to primary schools in a bigger volume than it is already. It was interesting to see how prepared the teachers felt about such changes coming into their school.

As well as gathering feedback from the students, it was important to speak to the head teacher and discuss the role and position of programming in primary schools as well as gather her opinions on the video and reading tutorials. This was doing in the form of an interview, the interview was informal and the head teacher was encouraged to expand on her answers and share her opinions.

Firstly, the interviewee asked the head teacher about their personal background on programming and video game design which they responded that they didn't have any traditional programming language experience such as any C languages or Java, for example. But, they did use LOGO during their time in primary school; LOGO is an educational programming language from 1967 that could be used to move a robot around the screen (remembered commonly as a turtle character) using commands issued by the user. Furthermore, they spoke about their use of the BBC Micro from 1981, the BBC Micro computer is briefly mentioned in section 1.2. With this particular knowledge the head teacher mentioned that they had an idea of what Scratch was and the concepts of sprites and scripts.

Consequently, they had not heard of the new BBC Micro: Bit which is due out this year and is mentioned, again in section 1.2. This was surprising because the BBC are pushing to get their new hardware into primary schools to promote programming with children. The head teacher suggested that they had not heard of the BBC Micro: Bit because of the school's lower than average OFSTED reports (OFSTED are the Office for Standards in Education, Children's Services and Skills, "They inspect and regulate services that care for children and young people" gov.uk (2016)). The head teacher further suggested that the Academy that runs the school may not want to introduce a programming curriculum until the current grades of students etc. are improved. Therefore, in relation to this project, it will more important now going into the second cycle than it was in the beginning of this project to design the tutorials in the way that tailors towards users that have not had any exposure to programming of any sort in a school environment. Admittedly, in the design the first version of the tutorials some of the terminology could have been explained better. Furthermore, as a result of the OFSTED reports the head teacher had no information regarding the UK government's plan for a programming curriculum that they plan to implement in the next few years. The head teacher did ask if the tutorials incorporated the government's programming curriculum which the answer is no. Instead of focusing on this particular programming curriculum, this project focuses on the ideas from Fleming's VARK framework (1987), the idea behind this project is that individuals learn differently from one another.

Moreover, the head teacher was asked what exactly the children currently use the school's computers for. They responded by saying the computers were mostly used for gathering information from the internet for use with modules and lessons they were doing at the time. The children would use search engines to find information and copy and paste it into Microsoft Word as well as using the BBC's Bitesize website (Which is a website dedicated to offering resources to key stage 1 and 2 children for help with subjects in the UK's curriculum.) From this information it could be concluded that the children in this particular school have basic navigational skills of a Windows based computer as well as understanding of concepts such as copying text or an image. This might be why some students in the first sessions have trouble controlling the video in the video player and why some weird confused to asked to navigate to the Scratch website to access the newest version instead of using the older version that are preinstalled on the laptops.

Finishing off the interview, the head teacher gave some opinions on the tutorials based on spending a few minutes with them, this involved quickly going through a reading tutorial and watching and listening to one of the videos, this is also without actually following the tutorials on Scratch. The head teacher said that the reading tutorials were detailed and the way they were formatted were advantageous for remembering information, the children could move forwards and backwards through the pages if they needed to recall something. Furthermore, they mentioned that they preferred the video tutorials personally because they could see exactly what they needed to do, they could see where the mouse on the computer was going and where to left click and where to right click. Although this is limited feedback it is important to note that the head teacher didn't have any negative points to say about the tutorials. As a result of this feedback, during the second cycle of the data collection more time will be given in the interview with the head teachers and the teachers as well, they should be given enough time to sit down with at least one part of the tutorials and

follow them. Then they will be able to give more meaningful feedback, this is important because the teachers know the students in this particular school and therefore, will be able to make points about elements of the tutorial they might not understand given their computing experience. This the first cycle there wasn't an opportunity to speak to any of the teachers due to time restraints with the project as well as within the school.

6.7 Summary of First Cycle

The first cycle was a pilot run that was advantageous to highlighting many areas of improvement in the actual design of the tutorials and the approach into how to bring in and expose the material to the students. With the improvements to the design and the structure the second cycle should show that the second iteration of the interventions are a more effective design for teaching Scratch, such changes involve alterations to the length of the tutorials, in particular the video tutorials. Next the actual content of the material of the tutorial will be given some revision.

Moreover, the results that were displayed in figure 10 from section 5.5 were unexpected as it was thought that students whom received a high visual mark in their VARK questionnaire would prefer the video tutorials over the reading ones but out of the 5 students that gave results this is not the case, although this might be for a number of reasons. For example, the quality of the video tutorials might be a factor or the student might have received a similarly high read/write score in the questionnaire.

Furthermore, the head teacher interview helped to understand the technical knowledge and experience of the students at this particular school, with the information going forward the difficult of the tutorials as well as the structure and delivery of the lessons would be adjusted in line with this.

Also, after discussing feedback about the tutorials from the students and the head teacher it was clear that the reading tutorials were lacking behind in design from the video tutorials so when it comes to making changes and improvements for the second cycle more care will be taken to ensure both tutorials are at a high quality as well as both as at the same quality. Consequently, it would be difficult to measure levels of effectiveness and productiveness of the tutorials if one were no doubt of a better quality than the other.

In conclusion to the first cycle, the reading and video tutorials were somewhat effective in introducing Scratch and its features to newcomers of video game design and programming. The feedback given in section 6.5 describes the student's ability to use Scratch after the tutorials has confidence. Going forward, the feedback and observations will help tailor a second version of tutorials and session structure to further improve effectiveness and productiveness of a VARK focused model to teaching primary school children introductory level programming.

7.0 Second DBR Cycle

Using feedback and observations from the sessions that were the first pilot DBR cycle improvements have been made to the video and reading tutorials as well as the structure of the sessions as well as how data is retrieved and recorded. Furthermore, this time round there will be more focus on what the teachers and the head teacher think of programming in schools in general as well as their thoughts on the tutorials that will be presented to their students

7.1 Design

Upon the results that were discussed in section 6.5 such as observations that no student completed any of the previous tutorials the decision was made to rethink the structure of the three current tutorials. Instead of having three tutorials have instruct the students to design three completely different projects this cycle will involve one project that will be broken up into key threshold concepts. The threshold concepts that were discussed in section 4.1 are still relevant therefore, the new structure of the tutorials will be a first part dedicated to teaching and developing the student's ability to manage Sprites, and this includes making, importing Sprites and editing costumes.

Next, part two featured a tutorial dedicated to Scripts and adding interactivity to the project, this will involve linking together and adding Script to the Sprites that the students created in the first part. This approach should be easier for the children to understand and follow, instead of three different projects that confused the students somewhat, as was observed.

As well as these changes to the tutorials, there will be changes to the structure of the sessions week by week. In the first cycle the students were given one tutorial a week over four weeks, this second cycle will still be over four weeks but because there will only be two parts to one tutorial instead of three different tutorials the students will be more time to catch up if they didn't finish the first part from the last week. Therefore the new structure will go: first week will introduce the tutorials and explain what they will be going as well as having the students do the VARK online questionnaire to retrieve their scores. On the second week the students will be introduced to the Sprites tutorial where they will spend the entire lesson following it, moreover, the class will be split into two like in the first cycle; one group for video tutorial and the other for reading tutorial. Furthermore, the third week will be used to introduce the Scripts tutorial as well as give students time to finish the Sprites tutorial, if they have not finished the Sprites tutorial than they will not be given the Scripts tutorial until they do. And finally, the fourth and final week the students will be given the chance to catch up and finish whatever they are doing, some students might use this time to develop extra skills if they have already finished by this point otherwise, the time can be used to finish both tutorials. Furthermore, depending on the progress of the students, feedback sheets can be given to those students who have finished so they can voice their opinion on the structure and tutorials, this shouldn't take any more than five minutes. Then, similarly to the first cycle, the VARK scores of the students will be compared and discussed against their feedback that they gave. From these

results, observations can be made and opinions can be formed about the effectiveness of the tutorials in the current form.

Also, going into the second cycle some more thought needed to be put into how the tutorials were actually going to be delivered to the students. Considering the feedback gave by the students as well as observations made by the teacher during the sessions, a lot of students had small technical troubles with navigating to the appropriate folders containing the tutorials and as well as swapping through the different Windows on the laptops, as one Window contained the tutorial either in .Doc format or video format and another Window contained an online version of Scratch through the web browser. This setup led to some confusion with students, some felt lost with the constant swapping between Windows so eventually stop swapping between them. Therefore, going forward, an alternative option should be considered. For example, the students could be given an additional screen to help counter act any confusion until they are more comfortable using the Windows system. This second screen could be another laptop or a tablet, this device would be dedicated to either playing the video tutorials or viewing the reading tutorials in the PDF format, but this would mean these devices don't necessary need to be as powerful as the machines running Scratch. Although, this solution would all depend on the resources the school could provide; during the head teacher interview, it was mentioned that the school did have iPads available so depending on the number this solution is viable. On the contrary, this solution may go against Mayer's and Moreno's (2003) work on the nine ways to reduce cognitive load; one of the types described in their work in called *"Essential processing"* which is when both sensory channels are overloaded. They suggest that there is better transfer of information when, for example, the printed words are placed near corresponding parts of the graphics. Consequently, adding an additional screen to the set up in these sessions would go against this and would require the student to literally turn their head away from the screen showing Scratch to another screen displaying the tutorial. Therefore, this may lead to cognitive overload which is something that is important to avoid to increase effectiveness of teaching and learning. Although placing a second screen or tablet/iPad centimetres away from the main screen this might not be an issue.

On the other hand, if for whatever reason the fore mentioned solution proves to be not possible then perhaps the a small section of the first session could be dedicated to teaching the students how to effectively navigate between the web browser and the Window that contains the tutorials, whether it be a video player or Adobe Reader. Alternatively, another solution is to put all the resources online so that the student would only have to switch between two tabs in a web browser. The PDF tutorials as well as the video tutorials could be uploaded to a file sharing site such as Google Drive and with the files being made public the students could all access these files and would be able to display them in the browser, therefore, with this being paired with another tab displaying the online version of Scratch the students would only be using one Window. Another outcome of this is, the teacher would not then have to rely on the school's own network for adding or removing resources as they would be on a system that is being controlled by the teacher directly. The only issue with this direction is that 10 to 15 students will be accessing the same files and this might cause some slowdown and unresponsiveness of the system.

Moreover, as in the first cycle the students will again partake in the VARK questionnaire online so that their scores in visual, aural, read/write and

kinaesthetic can be retrieved and compared with their feedback at the end as well as observations made during the sessions. As this second cycle will involve a different group of children then taking the VARK questionnaire will be necessary. Furthermore, the first session will also attempt to gain a better understanding of the individual student's experience with computers and in particular, programming. A Microsoft Word document will be produced to ask students quick, simple questions. This approach with the pre session questionnaire was something that was meant to take place in the first session of the first cycle but due to technical issues and time restraints there was only enough time for the students to do the VARK questionnaire. As a result of this, the questionnaire is already produced and there is no reason to revise the contents of it.

Moreover, after the sessions with the students have taken place, there will be separate sessions with individual teachers and the head teacher. These sessions will give the school staff a chance to share their thoughts on programming in primary schools and how effective they thought the tutorials were on their students. As mentioned in section 2.7, Shaughnessy and Fulgham (2011) suggested that teachers are still an important asset to classrooms, even with the growth of individual based learning from tools such as the internet. Their thoughts and opinions are important, despite this.

7.2 Implementation

This section will demonstrate the improvements that were incorporated into the reading and video tutorials that were derived from the evaluation of the first cycle feedback and observations discussed in section 6.5. As well as making improvements directly from the feedback from teachers and students there will be alterations made to the design and structure of the tutorials and sessions according to the theories discussed in the entirety of literature review or section 2.0. This section will be split into reading tutorials and video tutorials, focusing on the changes and improvements made to increase the effectiveness of the content as well as the delivery of the tutorials.

As mentioned in section 6.1 a questionnaire was produced in the first cycle with questions that were aimed at better understanding the student's experience with computers. Below are the 4 questions the students will be asked to answer before they start following the tutorials. These questions will be given to them during the first session along with the VARK questionnaire. Both of these questionnaires will make up the first week; the tutorials will start the following week.

Please take some time to answer these questions below:

Do you have computer or laptop at home?

If yes, are you a frequent user of this computer or laptop?

Have you had any previous experience of making a video game?

If yes, was it more design focused or programming focused? (Tick both, if applicable)

Have you used online tutorials before in the form of reading guides and/or videos?

Have you used the computer software Scratch before?

The questions above are simple, easy to answer questions aimed at primary school children, these questions only require a yes or no answer as well as a short sentence explaining why if they answered yes.

7.3 Reading Tutorials

The reading tutorial part of the interventions will be discussed in this section, here screenshots accompanied by discussions will outline the way the reading tutorials were built as well as the reasoning behind how and why they were built this way.

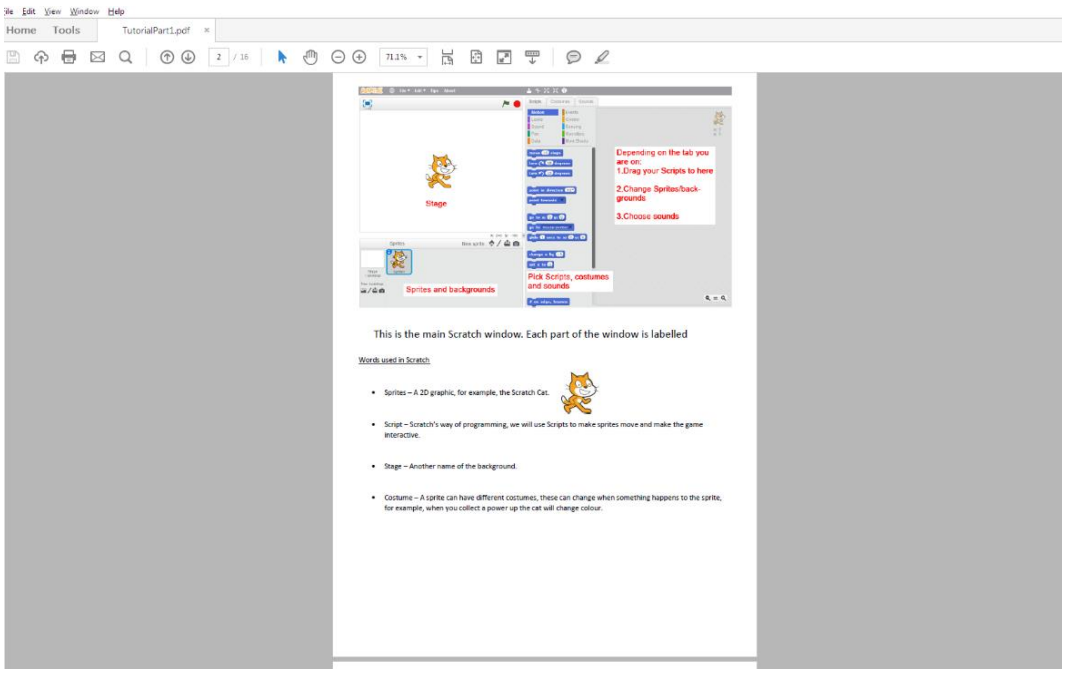

Figure 13: Screenshot of Tutorial Part1 Reading version

Figure 13 is a screenshot that shows the first part of the tutorial in reading format, the first thing to note here is that the reading tutorials are now in a PDF format instead of a Microsoft Word (.doc) format. This decision was made because of the observations and comments by students that some of the images in the last reading tutorials weren't very clear and on some

occasions the teacher had to manually resize the images in the Word documents so the students could see what they needed to, this obviously disturbed the format and text of the rest of the document.

One of the advantages of PDF is that the content is somewhat more scalable, therefore, the students can zoom in to see the images more clearly without disturbing the text because the text scales along with the images. On the other hand, because of the nature of PDFs it is more difficult to edit, if there is a clear grammar mistake etc. that is found during a session it cannot be altered without the original Word document, so extra care will be taken to spell and grammar check the content.

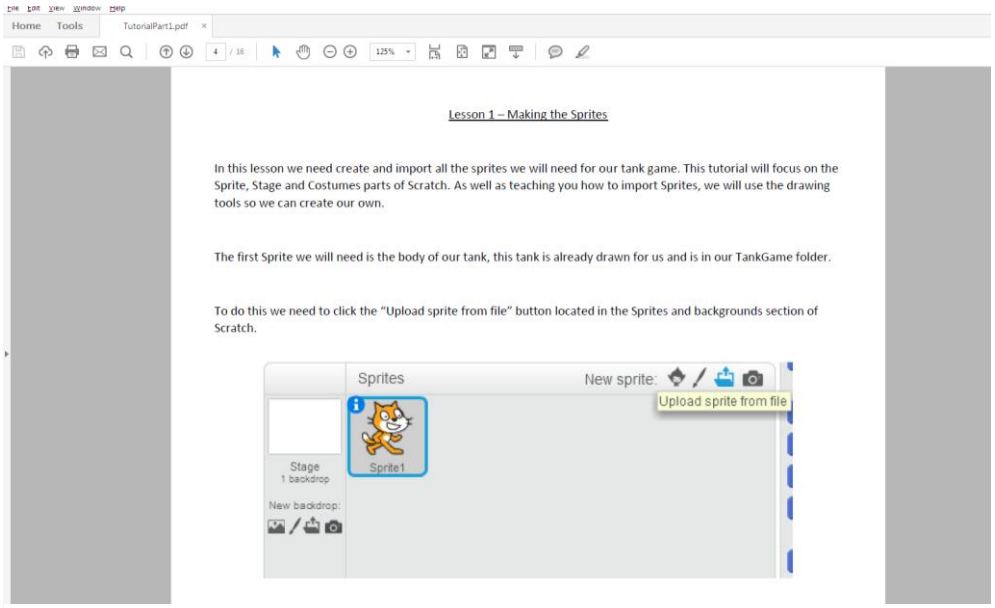

Figure 14: Screenshot of Tutorial Part1 Reading version, highlighting the objective of the tutorial

Figure 14 another screenshot of the PDF reading tutorial part 1. This part of the tutorial explains the objective of the tutorial which is to design and import all the appropriate Sprites into Scratch. In this tutorial the student will spend time getting familiar with the "paint new Sprite" and "Import Sprite from file" buttons as well as the Costume tab as long with the design tools such as the "Brush" tool. This format is different to the format of the last tutorials, in section 4.3 the format is described as being three different tutorials have each aim to develop three different projects. The decision for this change comes from the theory of threshold concepts (Cousin, 2006).

Moreover, clear threshold concepts were decided upon during the design of the first cycle (section 4.2) and were implemented into the three tutorials but upon observation the three different projects from week to week confused the students therefore, the tutorials were changed to develop just one project over four weeks. The project is the tank game that was designed in section 4.2 but during the first cycle the students never got to perform this tutorial because of technical issues, therefore it was redesigned and repurposed. This first part of the tutorials focuses on the creation of Sprites for the tank game because the understanding and management of Sprites is an important threshold concept that the students need to overcome.

Additionally, because of the contain and format of the reading tutorials, that is that it consists of text and images this means that there are two cognitive channels being stimulated instead of information being sent down one this is called off-loading. This will stop cognitive overload that was discussed in section 2.4 (Mayer and Moreno 2003), furthermore, another type of reducing cognitive overload is implemented; this is segmenting. Segmenting is described as *"Allow time between successive bite-size segments"* (Mayer and Moreno 2003), this relates to the way the parts of the tutorials was put together, as part one is primarily Sprites and part two is primarily Scripts based. These are bite size parts that take around an hour to complete that focus on the same subject. Moreover, segmenting also requires the content to be learner controlled, which by the ability to go back and forward through the pages of the PDF, it is learner controlled.

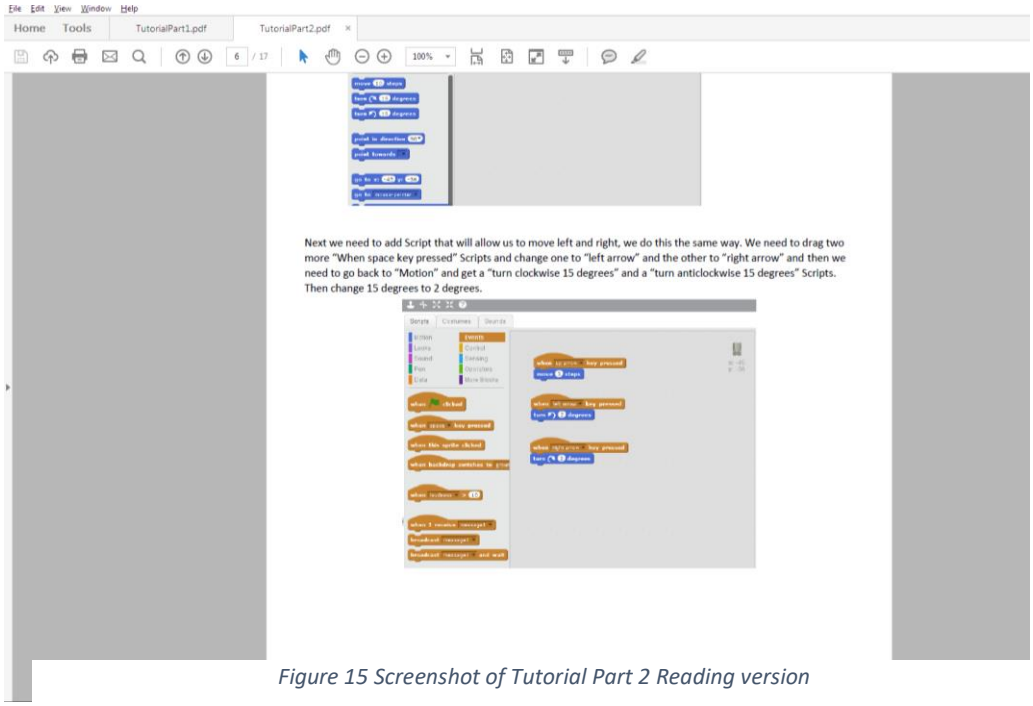

Figure 15 Screenshot of Tutorial Part 2 Reading version

Figure 15 shows tutorial part 2 which is the part of the tutorials that focuses on another threshold concept; Scripts. In this tutorial the students will open up their work from the previous lesson which will include all the Sprites that are needed for the game, they will then begin to add Script to the Sprites to give the project game mechanics and interactivity. This tutorial will only be given to the students once they have completed part one, otherwise the Sprites won't be present in their projects to add the Scripts to. This decision was made purely because during the first cycle none of the students had completed any of the tutorials fully, so now there is a requirement to finish the previous one to continue. Consequently, the students won't be starting from scratch on a new project each week like they had to do during the first cycle. So they can pick up from where they left off the previous week, therefore, there is a higher chance that the students will complete the tutorials and finish with a working, functioning tank game.

Additionally, these tutorials in their current form also incorporate the work of Praveen (2015) about multisensory techniques, as mentioned in section 2.6, Praveen suggests that *"to simulate visual reasoning and learning"* it is

more effective to use more than one sensory channel making developing teaching materials, in these tutorials this is done by text and screenshots next to each other on a page.

7.4 Video Tutorials

This section, similarly to section 6.3, will outline the implementation decisions of the video tutorials in this second phrase of design. Screenshots will accompany the discussion but as these particular tutorials as videos and therefore, are meant to be watched and listen to with the Scratch program at hand the screenshots won't present an accurate picture of these materials.

From the feedback gained in section 6.5 the video tutorials haven't changed that much in design, this is because the students didn't have any major issues with the video tutorials other than the audio volume was slightly low, therefore, volume was one small thing that was considered when recording these new videos. If the volume appeared to be too low after the recording then the volume can be artificially altered using the tools built into Camtasia Studio 8, which is the software that was used to record the screen and record the narration.

Furthermore, as the decision was made to change the structure of the tutorials from the original design of three different projects to one project in two parts, this meant that the videos had to be rerecorded. Consequently, this meant that more planning and consideration went in to the video tutorials before recording started. Firstly, taking what was learnt from Guo's work on optimal video length (2013) that the original tutorials drew upon (section 4.2) the videos were to be split down into small chucks of only a few minutes long. Moreover, as the tutorials were to be in two parts, each part was to be designed to take around an hour to complete; this was because that is how long the school required these sessions take. On the other hand, the videos weren't being designed to take exactly 60 minutes to complete because these sessions as the first time majority of the students will be exposed to Scratch and therefore, aren't going to understand the tutorials straight away so time must be allowed for them to re watch the videos until they understand and preform what they must do.

The video tutorials were split into sections with each video aiming to be around 2 to 3 minutes long, this resulted in there being 7 videos for part 1 of the tutorial. In total part 1 would take 11 minutes to watch without stopping, although, as mentioned in the previous paragraph the students will stop the video to go back and watch parts again as well as stop the video to actually preform the task on Scratch itself. Going back to the graph and studies performed by Guo (2013), looking back at the graph in figure 3 the dip in median time spend watching starts at the 9 to 12 minute mark, therefore, if a student prefer to watch all the videos first non-stop before going back and re watching them, for example, then the videos should keep the student interested during the entire length. Furthermore, the second part of the video tutorials are double part 1 at 22 minutes long in total and there being 10 videos all together.

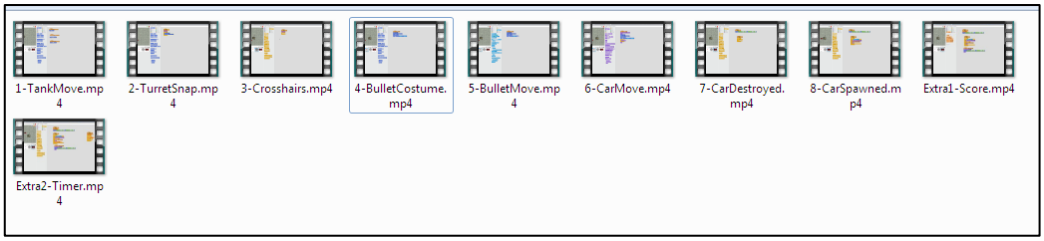

Figure 16: Screenshot showing the folder containing the videos for Part 2 of the video tutorials

Moreover, the reason for these higher numbers is firstly, because Script in Scratch as a concept and in execution is more difficult than Sprite management so therefore, will take longer to explain. Secondly, the structure this second cycle is taking (two part tutorial over four weeks) there might be a chance a student will finish earlier than the others. So instead of them waiting for the lesson to finish this student can engage in an 'extras' section which will involve advanced Scripting techniques. This extras section could only appear in the Script part of the tutorials because there is move to improve the mechanics of the game as well as introduce new ones, whereas, in the Sprites part there are only a finite number of Sprites needed for the game to function.

7.5 Discussion of Second Data Collection Cycle

After the reading and video tutorials, as well as the structure and delivery of the sessions were redesigned following observations from the students and teachers during the first cycle of data collection, the tutorials will brought into another school and a similar set of sessions took place.

Firstly, it was appropriate to discuss computing experience within the school and compare it to the pervious school, as mentioned in the first data collection cycle, previous computing and video game design/development experience is one of the elements that would determine the effectiveness of the reading and video tutorials, simply because students with more computing experience should be able to pick up using the Scratch application and follow the tutorials quicker than those with little to no previous computing experience. Consequently, in terms of computing education provided by the school the students in the second school had zero experience or teaching in video game design or any programming lessons but they did use the school's laptops regularly for word processing and internet research for other school subjects; this information was obtained from an interview with the class's regular teacher.

7.5.1 Assistant Head Teacher Interview

During the second cycle of data collection there was an opportunity to interview the class's teacher who also had the joint role of assistant head teacher. This teacher was present for the majority of sessions and even tried to help the children during the sessions, whether it was technical issues or general help with the tutorials.

The interview and the questions answered to this teacher were identical to the questions asked to the head teacher from the first school. Firstly, the teacher was asked about any personal computing experience; the only experience they had was word processing which is a skill they use daily in their work at school. Moreover, they mentioned a course that the teachers at this school were encouraged to go on (It was made clear that they didn't need to attend this course), this course involved Scratch, which is why the teacher had no trouble aiding the students with their problems in class. Although, the teacher mentioned that they didn't have an opportunity to expand or use the skills acquired from that course.

Furthermore, the teacher was asked if they knew anything about the UK's government's plans for computing in primary school curriculum, they said that they knew some of their plans and the fore mentioned training with Scratch was part of that but nothing else has come of it.

Consequently, it is worth mentioning that the government were pushing the new computing curriculum for the new school year (September 2015) there has been no more news on this at this time (April 2016). Also, the BBC Micro Bit (That was discussed in section 1.2) is also a year late as they said that every student in year 7 would have access to one by now, and that the Micro Bit would be commercially available to everyone.

Next, the teacher was asked they the children in her class use the school's laptops for; they said that their use was limited and that it was used primarily for learning support, for example, using the internet to collect research and place it in a Microsoft Word document (Therefore, some word processing). Also some online resources are used such as Numbershark and BBC Bitesize. This use of computers is common in primary, as the students in the first school used their laptops for exactly the same activities.

Moreover, the teacher was then asked about their opinion on programming in schools; their answer was positive in that they thought it was "Important" and "Exciting" and that there just needs to be more opportunities in primary schools. Also, they mentioned that the children are not too young to be starting programming at a primary school level.

Lastly, they were asked their opinions about the reading and video tutorials. The teacher was shown both tutorials and had the chance to listen and watch a video tutorial with headphones on. Although, the teacher wasn't put in the same situation as the students; they did not have multiple sessions to follow the tutorials and made a game in Scratch. Therefore, given the couple of minutes they had with both tutorials they said that they prefer the reading tutorial because it is "Easy to look back on" and "Breaks it down better". And that the video tutorials were "Clear" "Easy to understand" and they liked the fact that they were broken down into small two minute videos.

Another important point to note is, that the teacher mentioned the technical problems the students faced in their sessions and agreed that the hardware in the school were not up to the task of that the tutorials were trying to do. This point is comparable to what was seen in the first school also.

The points made above and what they mean in terms of the tutorials going forward and of the PRQ were discussed in a later section.

7.5.2 Discussion of Student's VARK Scores

Student's VARK scores against their preferred choice of tutorials

	Student 1	Student 2	Student 3	Student 4	Student 5
Reading		X		X	
Video	X		X		X
Students' VARK Scores	V:4 A:8 R:3 K:8	V:9 A:9 R:8 K:10	V:9 A:9 R:12 K:11	V:8 A:13 R:7 K:7	V:6 A:10 R:4 K:13

Figure 17: Table showing VARK scores and preferred choice of tutorials of five students.

V = Video, A = Aural, R = Reading/write, K = Kinaesthetic

As with the last data collection cycle the students were asked to take the VARK questionnaire on the first session, this time round more students finished the questionnaire and their results were there to be recorded (In the first school, many students turned their laptops off before the scores were recorded etc.) but for the purposes of fair comparison, five random students were taken from the sample and their VARK scores are displayed in figure 17 along with their preferred choice of tutorial (Reading or video). Their preferred choice of tutorial along with other general feedback questions were recorded on their last session, after three, one hour sessions using Scratch and the tutorials.

One thing to note in figure 17 is that students 2 and 4 have high visual scores (9 and 8, respectively), although, both students preferred the reading tutorials by the end of the sessions, as opposed to the video tutorials.

7.6 Discussion and Reflection of the Project

This section will attempt to bring the literature and the development of the tutorials as well as the data gathered from the school sessions together to reflect on the project and to discuss again the objectives of the project as well as the primary research question. The PRQ is as follows:

How effective might tutorials designed around the major learning areas of the VARK framework be to teaching primary school students entry level programming and game design?

And further project objectives:

To investigate the experience of a student using a tutorial tailored towards their learning preference.

To explore the advantages and disadvantages of such tailored tutorials against traditional methods of teaching in class rooms.

To start, the tutorials that were designed and developed for this project that drew from appropriate literature were somewhat effective in teaching primary school students programming, but, the effectiveness depended on many circumstances. These are as follows and will be discussed in more detail:

- The size of the group
- The hardware and software available
- Volunteering vs. non volunteering
- Teacher's knowledge

Firstly, the size of the group altered the effectiveness of the tutorials for a few reasons. One, is that during the second cycle the school had a limited number of laptops, therefore, there was one pair between one laptop. This lead to issues when it came to the VARK questionnaire as it is a personal questionnaire that needs to be answered on their own and not in a pair, furthermore, there was also an issue when it came to the video tutorials as there can only be one pair of headphones to each laptop, this meant that only one student could listen to the video at a time. On the other hand, there weren't any problems with the reading tutorial as both students could read it. And, when it came to actually making the game in Scratch, only one student could control the mouse at any one time.

Moreover, a bigger group requires the teacher to potentially assist more students if they had any issues, this was a problem that occurred in the first few sessions at the second school; there were many technical issues to overcome that majority of the students faced, it took more time to get through them all, there were 30 students in this class. Therefore, both tutorials would be more effective with a smaller group because each student should get a computer to themselves, which would allow them to work at their own rate and there would be less strain on the teacher as well.

Next, previously there were a lot of technical issues with the laptops in both schools. This is because the laptops given to the primary schools aren't designed to run such programs like Scratch, as agreed by the assistant head teacher from the second school. More powerful hardware with the purpose of running such software (Like the BBC Micro Bit and Raspberry Pi, as it has Scratch preinstalled) would result in less technical issues and therefore, more time spent actually following the tutorials.

Thirdly, the groups from both schools that took on these tutorials were both non volunteered groups. The sessions that took place at both schools were taken instead of their usual last lesson of the day. Therefore, none of the students in both groups asked or signed up for their sessions and so this meant some students weren't as motivated to follow the tutorials and use Scratch, this is evident by some of the student's comments made during the sessions, particularly in the first school. To increase effectiveness, the students have to be motivated and interested in programming otherwise their time is being wasted, as Hidi and Harackiewicz suggest *"Interests and goals have been identified as two important motivational variables that impact individuals' academic performances"* (2015).

Lastly, the teacher's knowledge of Scratch and computing in general evidently affected the outcome of the finished Scratch games. If both groups are compared then both groups have little to zero previous programming experience and both groups were the same size, the second group also had weaker hardware to work with than the first group. But, as seen in the last few sessions in the second school, there were effectively two teachers

walking around the class with Scratch knowledge assisting the students. Therefore, if there was an opportunity to continue this research then if another group of this size (30 students) were taken on then an additionally teacher might be an option. On the other hand, this might only be beneficial for an entry level class that has never done game design or programming before.

7.6.1 Discussion of Learning Theories in the Sessions

One major change from version 1 of the tutorials to version 2 was the use of threshold concepts (Meyer & Land, 2003). In version 1 the use of threshold concepts were minimally implemented, in that there were three different tutorials, each focusing on a different concept. This confused the students in the first school; this could have been due to cognitive overload, as it was their first time seeing and using Scratch and they were introduced to a new concept with a blank start each time, the students were given no time to absorb the information given to them in the first tutorial before moving on to the next.

Therefore, in the second version of the tutorials, clearer threshold concepts were identified in the form of two tutorials; one focusing on the creation and management of Sprites and the other focusing on Scripts. This meant that there was only one game being developed instead of three and the students could see a steady progression of their work over the sessions. Evidence of this can be seen in the student's final work that was taken from the last session. From this, it can be said clear threshold concepts of the subject that is being taught aids itself to the teaching effectiveness.

Furthermore, it could be said from the VARK scores and the student's preferred tutorials that giving the option of multiple forms of learning materials positively effects the effectiveness of the learning. As displayed in both figure 12 and 17 that it is not necessarily true that a student with a high visual score would prefer video tutorials, it could be said that the students picked up Scratch better reading about it as well as watching the task being performed in front of them in a video instead of just one or the other. On the other hand, Hardin and Ellington (2005) suggest that video is more effective at beginner and intermediate levels of the material than advanced levels. Therefore, at the later stages, the students started to lean towards the text based tutorials in terms of preference rather than video. Also Mayer (2001), when he proposed the individual difference principle suggested that multimedia presentations, such as *"Videos will not have the same benefit for all learners"* (DeVaney, 2009).

Comparatively, DeVaney (2009) conducted a research project around video tutorials and out of the 78 pupils that took part 51% voted "Strongly Agree" under "Rate the overall value of the tutorials you viewed" (2009). And furthermore, 55.4% voted "Strongly Agree" under "Compared to the textbook and guidesheets, I was able to better understand the material by viewing the material" (2003). With just over half of this group favouring the video tutorials it would be interesting to see what this percentage's VARK results would have done and their opinion on their own learning preference.

8.0 Conclusion

To outline this project, research into particular areas of learning and teaching theories, for example, VARK (1987) and practices was conducted as well as research into using interactive media such as videos to enhance the learning experience. From this, tutorials with the objective of teaching the Scratch software were developed and given to a class of children in two local primary schools.

Upon the children's and teacher's feedback, the reading and video tutorials in the current form, as well as the structure of the sessions described in this project; with the assistance of the VARK framework, are effective depending on different factors. But, as well as environment factors that were discussed in section 7.6, certain learning theories such as threshold concepts, which should be clearly defined and the option of multiple forms of tutorials, depending on the difficulty of the material also increase the effectiveness of the tutorials.

In reference to the project objectives, mentioned again in section 7.6, the tutorials did benefit the students in introducing Scratch to them for the first time and although it was a positive experience, it was more beneficial if there was more control over the classroom environment in terms of hardware and the school's system, if there was an opportunity to further progress this project than this would be a priority.

Furthermore, the research conducted here cannot suggest that the tutorials in their current form should replace the traditional teaching methods and the classroom environment that exists in primary schools today but, the tutorials could be used as an additional aid in giving students and teachers alike an entry level step to using Scratch.

Also, if this project were to be conducted again a pilot run with a couple of students would be considered. This would allow any initial issues to be overcome, for example, technical problems and it would also allow the format of the lesson from gathering their VARK scores to the feedback at the end to be tested. A pilot run would have to be planned well in advance as when performing tests that involve school pupils are often limited to the particular school's calendar and when they school can accommodate. I would also look into more similar studies and compare the results with the results in this project.

Appendices

Appendix A

Participant Information Sheet

Researcher: Jonathan Sidaway, Department of Informatics, University of Huddersfield

Supervisor: Dr James McDowell, Department of Informatics, University of Huddersfield

Hello!

I would like to invite you to take part in a research project which I am conducting at the University of Huddersfield, the write-up of which forms a part of my MSc by Research. Before you decide whether to take part, I want you to understand why I am conducting this research, and what it would involve for you. Please take time to read the following information carefully, and please talk to others about the project if you wish. If there is anything which you would like more information about please ask me for clarification. Take time to decide whether or not you wish to take part.

What is the purpose of the project?

The research aims to:

(i) Examine learner and tutor evaluations of the effectiveness of a technology enhanced learning intervention designed to teach children how to use the computer software Scratch as well as basic programming concepts

(ii) Investigate differences in two approaches to teaching; one focused on video/audio and the other on reading/writing approaches.

(iii) Explore the benefits of a video series with narration of developing different projects in Scratch as well as exploring the benefits of a written guide with accompanying images.

Why have I been invited?

You have been invited to participate as you are a student in primary that may or may not have pervious computer programming, and as such your input would be valuable in helping to evaluate how effective different approaches to learning work in this subject area.

Do I have to take part?

Your participation is voluntary and you can withdraw at any stage.

What will taking part involve for me?

- To participate you need to attend the after school session (day and times TBA)
- The after school session will involve following a written guide and a video tutorial on using the computer software Scratch
- The first session will also involve you an online survey that will determine your learning preference
- At the end of the last session you will be asked to provide feedback on the tutorials
- Your identity will be anonymised and your answers will be kept securely
- You have the right to see any feedback/comments which you have given at any time
- Nobody else will have access to the data

What will I have to do?

Sign this consent form, then participate by actively engaging in the learning activities, and take part in evaluating these by completing online surveys and joining in a feedback session at the end to share your experience of using the system.

What are the possible benefits of taking part?

It is hoped that by taking part in the project you will be helping me to develop better approaches to learning computer programming.

Thank you for reading this information sheet.

Jonathan Sidaway

Participant Consent Form

Names of Researcher: Jonathan Sidaway, University of Huddersfield

Please initial box

1. I confirm that I have read and understand the information sheet dated Month DD for the above project. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason.

3. I consent to any feedback left in the online survey, together with any comments made in the recorded feedback session if appropriate, being included in anonymised form in any future reports, journal articles and theses resulting from the project.

4. I agree to take part in the above study.

Name of Participant:

Date:

Signature:

If you have agreed to participate in this project then please take some time to answer these questions below:

1. Do you have computer or laptop at home?

   If yes, are you a frequent user of this computer or laptop?

2. Have you had any previous experience of making a video game?

If yes, was it more design focused or programming focused? (Tick both, if applicable)

3. Have you used online tutorials before in the form of written guides and/or videos?

4. Have you used the computer software Scratch before?

Appendix B

If you have agreed to participate in this project then please take some time to answer these questions below:

1. Do you have computer or laptop at home?

   If yes, do you use the computer or laptop a lot?

2. Have you had any previous experience of making a video game?

   If yes, what was it you used to make the game?

3. Have you used online tutorials before like on YouTube or somewhere else?

4. Have you used the Scratch before?

VARK Scores

Name:

Scores

Visual:

Aural:

Read/Write:

Kinaesthetic:

Thank you for taking part in this research project, please take the time to give some feedback on your experience:

Tick the appropriate boxes.

Which form of learning did you prefer; reading tutorial or video tutorial?

Reading Tutorial	Video Tutorials

What did you think about the length of the tutorials?

Too short	Just right	Too long

Did you find the tutorials difficult?

Yes	No

Why?

Did you finish the tutorials?

Part 1 - Sprites	Part 2 - Scripts

Was the reading tutorial clear?

Did the reading tutorial give you enough information?

Were the videos clear?

Did the videos give you enough information?

On a scale of 1 to 10, how do you feel using Scratch after these tutorials?

1	2	3	4	5	6	7	8	9	10

How would you make the reading tutorial better?

How would you make the video tutorials better?

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