Problem Based Learning, the Socratic Method and Semiotic Mediation – A Case Study

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Declaration

I declare that the work described in this dissertation is, except where otherwise stated, entirely my own work and has not been submitted as an exercise for a degree at this or any other university.

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Abstract

There is a belief that the more information a student has, the better his learning experience will be and the more information he will retain for future recall and reuse (Mayer, Heiser, & Lonn, 2001; Moreno & Mayer, 2007). However, in practice an over-supply of rich content can result in superficial learning and can cause cognitive overload (Moreno & Mayer, 2007; Kalyuga, Chandler, Sweller, & Tuovinen, 2001).

Cisco's Certified Networking Associate (CCNA) curriculum is an example of this phenomenon. A rich thick form of content is available, comprising of online course notes, books, animations and hands-on laboratory exercises which can be completed on Packet Tracer™, a network simulator provided by Cisco. However, the content of the practical labs which accompany the theoretical part of the course is overly scaffolded. This results in students working through a task list without really understanding what they are doing.

This research investigated if adopting a problem based learning pedagogy facilitated by the Socratic Method and semiotic tools could give rise to deeper learning. Problem based learning was introduced to replace the standard CCNA labs in an attempt to engage students' high order thinking skills. These activities were facilitated by a Socratic led teaching and learning strategy and interactive simulators were used as tools of semiotic mediation. The combination of these elements was used as a means of enhancing development of meaning for the students in an effort to advance their cognitive structures.

Both quantitative and qualitative data were collected from the learning experiences and the yield from the data analysis provided evidence supporting the benefits of combining problem based learning, the Socratic Method and semiotic tools.

The findings from this limited study indicate that the students experienced a deeper understanding and felt that the whole experience was a more effective and enjoyable approach to teaching/learning the practical aspects of the CCNA curriculum.

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Abbreviations

ICT	Information and Communication Technology
CLI	Command Line Interface
CCNA	Cisco Certified Network Associate
DHCP	Dynamic Host Configuration Protocol
FTP	File Transfer Protocol
IP	Internet Protocol
ISP	Internet Service Provider
LAN	Local Area Network
LCD	Liquid Crystal Display
MAC	Media Access Control
PC	Personal Computer
SSID	Service Set Identifier
VLAN	Virtual Local Area Network
WAN	Wide Area Network
WEP	Wired Equivalent Privacy
WLAN	Wireless Local Area Network

1. Introduction

1.1. Background

When students engage in surface learning they are involved in activities which have a low cognitive level (Biggs, 1999) and which require minimum effort on the part of the student to complete the task. This results in students not developing a deep, or lasting, understanding of the content in question. When students adopt surface approaches to learning they are unable to apply their knowledge to unforeseen and unexplained problem-solving scenarios (Honebein, Duffy, & Fishman, 1993, as cited in Malabar & Pountney, 2002). Certain teaching tools promote this practice by making tasks too mechanical and easy to complete (Biggs, 1999). Cognitive elements need to be introduced into the learning environment to develop the necessary linkages for knowledge to be constructed and hence deeply learned (Goldstein, Leisten, Stark, & Tickle, 2005).

The particular instance of the phenomenon which this research focuses upon is the practical laboratories associated with the CCNA course. The case is chosen as CCNA is very widely used - 9000 academies in 165 countries, with more than 800,000 students in the program each year, makes extensive use of ICT and is the route to a well regarded professional qualification. However, this thesis argues that the instructional design of the CCNA practical labs promotes surface learning. The lab structure uses a sophisticated computer simulation and follows an example-based learning approach whereby students are given step-by-step instructions of the commands necessary to complete each activity.

This research sought to address this problem by investigating if the combination of a problem based learning pedagogy, the Socratic Method and semiotic tools could encourage high order thinking and discourage surface learning. Literature is examined around these central themes to inform the design of the learning experiences and the role of the instructor during the sessions, to offer the optimum learning experience for the students.

1.2. Design of the Learning Experiences

Four learning experiences were designed incorporating a problem based learning pedagogy. Two interactive simulators were used as tools of semiotic mediation with the instructor exploiting the mediating function of the artefacts through Socratic dialogue to aid in the development of meaning for the students.

1.3. Implementation

The research was conducted in a College of Further Education with an adult group of approximately twenty five students. The students were enrolled on a two year Data Networking course and this researcher teaches CCNA to the current first year students. The second year students are also taught by the researcher but two different subjects - Java and System Software. The research was carried out over a period of four weeks and incorporated four learning experiences each of which lasted between two and three hours.

1.4. Methodology

As rich descriptive data was required, the case study methodology was chosen in order to understand the students' learning experience. For data collection purposes, a variety of instruments were used incorporating - observations, video, audio, a semi-structured interview, questionnaires and a post-test. The collection of both quantitative and qualitative data allowed triangulation to be applied between the various datasets adding validity and credibility to the study.

1.5. Research Question

This dissertation addresses the following question:

> Would the adoption of a problem based learning pedagogy facilitated by the Socratic Method and a semiotic tool encourage high order thinking and avoid surface learning caused by rich multimedia?

1.6. Thesis Roadmap

Following this chapter a review of current literature is examined around the subject domain to inform the design of the learning experiences. The third chapter describes the design of the learning experiences and is followed in the fourth chapter by the research methodology adopted throughout the study. Chapter five details the analysis of the data collected from the various activities and discusses the major findings. The final chapter discusses the conclusions, the limitations of the study and areas for further research.

2. Literature Review

2.1. Overview

This research investigated if adopting a problem based learning pedagogy facilitated by the Socratic Method and semiotic tools could encourage students to engage in higher order thinking and discourage surface learning. To inform this study, literature was examined around these core themes. A critique is also included on the Cisco Program as well as an anecdote of this researcher's experience of teaching CCNA.

2.2. Knowledge Construction

The predominant teaching style in third level education today is lecture style. This didactic, one-way communication medium, involves the teacher 'pushing' the information to the students. Learners tend to be in a passive role and are expected to progress in a linear sequenced fashion through a pre-planned curriculum which when completed should signify that learning has occurred (Conole & Dyke, 2004). This methodology has resulted in many students being unable to apply their own knowledge to unseen and unexplained problem-solving scenarios (Honebein et al., 1993, as cited in Malabar & Pountney, 2002). It also goes against Piaget's belief that knowledge is not simply transmitted between teacher and student but actively constructed by the mind of the student and that instruction should consist of experiences that facilitate knowledge construction (Jonassen, 1999; Kafai & Resnick, 1996; Mayer & Chandler, 2001).

Constructionism suggests that learners are more likely to construct new knowledge when they are actively engaged in making some external artefact which can be reflected upon and shared with others. According to this approach, students do not get ideas; they make them (Kafai & Resnick, 1996). Scheele, Wessels, Effelsberg, Hofer, and Fries (2005) claim that the major difficulty with the lecture mode of teaching is the lack of interactivity with the students, a factor which is also contrary to Vygotskian principles. Active involvement of the learner should have a positive effect on their learning outcome (McRitchie, 2005). This would indicate that increasing the students' level of interactivity should facilitate deep learning and have a positive effect on their motivation, attention span and the development of cognitive structures (Cameron, 2003; Evans & Gibbons, 2007; Scheele et al., 2005).

Bonwell and Eison (1991) describe active learning as “instructional activities involving students in doing things and thinking about what they are doing”. They state that in order for a student to be actively engaged, high-order thinking tasks such as problem-solving, analysis, synthesis and evaluation need to be introduced. Bruner (1966) also believed that learning needs to be an active process and this is not offered to the students using the lecture mode. He argued that instruction is an effort to assist or shape growth and is a provisional state which has as its purpose the self-sufficiency of the learner. For him, learning and problem-solving depend upon the exploration of alternatives, so instruction must facilitate the exploration of alternatives on the part of the learner. Bruner states that there are three aspects to the exploration of alternatives – activation, maintenance and direction. Uncertainty is one of the prerequisites for activating exploration and if a task is too cut-and-dried, there is no room for exploration. To maintain the exploration, the benefits from exploring alternatives should be greater than the risks incurred. If the instruction is effective, Bruner claims that learning with the aid of an instructor should be more fulfilling and less risky than learning on one’s own. The direction of the exploration depends upon the knowledge gained from the results of one’s trials and instruction should provide this information at a time when the knowledge can be used most effectively for correction.

In a constructivist environment, the role of the educator is not to impart knowledge but to allow opportunities for students to construct the knowledge for themselves – or to quote from the poet Kahlil Gibran, the wise teacher *“does not bid you enter the house of his wisdom, but rather leads you to the threshold of your own mind”.* By adopting a constructivist approach, the goal shifts from mastery of procedural skills to the ability to function in unknown problem-solving situations (Malabar & Pountney, 2002). Vygotsky (1978) claims that exposing students to new material through oral lectures does not allow for adult guidance or social collaboration with their peers. He views learning as a social process and emphasises the need for the instructor to be involved in the internal development process of the student for learning to occur. To him, teaching is the means through which development is advanced.

Vygotsky (1978) introduced the concept of the zone of proximal development to define two stages in a person's development. The first stage is a person's actual mental maturity, i.e. the skills that a person has mastered and is capable of performing on their own. The second stage is their potential level of development of a particular skill set achievable under the guidance or in collaboration with a more capable other. This theory allows a new formula to be developed which states that the only learning which is 'good' learning is that which expands the mental development of an individual. Vygotsky proposes that an essential feature of any learning is that it creates the zone of proximal development; this means that any learning evokes a variety of internal development processes that can only operate when an individual is collaborating on a social level with people. When these processes have been internalised, they become skills which are capable of independent delivery and give an indication that the zone of proximal development has been increased.

2.3. Rich Media Learning

Rich media learning is synonymous with multimedia learning. Multimedia learning refers to the presentation of information in words, pictures or sounds while multimedia instruction refers to the presentation of words and pictures intended to foster learning (Mayer & Moreno, 2003; Mayer, 2001). Human beings can accept information both visually and verbally. The traditional instructional format for presenting material is through words – both spoken and text but the latest technological developments have allowed material to be presented in a visual and auditory manner - animations, video, graphics, sound etc. It is anticipated that individual learning styles are catered for by presenting material in differing modalities alongside the notion that learners receiving information on two channels results in more meaningful learning. This concurs with Paivio's theory of dual coding which predicts that more effective learning takes place when information is encoded both verbally and visually (Paivio, 1990).

Mayer (2001) contends that there are two possible explanations – the quantitative rationale and the qualitative rationale, why receiving material in multiple modes is considered to be more conducive to meaningful learning. The quantitative rationale states that more material can be presented on two channels than on one and therefore presenting material twice gives the learner double exposure to the material. In contrast, the qualitative rationale is that words and pictures complement one another and understanding occurs when learners can mentally integrate both visual and verbal representations resulting in a deeper understanding than from words or pictures alone could yield.

While it is accepted that the students' learning experience *may* be more enjoyable and visual as a result of this rich media, whether the appropriate linkages are being made, which will allow knowledge to be transferred to new concepts, yet to be learned, is questionable (Goldstein et al., 2005). Mayer et al. (2001b) intimate that the presentation of additional but largely irrelevant multimedia material diminishes the learning performance of the student. The term coherence effect is used to refer to situations in which adding words or pictures to a multimedia presentation, results in poorer performance on tests of retention or transfer, through overloading the sensory channels of the student.

For students to meaningfully learn within these multimodal environments, the student needs to select the relevant verbal and non-verbal information to process in working memory. This information then needs to be organised into a mental model and integrated with prior knowledge. Because all of this happens in working memory, a cognitive load is experienced. Schnotz and Rasch (2005) recognise that multimedia learning can offer active learning opportunities to students through interactivity and exploration. However, they concur with Mayer et al.'s (2001b) view by recognising that these rich learning environments can place new demands on learners through complex navigation spaces and the need to integrate multiple representations of material into coherent structures.

Mayer and Moreno (2003) contend that the problem area in multimedia learning is the limited mental capacity of working memory. Cognitive overload occurs when the total intended processing exceeds the learner's cognitive capacity thereby hindering deep learning. Examples include poorly designed feedback messages which produce split attention when they appear in a separate window or cover the task statement or the field for entering the solution. Also, when excessive amounts of information are introduced, expecting learners to manipulate too many elements, causing learners to observe concurrent changes in different locations on the screen (spatial split-attention) or keep track of sequential events (temporal split-attention).

Poor instructional design can also cause an overload of cognitive resources by diverting them to activities which do not contribute to learning. Active learning environments need to be created with effectiveness in mind, i.e. degree of cognitive load imposed and mental effort spent and not just efficiency. The challenge for instructional designers in a rich learning environment is that multimedia instruction needs to be designed in ways that minimise any unnecessary cognitive load. Mayer and Moreno (2003) conclude by recommending that the best way of improving instruction in multimedia learning environments is to understand firstly how people learn.

2.4. Problem Based Learning

Within a constructivist learning environment a problem, a question or a project drives the learning. The goal for the learner is to solve the problem, answer the question or complete the project. Cognitive tools help the learners to interpret aspects of the problem and collaboration/conversation enables a community of learners to form to co-construct meaning for the problem (Jonassen, 1999). Rather than the problem, question or project being just used as an example of theories and concepts already taught, the problem becomes the driver. Students learn content to solve the problem rather than solving the problem as an application of learning.

The design of the problem should be interesting, relevant and engaging. The reason for this is to make the problem meaningful to the learner because only then will the learner take ownership of it. The problem should be ill-defined or ill-structured to encourage a variety of skills on the part of the learner to solve the problem.

However, research has shown that extensive problem-solving activities can be an ineffective way of learning (Kalyuga et al., 2001). This has been attributed to cognitive load theory which specifies that devoting limited working memory resources to activities which are not directly related to knowledge construction inhibits learning. Providing examples of solutions instead of presenting problems should reduce the cognitive load and allow the student to study each problem state without overloading their memory. By eliminating redundant information, limited mental resources can be fully directed to the appropriate information which aids knowledge construction and thereby reduces the risk of cognitive overload. This is known as the redundancy effect (Kalyuga et al., 2001; van Merrienboer & Sweller, 2005).

An alternative to pure problem-solving is a type of instructional activity known as example-based learning. This type of activity consists of presenting a problem statement, one or more solution steps and then a final solution to the problem. The purpose behind this form of instructional design is to provide the student with an expert's method of solving the problem which the learner can then use for their own problem-solving efforts (Atkinson & Renkl, 2007). The example-based problem is then followed up with practice problems which the learner completes using the methodology demonstrated.

However, Kalyuga et al. (2001) have concluded that this type of activity does not suit all learners and is most successful when learners have little domain knowledge. They claim that learning from examples is better than problem-solving for learners who have little domain knowledge. However, this method loses its advantage as the learners gain more content knowledge and problem-solving is a better instructional activity for more expert learners. This phenomenon is known as the expertise reversal effect and occurs when instructional methods that are optimal for novices may hinder learning for more expert learners (Kalyuga, 2007; van Merrienboer & Sweller, 2005). Episodes of expertise reversal effect have implications for the design of instruction. van Merrienboer et al. (2005) suggest that a training program starts best by using worked examples and gently works up to conventional problem-solving.

For the learner with greater domain knowledge, offering instructional advice can cause cognitive overload, due to the need to process the information from two sources – the instructor and the student's own long term memory (Kalyuga, 2007). As the learner acquires more knowledge, problem-based learning becomes superior to studying worked examples because these worked examples have become redundant. Instructional procedures need to be levelled at the expertise of the learner to avoid cognitive overload (van Merrienboer & Sweller, 2005). Differing levels of learner expertise should be taken into account before designing instructional methods for a specific task.

2.5. Socratic Facilitation

Socratic teaching originated in the Platonic dialogues using a particular technique known as the *Elenchus*. It is a pedagogy characterised by self-discovery; an education by interrogation (Rowlands, Graham, & Berry, 1997). The purpose behind the Socratic Method is the engagement in active dialogue between instructor and student in the hope of achieving purposeful engagement. The purpose of Socratic questioning is to prompt and guide students' thinking, instead of imparting information by direct instruction. The questions should be qualitative to allow the student arrive at the intended goal without the teacher instructing him/her directly (Rowlands et al., 1997). Socratic questioning allows students the opportunity to exercise critical thinking of their own prior knowledge. Socratic questioning can also be used to assess the extent of a student's knowledge on a particular subject which could then be used as a starting point for further instruction (Paul & Elder, 2007).

The most important rule of Socratic teaching is the rule of non-authority (Birnbache, 1999). The teacher's task is not to teach the students but to steer them in the right direction. The teacher's role is also one of facilitator through guiding and informing the lesson, with students being in a more proactive, reflective role. The teacher needs to strike a balance between giving no guidance or direction and giving too much, either of which are easier ways of teaching the topic at hand (Birnbache, 1999; Fink Chorzempa & Laurie, 2009; Rhee, 2007).

The type of questions asked, has a strong influence on how the student embraces the information and in turn constructs their own knowledge from it (Chin, 2007). Rowlands et al. (1997) see Socratic questioning as the link between both ends of the zone of proximal development. With Socratic questioning the facilitator asks concept-questions which enable the student to reach the target concept on his own without direct instruction. The aim of Socratic questioning is to highlight any erroneous misconceptions that impede attainment of the target concept. The target concept stands at one end of the zone of proximal development and spontaneous concepts stand at the other. Parallel questions stand in between. These questions should not be seen as working alongside the spontaneous concepts but rather as a challenge to the student's 'misconceptions' and cognitive state. This is consistent with Vygotskian theory that scientific concepts start their lives in students' minds at the level where their spontaneous concepts will reach only later.

2.6. Semiotic Tools

Using technology in the classroom allows students to engage in discovery-based rather than routine-based learning (Malabar & Pountney, 2002). Knowledge is built up from personal experiences and the more dynamic these experiences the better the cognitive structures they build. Using a visually interactive multimedia artefact can provide these rich dynamic experiences to allow maximum opportunity for learning to occur. Activities that are carried out using technology can provide meaningful experiences for students which allow them to transfer this knowledge to other problem domains.

Introducing technology in the classroom has given false optimism that learning is guaranteed to occur but there is nothing inherent in technology that presupposes this fact (John & Sutherland, 2005; Malabar & Pountney, 2002). For technology to be used effectively in any learning process it must be highly visible as a learning tool and highly invisible as a mediating technology. The mediation function of a computer is based on its ability to create a channel of communication between the teacher and the student based on a shared language (Mariotti, 2000). From the teacher's perspective, introducing a technology tool involves the teacher developing a new relationship between their knowledge and the computer and requires him/her to adapt their role as mediator to take cognisance of the new elements introduced by the technology.

The constructivist use of the computer provides students with rich vivid experiences which allow them to convert the concrete into the abstract more successfully (Dubinsky, 1991, as cited in Malabar & Pountney, 2002). Learning with tools is considered a richer form of learning than that which consists of paper and pen (Bartolini Bussi, Chiappini, Paola, Reggiani, & Robbuti, 2004.). This is because the tool is the result of a thought process which is aimed at achieving some result and as such it is the embodiment of ideas. The meaning is not only in the tool or in the interaction between the student and the tool but also between the student and the teacher (Mariotti, 2002). The meaning also lies in the aims which the tool is used for and the various activities that can be engaged in by using the tool. Bartolini Bussi and Mariotti (2008) claim that the semiotic mediation function of an artefact can be exploited by the teacher who has an awareness of its semiotic potential and uses it to guide the development of meaning for the student.

Mariotti (2002) claims that an artefact has a double interpretation. On the one hand it is an object that has been designed with a specific purpose in mind to achieve some goal. On the other hand, it is an instrument which is the result of the student's individual manipulation of the object. She claims that the instrument is an internal construction of the object and is different for every student who uses it. By using a technological artefact, a channel of communication is opened up not only between the student and the artefact but also between the student and the teacher with the artefact acting as the mediation (Mariotti, 2002).

Vygotsky distinguishes between the mediation function of tools and signs (or instruments of semiotic mediation). Vygotsky sees tools as having an external focus – to enable the user to perform some activity and he sees signs as being internally focussed belonging to the internal activity of the user. The external tools are made up of the tool/artefact, paper and pencil and signs are made up from dialogue and gestures (Mariotti, 2000). Tools have a two-fold function. Firstly, externally oriented, they are used to accomplish a task. Secondly, internally oriented, they are aimed at controlling the action. Through internalisation, tools may be converted into psychological tools which when internally oriented will shape new meanings and therefore function as semiotic mediators (Vygotsky, 1978).

An artefact which is to be used as a tool of semiotic mediation is characterised by the presence of:

- An object constructed to perform some function, which is used by the student to accomplish the goal of the task.

• Utilisation schemes - the different modes of actions which are accomplished by using the artefact to achieve the goal.

The artefact has a double function: firstly meanings emerge when the student uses it to achieve the goal and secondly it is used by the teacher to direct the development of meanings for the student with regard to the problem at hand. By using the artefact, the knowledge built into it becomes accessible to the student but to construct and develop meaning from the artefact comes from the social construction in the classroom under the guidance of the teacher (Mariotti, 2000).

2.7. CCNA Critique

Cisco Systems design, manufacture and sell networking devices to enterprises, public institutions and telecommunication companies. The Cisco Network Academy was founded in 1997 to teach students about computer networks. Cisco is unique in the corporate world due to its involvement in vocational education, making it a leader in this innovative approach. What follows next is a brief literature review on the CCNA Program.

Maj, Kohli, and Fetherston's (2005) analysis of the CCNA curriculum found that it primarily teaches networking via case studies using a traditional Command Line Interface (CLI). They saw the negative aspect of this approach being the sheer volume of output which must be interpreted by the learner and the difficulty for novices to understand this output. Secondly, status information from the many different device protocols, interfaces etc. must be obtained by a number of different CLI commands making it difficult for students to identify and understand the concepts underlying the use of the CLI. Another criticism by Maj et al. is the definition of devices in the Cisco Program as 'black boxes'. By not explaining specifically the function of devices, students are denied the opportunity to construct their own knowledge, making it an ineffective teaching strategy. They recommend that students should be provided with a conceptual model at the start of their studies, which must not only be technically correct but valid for different levels of complexity. The provision of this model assists students in building better conceptual structures by forming a bridge between a student's existing ideas and ideas that form part of the body of knowledge.

Maj and Kohli (2004) from Edith Cowan University in Perth developed such a conceptual model and evaluated its use as the pedagogical foundation of a networking curriculum in the university. Two groups were selected – the first group were doing an undergraduate course in networking and were taught CCNA in the normal Cisco prescribed manner. The second group were postgraduate students and they were taught using the conceptual model designed by Maj and Kohli. The two groups were evaluated at the start of the semester, the end of the semester (totalling ninety six hours) and then again six weeks after the final examinations.

The results of the research demonstrated that the undergraduate students using the Cisco curriculum were able to provide standard definitions to questions asked but appeared to lack a detailed understanding of device operation, indicating that the students were simply recalling learnt material. The postgraduate students taught using the conceptual model were also able to provide accurate definitions but demonstrated a far better understanding of device operation. Maj et al. surmised that these postgraduate students are more likely to retain learnt material as it is linked to more and better concepts which will enhance recall.

Richard Murnane of Harvard University's Graduate School of Education is co-author of a report written about how the Cisco Academy dealt with generic problems which were besetting the American education system, while delivering their program in high schools and community colleges (Murnane, Sharkey, & Levy, 2002). The research was initiated firstly in the hope that based on Cisco's experience, solutions might be found which would help deal with obstacles that were hindering progress in general education matters and secondly to understand, due to the Cisco Program's extraordinary rate of growth, how the program works and why it was appealing to high schools and community colleges.

In this study, the Cisco instructors interviewed by Murnane et al. criticised the instructor training which they had received, claiming that it was less successful in imparting pedagogical skills than it was in delivering content and that a didactic teaching style was too prevalent during the training. This was contrary to Cisco's best practices document in which it was very clear on the importance of engaging students in hands-on activities and that time spent lecturing should be limited. Selinger (2004), the education strategist employed by Cisco with responsibility for Cisco's social investments in education, claimed that instructor training needs to devote more time to developing a range of teaching strategies aligned to the pedagogical perspectives for both labs and theory, to ensure student success. The Cisco Academy recommends that more time should be spent on students engaging in hands-on activities than listening to the instructor lecturing (Murnane et al., 2002). Murnane et al. concluded that the quality of the training which the instructors received was a direct consequence of the quality of the Regional Academy instructors and that technology should *complement* the skills of the instructors and is not a *substitute* for instructors who model best teaching practices.

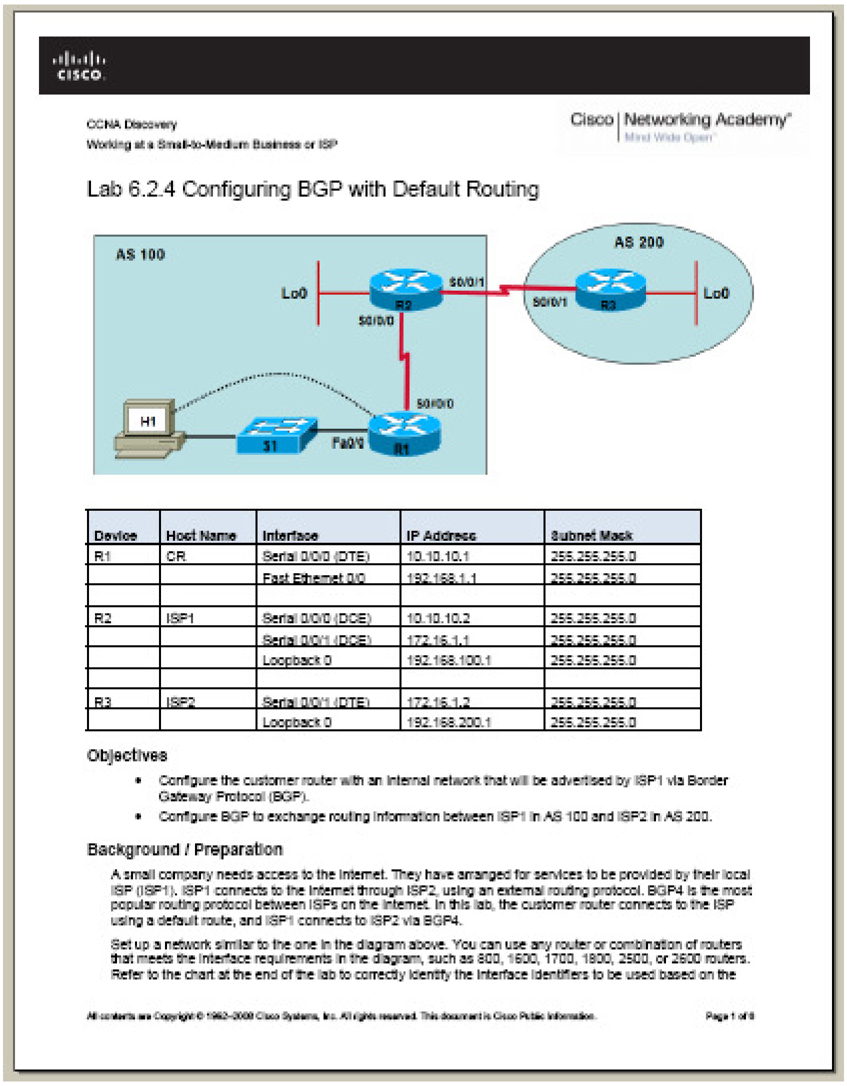
Personal Experience

The following paragraphs are anecdotal and based on the researcher's observations and personal experience from delivering the CCNA curriculum over a period of years.

The Cisco CCNA curriculum consists of four semesters each of which covers between seven and eleven topics. Each semester builds on the previous one and each topic progresses from simple concepts to the more complex. Contrary to Vygotskian principles, the lecture mode is chosen as the most effective medium for delivering content, based on this researcher's experience, other instructors' opinions and literature reviewed, due to the sheer volume of theoretical concepts which need to be imparted to the students.

The CCNA curriculum is lab intensive, with approximately seventy five percent of all class time spent doing lab activities. The hands-on labs, which are provided as part of the CCNA curriculum, follow an example-based learning approach which gives the student an expert's method of how to complete the lab exercise. These labs provide opportunities for students to be actively engaged and also allow students to socially collaborate with their peers and receive guidance from the instructor when necessary. This aligns well with Vygotsky's ideas in principle, giving students the opportunity to increase their zone of proximal development, but in practice students seem to be engaging in surface learning. This is evident from both observations by the researcher during lab sessions and when a similar task needs to be performed subsequently, the learners need to source all information again, indicating that the necessary knowledge was not constructed and internalised in the first instance.

The problem, which this study is attempting to address, stems from the over-scaffolding of the labs thereby making the tasks too cut and dried for the students and allowing them to complete the steps in the exercise without understanding the underlying process. An example of a typical CCNA lab sheet is as follows:



cisco

CCNA Discovery
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Lab 6.2.4 Configuring BGP with Default Routing

Device	Host Name	Interface	IP Address	Subnet Mask
R1	CR	Serial 0/0/0 (DTE)	10.10.10.1	255.255.255.0
		Fast Ethernet 0/0	192.168.1.1	255.255.255.0
R2	ISP1	Serial 0/0/0 (DCE)	10.10.10.2	255.255.255.0
		Serial 0/0/1 (DCE)	172.16.1.1	255.255.255.0
		Loopback 0	192.168.100.1	255.255.255.0
R3	ISP2	Serial 0/0/1 (DTE)	172.16.1.2	255.255.255.0
		Loopback 0	192.168.200.1	255.255.255.0

Objectives

- Configure the customer router with an internal network that will be advertised by ISP1 via Border Gateway Protocol (BGP).
- Configure BGP to exchange routing information between ISP1 in AS 100 and ISP2 in AS 200.

Background / Preparation

A small company needs access to the Internet. They have arranged for services to be provided by their local ISP (ISP1). ISP1 connects to the Internet through ISP2, using an external routing protocol. BGP4 is the most popular routing protocol between ISPs on the Internet. In this lab, the customer router connects to the ISP using a default route, and ISP1 connects to ISP2 via BGP4.

Set up a network similar to the one in the diagram above. You can use any router or combination of routers that meets the interface requirements in the diagram, such as 800, 1600, 1700, 1800, 2500, or 2600 routers. Refer to the chart at the end of the lab to correctly identify the interface identifiers to be used based on the

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Figure 1: CCNA Lab Sheet

As can be seen from the above example, the lab structure displays the network topology - all necessary devices are presented, including the interfaces which need to be configured and the IP addressing scheme. This denies students the opportunity to consider alternative design/networking solutions and to practice their subnetting skills.

The students complete the first lab in a chapter by simply following the instructions with regard to the physical build of the network, the IP addressing scheme to be used and then copying the appropriate commands from the lab sheets to configure each physical device. It is evident that very little cognitive processing and high order thinking is being done by the students. To complete any subsequent labs, students usually refer back to the first lab and copy the appropriate commands thus providing the solution.

The Cisco Academy recognises the value of students engaging in problem based activities and provides a troubleshooting lab in each chapter. An ill-configured network topology is presented which the students need to troubleshoot and correct, giving them the opportunity to engage in high-order thinking and problem based activities. However, once again students usually refer back to the first lab which provides the correct configuration commands and copy as appropriate. Students engaging in this practice are operating in a passive capacity by not attempting to source the information themselves, which might help reinforce the concepts. This leaves students in a situation where the new knowledge they have gained has not passed through the cognitive processes of assimilation and accommodation which enables their learning to move from short term memory to long term memory, resulting in this new knowledge being forgotten in a relatively short period of time. This practice by students suggests that success in the chapter exam is their main priority and the labs are simply activities which need to be completed. Because the curriculum is so assessment heavy, students are reluctant to invest time in areas which are not directly assessed, demonstrating a lack of understanding by the student of the educational benefit that practical activities can offer.

Another aspect of the CCNA labs which the students dislike is the narrow focus of each lab. Currently a lab presents a network topology to the students but the only part left uncompleted which requires student involvement, is the task related to the focus of the current chapter – all other devices have the network addresses applied to them and all the configuration commands have been preconfigured. These other device configurations would have related to previous chapters and the students perceive this as a lost opportunity which could have allowed them to recall and use prior knowledge.

2.8. Summary

Rich media can give rise to surface learning. Based on the literature reviewed and this researcher's experience, CCNA is a prominent example of this in practice. This results in students not developing a deep or lasting understanding of the content in question. The literature review puts forward a number of aspects which can lead to a deeper learning experience.

The literature states that by increasing students' levels of active engagement, deeper learning is facilitated. Problem based learning is an example of an activity that can actively engage students by utilising their high order thinking skills. By making the problem meaningful, relevant in context and ill-defined, students can take ownership of the task and explore alternative solutions. The problem based activities can be designed to create the zone of proximal development, allowing students to be challenged beyond what they are capable of doing on their own. The literature argues that the ability to recall information does not constitute learning, but the ability to apply it to unforeseen problem-solving situations does.

The literature claims that students are more likely to construct new knowledge when they are actively engaged with an external artefact. A richer form of learning occurs when the semiotic mediation function of the artefact can be exploited by the instructor. Socratic dialogue can be used for this purpose as well as allowing the instructor to be involved in the internalisation process, without giving direct instruction. Socratic questioning can be used as a bridge within the zone of proximal development and can highlight any erroneous miscomprehensions that may impede attainment of the target concept.

This researcher argues that a combination of problem based activities, interactive simulators acting as tools of semiotic mediation and the Socratic Method, working in tandem, can give rise to a deeper learning experience for the students. A case study was conducted in this researcher's CCNA class to investigate this hypothesis and understand how the different elements interact with each other.

3. Design of Learning Experiences

The literature review has demonstrated that problem based activities, semiotic tools and the Socratic Method, working together can provide a rich environment for students and give rise to a deeper learning experience. This chapter puts these generic principles into practice by applying them to individual learning experiences in place of the standard CCNA labs, to test out the hypothesis that the combination of these three elements working in tandem can engage students' high order thinking skills and discourage surface learning.

3.1. Design of Individual Activities

The individual learning experiences comprised of three elements - *problem based learning activities* performed on interactive simulators, which would be used as *tools of semiotic mediation,* facilitated by the instructor using *Socratic dialogue*.

The literature review has demonstrated that problem based learning is recognised as a mechanism for encouraging high order thinking. It has also demonstrated that the current presentation of the CCNA labs is overly scaffolded, allowing students to surface learn. For this reason the problems in this study were presented to the students in purely textual format without any documented scaffolding. No graphical topologies were presented to the students as the purpose was to allow students the opportunity to plan and design alternative solutions without any visual guidance. The activities were designed to give students an opportunity to increase their zone of proximal development which required a careful balance between making the tasks complex enough to challenge the students without being overly complicated thereby causing cognitive overload.

The literature review has suggested that learners are more likely to construct new knowledge when they are activity engaged with an external artefact. This study had the benefit of two external artefacts – a digital abaci and a network simulator. These artefacts were intended to be used as tools of semiotic mediation. It was anticipated that the semiotic mediation function of the artefacts could be exploited by the instructor using Socratic dialogue to allow the knowledge built into them be accessible to the student and help guide the development of meaning, without giving direct instruction (Mariotti, 2000).

The literature review demonstrated that Socratic questioning is valuable for assessing the extent of a student's current knowledge and then uses it as a starting point for further instruction. This was most useful in the first learning experience when it was necessary to understand how well the students remembered decimal positional value as a precursor to learning binary positional value.

The first learning experience was designed to allow students to experience a technological artefact as an 'object to think with' facilitated by the Socratic Method. Socratic dialogue in combination with the artefact was used to help students first of all recall their prior knowledge of the decimal numbering system and secondly to transfer this knowledge to help understand binary positional value. The semiotic function of the artefact could be manipulated to its greatest extent as the researcher was completely in control of directing the session and understood fully the potential of the artefact, through having developed it.

The subsequent three learning experiences presented students with a problem based activity which required the use of the network simulator for implementation. Socratic dialogue was used by the instructor with the simulator to exploit the mediating function of the tool. The three learning experiences were similar in context but differed slightly in content. They were designed primarily to provide comparative data revealing the success or otherwise of combining problem based activities, a semiotic tool and the Socratic Method to achieve a deeper learning experience for students.

3.2. Pilot Study

First Learning Experience - Understanding Binary Positional Value

A pilot study was carried out by the author in the academic year 08/09 in which an interactive tool was built to help teach number systems - an understanding of which is important prior to learning network addressing. A Socratic approach was adopted and three students were chosen as a purposeful sample. The findings from this previous study demonstrated that all of the students were successful in learning how to convert a binary number to a decimal number and vice versa within a short period of time. According to the students, much of the success of the exercise was contributed to the successful recall of decimal positional value through the interactivity of the decimal abacus and the use of Socratic dialogue for manipulating the semiotic mediation of the tool. The students felt that the visually interactive artefact allowed them to think and play with different combinations.

Varying degrees of scaffolding were provided on an as needed basis which allowed the students the opportunity and time to construct their own knowledge without receiving direct instruction from the researcher. Socratic dialogue was hugely beneficial in recalling prior knowledge of decimal positional value and also when trying to transfer this knowledge to the binary abacus. The findings suggested that the combination of the software artefact, the recall of prior learning and Socratic dialogue were all essential ingredients for the successful outcome of this exercise.

Based on these findings from this previous study, a similar exercise was carried out with this researcher's CCNA students. In this current study, the session was conducted with the whole class group rather than individual students as learning binary positional value is part of the CCNA curriculum and as such needed to be taught to all students. The following graphic displays the decimal abacus, which was used to help students recall their prior knowledge (see Figure 2).

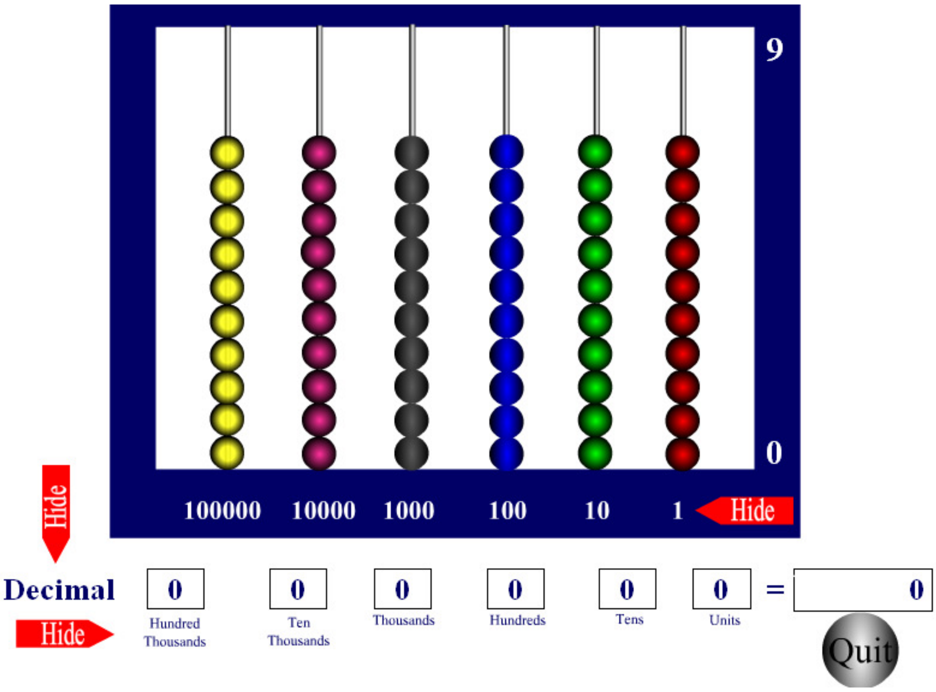

Figure 2: Decimal Abacus

The graphic below displays the binary abacus which was anticipated the students would understand by transferring their prior knowledge of the decimal numbering system.

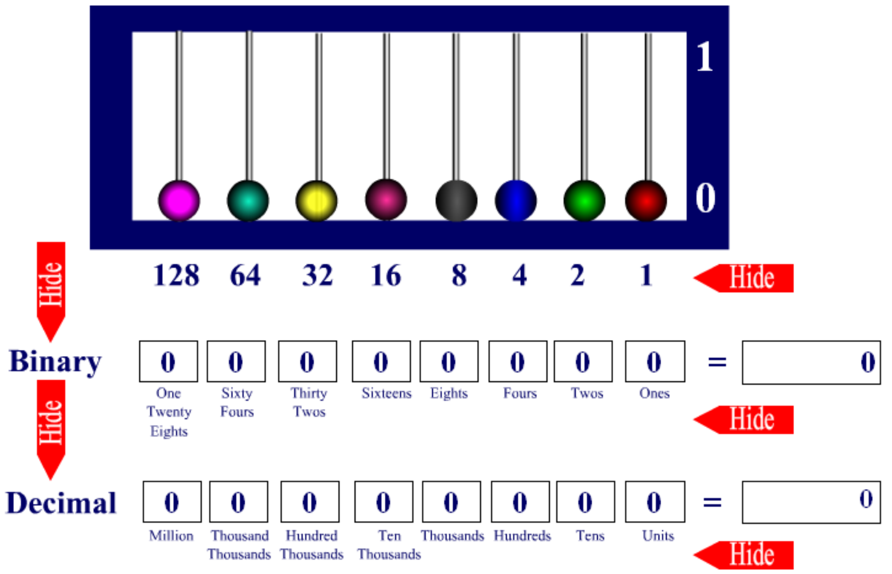

Figure 3: Binary Abacus

This first learning experience was an opportunity for students to increase their zone of proximal development with the researcher playing the role of facilitator to scaffold their learning through the semiotic mediation of the tool, but without giving any direct instruction.

3.3. Problem Based Learning Activities

As demonstrated in the literature review, the CCNA labs are overly scaffolded allowing students to engage in surface learning. In each of the subsequent three learning experiences, the problem was relevant to the current topic in the original CCNA lab. A problem based activity was presented in textual format to the students with no graphical scaffolding offered, allowing students to both take ownership of it (Jonassen, 1999) and the scope to explore alternative solutions (Bruner 1966). As per the arguments discussed in Section 2.9, these activities should assist in knowledge construction while offering an opportuntity for students to test their knowledge base through recalling prior knowledge to solve unforeseen problems (Honebein et al., 1993, as cited in Malabar & Pountney, 2002). The activities were also an opportunity for students to increase their zone of proximal development (Vygotsky, 1978).

Two of the learning activities were conducted in groups to allow students an opportunity to socially collaborate with their peers (Vygotsky, 1978). The third activity was performed individually to allow students test their knowledge base and understand if they had constructed the necessary knowledge to solve the problem. The Socratic Method was the teaching/learning strategy used in all the activities which allowed the instructor to exploit the mediating function of the artefact (Bartolini Bussi & Mariotti, 2008) and be involved in the internalisation process (Vygotsky, 1978).

In these activities, Packet Tracer™ - a network simulator, was the external artefact used to assist in knowledge construction (Kafai & Resnick, 1996). It provided the platform which allowed students to design and implement a network solution which would not be otherwise possible due to a lack of physical resources (Park, Lee, & Kim, 2009). More importantly it was used as a tool of semiotic mediation by the researcher to assist in the development of meaning for the student (Bartolini Bussi & Mariotti, 2008).

The three learning experiences are now described in turn.

A Local Area Network in a Small to Medium Business

This activity was conducted in a group setting with the students deciding themselves on the individual groupings. This decision was taken so that students would feel comfortable working within their chosen group rather than the researcher insisting on particular structures.

The activity required the students to take on the role of a Network Consultant charged with setting up a local area network for a small insurance company (see Appendix I) incorporating both wired and wireless routing.

Wired routing had been covered earlier in the term so this was an opportunity for students to recall prior knowledge. Wireless routing was a new topic introduced in the previous week so the activity also involved knowledge construction in which students could increase their zone of proximal development.

Network Upgrade in a Small Office/Home Office

As businesses expand, networks often outgrow their initial design. Upgrading a network involves considerations of scalability and design issues. Prior to any implementation, a network design needs to be drawn on paper and agreed with all stakeholders. This activity was an individual exercise to allow students to assess their own understanding and knowledge base (see Appendix II).

In this activity, students firstly had to draft on paper their recommended network design, prior to any build in Packet Tracer™. This gave students experience of planning a network upgrade by deciding on the necessary devices and cabling required to satisfy the business need. This activity incorporated all the topics which the students had covered since the beginning of term so it was a real opportunity for students to assess their knowledge base to understand if they had constructed the necessary knowledge to implement the solution. As this was an individual activity, it was also an opportunity for students to compare group work with individual work to understand the benefits or otherwise of each.

Inter-VLAN Routing

This activity was conducted with the second year students as it was felt that they would be in a better position to compare and contrast this proposed alternative approach for conducting the CCNA labs to the method they currently use. The second year students have a different CCNA instructor and he was asked to design a problem based scenario around their current focus of study (see Appendix III).

In designing the activity, the instructor was asked to be mindful of the design decisions of the study as outlined in Section 3.1. This activity was performed in groups which were formed by combining stronger students with weaker students based on prior exam results. This was done to avoid the possibility of the weakest students exclusively belonging to one group and the strongest students in another. This could have the impact of skewing the data analysis because of individual capabilities rather than individual experiences. It was anticipated that by combining the stronger and weaker students in a group, more realistic data would be collected and also collaboration within the group might be more effective.

3.4. Summary

The current CCNA labs are overly scaffolded allowing students to surface learn. The literature has demonstrated that introducing problem based activities can actively engage students and by using Socratic dialogue to exploit the semiotic mediation function of an artefact, students are afforded the opportunity for a deeper learning experience. The activities in this chapter were designed to encompass these generic principles and replaced the standard CCNA labs. The next chapter discusses the research methodology, ethical considerations, proposed setting and participants, data collection instruments and data analysis methods which were used in this study.

4. Research Methodology

4.1. Overview

Having discussed the design of the learning experiences in the previous chapter, this chapter deals with the reasoning and considerations behind the choice of the case study methodology and the advantages it offers for this particular research topic. This chapter also discusses the participants, the planned settings for the activities and the data collection methods. It concludes with an overview of the preparation technique used to analyse the data.

4.2. Literature Review

This section briefly discusses research methodologies and the rationale behind their adoption. Particular studies have been highlighted which reflect similarities in context, purpose or approach to this proposed research. The purpose of this brief review is to understand the various research methodology choices and data collection options with a view to informing this research in its chosen methodology.

When it was obvious that conclusions needed to be drawn from the students' own experiences, it became clear that qualitative research methods needed to be adopted. Smith (2008) states that behind each approach to qualitative research, is a concern with human experience, the richness of which is invaluable in research methods and drawing conclusions. The strength of the case study is in its ability to deeply examine a case within its "real-life" context (Yin, 2006). It is most appropriate when research topics are broadly defined, covering multiple conditions and not isolated variables and when the research relies on multiple and not singular sources of evidence. However, the case study should be complemented with other methodologies e.g. surveys, questionnaires, experiments etc. so that the strengths of each of these methodologies can counteract any inherent weaknesses, thereby offering the widest perspective and the most complete, rich, thick data set (Shavelson & Towne, 2002; Yin, 2006). Creswell and Garrett (2008) concur and declare that when researchers bring together both quantitative and qualitative research, the strengths of both approaches are combined, leading to a better understanding of research problems than either approach alone could yield.

This gives rise to a basis for a new approach to research called “mixed methods research” in which the researcher links both quantitative and qualitative data to provide a unified understanding of a research problem (Creswell & Garrett, 2008). Tashakkori and Teddlie (2003, as cited in Creswell & Garrett, 2008) have described this mixed methods approach as the third movement in the evolution of research methodology after quantitative and qualitative and is perceived to be the way most educators will approach research in the future.

As this particular piece of research addresses a descriptive question which requires rich thick data for analysis purposes, a case study was the most appropriate approach to adopt (Yin, 2006). Since all studies rely on a limited set of observations, it needs to be possible to generalise the findings to a broader setting (Shavelson & Towne , 2002; Yin, 2006). Shavelson and Towne claim that knowledge can only advance when the findings can be reproduced and applied in a more global setting and a range of times and places. By conducting several activities around different problem-based scenarios, it was anticipated that the yield from the data analysis would provide evidence allowing generalisations to be drawn around the benefits of problem-based learning facilitated by the Socratic Method and semiotic tools.

These multiple activities would represent confirmatory cases, i.e. “presumed replications of the same phenomenon” but with related variations among the cases (Yin, 2006 p. 115). It was also anticipated that by engaging in multiple activities, the findings of the entire study would be strengthened through the collection of a reasonable amount of comparative data for analysis. This was to counteract the possibility that a single activity could be considered standalone or idiosyncratic and have limited value beyond the circumstance of that singular activity (Yin, 2006).

A number of similar studies from the literature are discussed below with a view to identifying best practice in research methodologies and instruments which can be adapted for this research.

As outlined in Section 2.9, Murnane et al. (2002) conducted a study on how the Cisco Academy dealt with problems while delivering their program in high schools and community colleges. They interviewed instructors and students in six Local Academies and four Regional Academies in the New England area, developing semi-structured interview protocols to guide these interviews. They spent several hours observing classes and also spent two days at the Cisco Academy's Curriculum and Assessment Development Centre in Phoenix, interviewing the Cisco personnel who started the program and those currently responsible for curriculum, student assessment and instructor training. An early draft of the results was sent to the Cisco employees and instructors for their comments and corrections of factual errors and the feedback they gave was used to revise the paper.

Through the variety of channels which Murnane et al. adopted, the collection of multiple sources of rich data helped them triangulate their findings and add strength to their research. Due to the similarity in context between Murnane et al.'s research and this study, it is also proposed to use a semi-structured interview and observations.

Crossley, Osborne, and Yurcik (2002) conducted a study on the development and evaluation of a pilot computer architecture CD-ROM which taught children "how a computer works". The data collection methods used in this study were observations and semi-structured interviews of the participants while being recorded on video. Teachers were also surveyed for their views on the benefit the tool offered in a classroom setting. It is proposed in this research to also video students and interview instructors to understand individual experiences of delivering CCNA.

Rieber, Tzeng, and Tribble (2004) conducted a study to investigate ways of facilitating or enhancing referential processing when users were interacting with a computer-based simulation supplemented with brief multimedia explanations of the content. Rieber et al. used traditional performance measures, e.g. question based pre-tests and post-tests to assess participants' explicit understanding of the science principles modelled in the simulation. However, Rieber et al. admitted that they believed their research would have benefitted from qualitative data, such as observing and interviewing participants as they completed the simulations, due to the "explanative power of rigorous qualitative methods" (Rieber et al., 2004, p. 321).

From this advice, it is proposed to conduct qualitative research in this study to collect the rich descriptive data of the students' experiences.

Goldstein et al. (2005) conducted an experiment to investigate and measure the change in understanding that occurs when a simulation tool is used to facilitate active learning. Goldstein et al. designed practical sessions using a network simulator to facilitate active learning by providing an analytical, problem-solving and evaluation framework. They assessed students both before and after participating in a session using a pre-test and a post-test. As this researcher's study has similarities in approach and design, the decision was taken to post-test the students after the first learning experience based on Goldstein et al.'s and Rieber et al.'s research methods.

This post-test would assess student success in binary to decimal and decimal to binary manipulations. As the students had no prior knowledge of binary positional value, there was little point in conducting a pre-test. The results of the post-test should provide quantitative evidence of the success of this session, as the students were starting from a zero knowledge base, notwithstanding the fact that an alternative teaching method could produce the same result. A discussion forum was also planned to collect data on the students' own experiences, thus providing the qualitative data that Rieber et al. felt was lacking in their study.

Rieber et al. concluded that unlike traditional approaches where simulations are usually used as follow-up practice activities to tutorials, it may be possible to centre learning on the highly interactive and experiential nature of a simulation. This current research proposes investigating this latter point further through its investigation of centralising learning around problem based scenarios facilitated by the use of an interactive simulator. By adopting Rieber et al.'s approach, advice and data collection mechanisms, evidence should be elicited that allows the research question to be successfully answered.

This concludes the brief literature review on research methodologies. Based on this review, the case study methodology will be adopted and complemented with various other data collection techniques, which should provide a rich thick data set from which the research question can be answered.

4.3. Ethical Approval

Human participation is required in qualitative research when the intent is to yield detailed information, reported in the voices of the participants, contextualised in the setting in which they provide experiences and the meanings of their experiences (Creswell, 2008). As this research involved human subjects, it was necessary to obtain permission from Trinity College's Research Ethics Committee, the school Principal where the research was intended to be conducted and the participants themselves.

An information sheet (see Appendix IV) was compiled, informing students that they were participating in a study, describing the purpose of the study, the proposed research, the intended data collection methods and the timescales involved (Creswell, 2008). This information sheet together with a Request for Permission form (see Appendix V) to conduct the research was signed by each student and counter-signed by the researcher. As the proposed participants were this researcher's own students, a conflict of interest was declared, which required the Principal to also approve the research to Trinity College. Formal approval was received which allowed the problem based activities to commence.

4.4. Proposed Setting and Participants

In qualitative research, the aim is not to "generalise" to a population but to develop an in depth exploration of a central topic (Creswell, 2008; Yin, 2006). With this in mind, the services of the first and second year Data Networking students in a College of Further Education in Dublin were engaged as a purposeful sample.

To present multiple perspectives of individuals in an attempt to represent the complexity of the subject area (Creswell, 2008), other participants in the study included CCNA instructors from various Cisco academies around the country. It was anticipated that these instructors could provide information on their approaches to teaching the CCNA curriculum as well as their perspectives on their own students' learning experiences.

4.5. Data Collection

The purpose of data collection is to gather the types of data needed that will address the research question (Creswell, 2008). By using a variety of data collection techniques, a multiplicity of data should emerge to allow triangulation or the establishment of converging lines of evidence which should make the findings as robust as possible (Yin, 2006). The following data collection instruments were used to gather this multiplicity of data with the aim of providing confirmatory evidence which allowed the research question to be answered (Yin, 2006).

Audio/Video Material

The first learning experience was videoed in an attempt to collect evidence on the whole class group's interaction with the digital abaci. The decision to video only the first learning experience was taken because the researcher was completely involved in directing this activity, making it impossible to observe the students' interactions whilst at the same time deliver the session, whereas in the latter three learning experiences, the researcher was a participant observer able to view first hand the students' experiences. A video camera was positioned in the classroom in such a way as to capture the LCD screen displaying the artefact as well as the interaction of the students with the artefact. Analysing the output from the video session provided evidence of the degree of activity/engagement by the students.

A tape recorder was used during the semi-structured interview to capture all the comments from the student groups. The audio output was transcribed for later analysis purposes.

Observations

In this study, observational data such as the behaviours of individuals, sequence of events, quotes made by individuals etc. were recorded using descriptive field notes on an observational protocol form (see Appendix VI) and from reviewing the audio/video output after the sessions had completed. As opportunities arose during the sessions, reflective field notes were also recorded, describing personal thoughts or insights of the researcher. The researcher adopted the role of a participant observer by engaging in the activities, allowing the opportunity to view first hand, the experiences from the perspective of the participant. By performing multiple observations over the entire research process, data was gathered from a variety of activities which strengthened the findings of the entire study (Yin, 2006). Prior to each activity a checklist was compiled outlining key areas which needed to be observed in an attempt to answer the research question.

Interview

A semi-structured group interview was conducted with the second year networking students after the final activity in order to collect data on these students' experiences with this alternative approach to teaching the CCNA. As these students were exposed to the Cisco prescribed method of delivering the CCNA labs from the previous year, it was anticipated that they would be in a prime position to compare and contrast this different approach and that an interview would be the best medium to capture these experiences.

Questionnaires

Questionnaires were circulated after the latter three activities to collect data on the students' experiences with the specific session (see Appendix VII). A combination of open-ended and closed questions was included. The close-ended questions required students to tick a box indicating their preference. To complement this quantitative data, open-ended questions in which the participant could voice their opinion on their experiences, unconstrained by particular options or the researcher's perspective, were also included. The questionnaires were anonymous to allow students the freedom to be critical, without the fear of being identified by the researcher (Creswell, 2008).

Questionnaires were also circulated to other CCNA instructors in an attempt to understand their views on their students learning experiences while studying CCNA and to reveal different approaches taken to teach this subject (see Appendix VIII).

Discussion Forum

An open-forum discussion was conducted in the class with the students following the first learning experience. This forum provided an opportunity to understand the students' experiences of using the digital abaci and whether they felt more actively engaged by the addition of the technology.

Network Topologies from Packet Tracer™

The completed topologies built by the students using the network simulator were analysed to understand if the students were successful in solving the problem. Evidence of success was collected from both the internal configuration of the various devices in the topology as well as the ability of the devices to communicate with each other using the Internet Control Message Protocol, i.e. ping.

Post-Test Exercise Sheet

After the first learning experience, an exercise sheet was circulated to ascertain student success in binary/decimal manipulations. This took the form of twenty decimal-binary conversion algorithms and twenty binary-decimal conversion algorithms. A rating of fifteen or more on each test was considered proof of mastery.

The following table demonstrates which data collection instruments were used in each of the four learning experiences (see Table 1).

Data Collection Instruments	First Learning Experience	Second Learning Experience	Third Learning Experience	Fourth Learning Experience	Other CCNA Instructors
Audio/Video	✓			✓	
Observations		✓	✓	✓	
Interview				✓	
Questionnaires		✓	✓	✓	✓
Discussion Forum	✓				
Network Topologies		✓	✓	✓	
Post-Test Exercise Sheet	✓				

Table 1: Data Collection Instruments per Learning Experience

4.6. Data Analysis Preparation

The data was hand-analysed, due to the relatively small amount of data, non-familiarity with a software program and to be closer and have a more hands-on feel for the data (Creswell, 2008). As the activities in this research took place in a sequential fashion, it was possible to perform data collection, analysis and report writing simultaneously. Undergoing these continuous cycles informed alterations necessary to the next planned activity.

As each activity was completed and the necessary data transcribed, an initial exploration was done to get a general feel for the data. Brief notes were placed alongside particular themes or opinions to help form an initial analysis. The next stage in the analysis process was to code the data which involved labelling the text to form descriptions and broad themes in the data. This process involved going from the particular, i.e. transcribed notes from audio/video output, to the general – codes and themes.

After this process, all code words were analysed for similarities and/or redundancies. From this new list, the documents were re-analysed to understand if the codes catered for all of the ideas expressed in the documents. All quotes supporting specific code words were circled in red.

The codes were then generalised into a smaller number of themes - five in total, which consisted of the most common ideas, most unusual, most expected or have the most evidence to support them (see Appendix IX for an example). A matrix was formed by re-analysing the data again from the theme perspective to ensure all ideas expressed in the documents were captured by these themes.

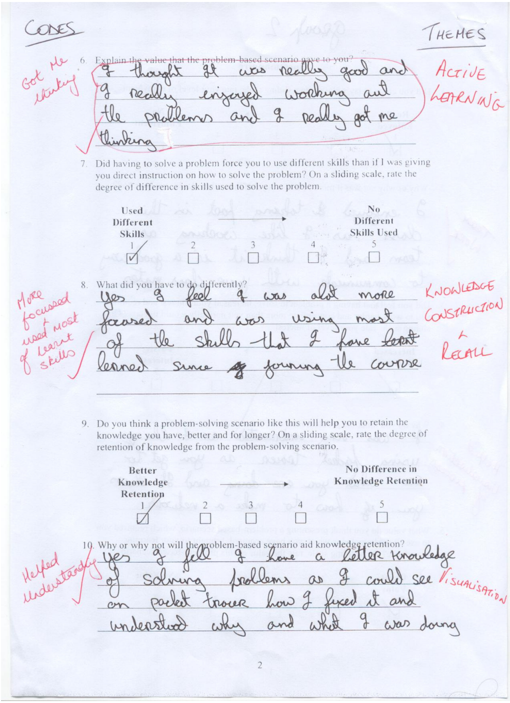
CODES
THEMES
6. Explain the value that the problem-based scenario gave to you?
Got me thinking
I thought it was really good and I really enjoyed working out the problems and I really got me thinking
ACTIVE LEARNING
7. Did having to solve a problem force you to use different skills than if I was giving you direct instruction on how to solve the problem? On a sliding scale, rate the degree of difference in skills used to solve the problem.
Used Different Skills → No Different Skills Used
1 2 3 4 5
8. What did you have to do differently?
More focused & used most of learnt skills
Yes I feel I was alot more focused and was using most of the skills that I have leant learned since joining the course
KNOWLEDGE CONSTRUCTION & RECALL
9. Do you think a problem-solving scenario like this will help you to retain the knowledge you have, better and for longer? On a sliding scale, rate the degree of retention of knowledge from the problem-solving scenario.
Better Knowledge Retention → No Difference in Knowledge Retention
1 2 3 4 5
10. Why or why not will the problem-based scenario aid knowledge retention?
Helped understanding
Yes I fell I have a better knowledge of solving problems as I could see on packet tracer how I fixed it and understood why and what I was doing
VISUALISATION
2

Figure 4: Codes and Themes

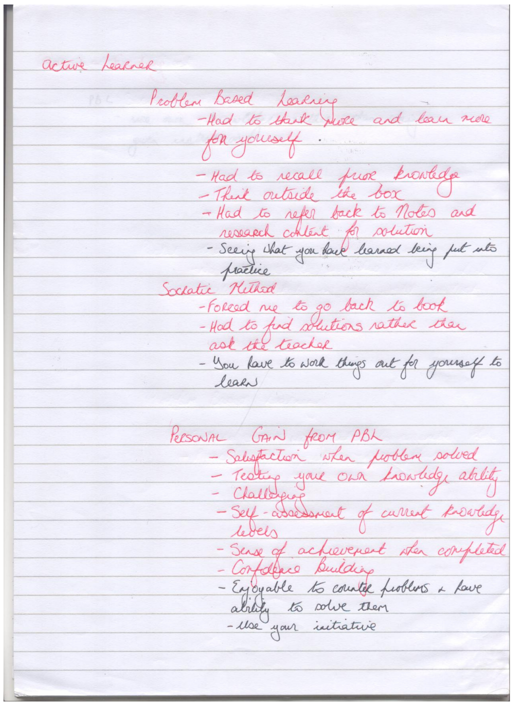
Active Learner
Problem Based Learning
- Had to think more and learn more for yourself.
- Had to recall prior knowledge
- Think outside the box
- Had to refer back to Notes and research content for solution
- Seeing what you have learned being put into practice
Socratic Method
- Forced me to go back to book
- Had to find solutions rather than ask the teacher
- You have to work things out for yourself to learn
Personal Gain from PBL
- Satisfaction when problem solved
- Testing your own knowledge ability
- Challenging
- Self-assessment of current knowledge levels
- Sense of achievement when completed
- Confidence building
- Enjoyable to consider problems & have ability to solve them
- Use your initiative

Figure 5: Re-analysing from Theme Perspective

The following table quantifies the number of codes supporting the individual themes (see Table 2). Whilst 'Enjoyment' emerged as an overriding theme, this was evidenced mostly from both observations by the researcher and quantitative data (see Figure 9). The *reasons* for the 'enjoyment' were evidenced qualitatively through coding and theming.

Major Themes	Number of Codes Supporting Theme
Active/Independent Learning	80
Knowledge Construction & Retention	35
Real Life Context	30
Collaboration	67

Table 2: Number of Codes Supporting Themes

Finally, a narrative description of the findings produced from the analysis was documented. Dialogues supporting the themes were identified and particular quotes which captured specific feelings of individual student's learning experiences are reported in the Data Analysis and Findings chapter. Any contradictory experiences were also highlighted.

As a validation strategy, the data was triangulated among the different data sets to enhance the accuracy and credibility of the study by demonstrating that information was not drawn from one single source, individual, or process of data collection (Creswell, 2008).

4.7. Summary

This chapter has outlined the research methodology, the data collection tools and the preparation of the data for analysis. The next chapter analyses this data in an attempt to yield findings which answer the research question.

5. Data Analysis and Findings

5.1. Overview

Having discussed the research methodology used for this study in the previous chapter, this chapter details the process of analysing the data collected from multiple media, to yield findings which provide an answer to the research question:

> Would the adoption of a problem based learning pedagogy facilitated by the Socratic Method and a semiotic tool encourage high order thinking and avoid surface learning caused by rich multimedia?

An over-supply of rich media can result in superficial learning and cognitive overload (Moreno & Mayer, 2007; Kalyuga et al., 2001). Cisco provides rich thick content for the CCNA curriculum but the content of the practical labs which accompany the theoretical part of the course is overly scaffolded which promotes surface learning. This places learners in a passive role and results in the necessary linkages to allow new knowledge to be constructed not being developed.

This research sought to address this problem by investigating if the combination of a problem based learning pedagogy facilitated by the Socratic Method and a semiotic tool could encourage students to use high order thinking and discourage surface learning. The literature has demonstrated that problem based learning is an example of a high order thinking task that actively engages the students (Bonwell & Eison, 1991). The Socratic Method was adopted as the teaching/learning strategy, to allow the semiotic mediation function of the interactive simulators to be exploited (Bartolini Bussi & Mariotti, 2008) and also to allow the instructor to be involved in the internalisation process (Vygotsky, 1978).

5.2. Analysing the Data

Interpretations by the researcher are subjective and the researcher recognises the interpretative influence of the research but accepts the difficulty of removing oneself from the study to report objectively (Creswell, 2008). However, an attempt was made to interpret the data in view of past research gained from the literature and through data triangulation. The findings below are based on common themes which emerged from the data analysis.

Before going into detailed analysis of the sessions, an overview of the learning experiences is discussed. The combination of problem based learning, the Socratic Method and the semiotic tool provided students with a rich learning environment in which they collaborated and enjoyed a deeper learning experience. From observations and data collected, a major contributor to the success of the sessions was the students not being 'spoon-fed'. Even though the step-by-step instructional format of the CCNA labs make it easier for the students to complete, it was very obvious that this was not how they wanted to learn. They wanted to be independent learners, challenged to source a solution which both gave them confidence in their ability when they were successful and provided evidence that they had constructed the necessary knowledge to solve the problem. Even if they weren't successful in solving the problem, the experience allowed them to develop a methodology on how to approach problem solving which will be beneficial to them in the future. In this study, the combination of the three elements did achieve the required result and discourage students from surface learning.

What follows next is a detailed analysis of each of the learning experiences. The data collected from the first learning experience was analysed separately as it differed in approach, content and delivery from the other three learning experiences. Following on from this, the three subsequent activities were analysed together to extrapolate common themes. As the study incorporated three elements – problem based learning, the Socratic Method and a semiotic tool, each of these elements was analysed for common themes and to understand the degree of importance and value which each element offered. The following datasets were used to triangulate the data from which five major themes emerged:

- Semi-structured interview recorded on tape from 9 students.
- Quantitative and qualitative data yielded from 41 questionnaires completed by students.
- Network topologies from Packet Tracer™ (approx 24)
- Post-test result after first learning experience from 12 students

– Other CCNA instructors (6) views collected by questionnaire

The data represented in graphical form throughout this chapter is a summative analysis sourced from three learning experiences.

5.3. Analysis of Data Collected from First Learning Experience

The data analysed from this session was collected from three sources – audio/video output, an open-forum discussion with the whole class group after the session had completed and a post-activity exercise sheet which was used to ascertain student success in binary/decimal manipulations.

From the outset, on the day the research was being conducted, there was an air of anticipation in the classroom. The introduction of the video camera and its initial set up, added to this anticipation. The students were unaware of the content of the class or how the class would be conducted which was deliberate by the researcher in an attempt to increase the energy, engagement and anticipation of the students.

As the session progressed, it was clear that the students were very engaged and interested. This was evident by the continuous and numerous responses to the various questions posed by the researcher whilst using the Socratic Method indicating that they were concentrating and trying to recall their prior knowledge as well as construct new knowledge. At various points during the session, the students were asked to convert a decimal number to binary or vice versa. During these exercises there was complete silence in the class, which would not be normal behaviour, indicating that the students were actively engaged.

The students were quite competitive with each other in their attempt to be the first to complete the exercise. They were encouraged to write their answer on paper rather than shouting out the answer to everyone. This allowed the researcher to individually check each student’s result, giving immediate feedback on the students’ levels of understanding as well as allowing the weaker students the time to complete the exercise or receive further scaffolding if necessary. The literature states that feedback is critical in helping the learner to build cognitive structures and in constructing new knowledge (Rieber et al., 2004). Bruner (1966) claimed also that the direction of exploration depends upon feedback received from the results of one's trials. Using the number of correct answers by the students as an indicator, helped gauge the pacing at which the class could progress. It also highlighted students who were having difficulties and who needed extra scaffolding. These actions allowed students to be supported on both the content learnt and the learning process.

Socratic dialogue was used in conjunction with the digital abaci to help students firstly recall prior knowledge and then to control the pacing of the class based on signs emerging through the semiotic mediation of the artefact. It was anticipated that through using the artefact, the knowledge built into it would be accessible to the students and Socratic dialogue was the means through which this information would be extracted (Mariotti, 2000).

The following sample dialogue demonstrates the value of the Socratic Method in helping a student construct knowledge. From observing this student's demeanour during the session, it became clear that he did not have a great understanding of decimal positional value so at this point, even though the class had progressed to the binary abacus, it was necessary to return to the decimal abacus for a time.

Instructor:	*Let's start again at the beginning. Do you remember when I showed you the decimal abacus you said to me that the 1st column was 1 and what did you say the next column was?*
Participant:	*10*
Instructor:	*And what was the next column?*
Participant:	*(Long pause). 20*
Instructor:	*Lets go back now for a second to the decimal abacus. So what did we say the 1st column was?*
Participant:	*1*
Instructor:	*Ok, and the 2nd column?*
Participant:	*10*
Instructor:	*And the next one?*

Participant: *100*

Instructor: *OK <pointing to the next column>*

Participant: *1000*

Instructor: *OK <pointing to the next column>*

Participant: *10,000*

Instructor: *OK, so what did you do to each column to get to the next one?*

Participant: *Multiply by 10*

Instructor: *So you multiplied 1 by 10 to give you what*

Participant: *The next column*

Instructor: *Yes, so what would that be?*

Participant: *<No response>*

Instructor: *So you are telling me this is units here in this column <pointing to units column> and how do I get the value of this column here <pointing to the tens column>*

Participant: *Multiply by 10*

Instructor: *So if I multiply this column by 10 what value does this column have <pointing to tens column>?*

Participant: *100*

Instructor: *Well what value does the first column have?*

Participant: *<Silence at first and then> 10*

Instructor: *Not the first column, no. What did you say a minute ago the first one was? Remember I did this <clicking on 3 buttons in units column> what is this value?*

Participant: *<Silence>*

Instructor: *What is that value if I click those 3 buttons?*

Participant: *3*

Instructor: *Yes it is. And if I click this one <click a button in 10s column), what is that?*

Participant: *9*

Instructor: *Where did you get 9 now?*

Participant: *0*

Instructor: *If this is 3, what value does this column have <pointing to units>*

Participant: *<Silence> Don't know!*

Instructor:	*What did we say the relationship was between the columns of the abacus?*
Participant:	*10*
Instructor:	*Great! Hold onto that! So it's 10 OK? So what do you do to this column to get the value of the next column?*
Participant:	*Multiply by 10*
Instructor:	*Perfect! Great! You multiply by 10.*

Eventually the student understood the positional value of each column and the relationship between the columns and could progress onto the binary abacus with the rest of the class. The abaci were instrumental in helping this student understand binary positional value. Being able to readily switch from the binary abacus back to the decimal abacus maintained the student's concentration levels keeping him engaged throughout. The visual design of the abaci made it easy for the instructor to 'point' to specific columns by referring to them by colour. Also by clicking on the individual buttons and making them 'jump', helped the student to visually recognise the numeric value. The scaffolding built into the abaci, which allowed the actual values to be displayed textually as well as visually, provided an application of dual coding theory (Paivio, 1990) and gave the instructor a helping hand when it was felt the student was getting embarrassed because he could not understand or losing interest because he felt he was getting nowhere.

After the session was completed, an open-forum discussion was conducted in the class to gain feedback on the students' own experiences. One of the purposes behind this learning experience was to encourage more active engagement by the students. Firstly the students were asked to display a show of hands on who had enjoyed that day's session. The entire class groups' hands were raised - eighteen in total! When asked if the students had noticed anything different about the way the class was taught compared to other classes, one student stated:

> '*There was more doing stuff, than just listening and instead of you just saying stuff and we have to take it in by just listening, it allowed us to get in and do it ourselves. The more you do it, the more it is going to stick in your head.*'

The literature states that learning needs to be an active process and this is not offered to the students using the lecture mode (Bruner, 1966; McRitchie, 2005). Another student replied:

> '*The main thing I noticed, which I thought was very good, was that you stepped back a little and you allowed people to figure things out for themselves. If they needed a little help, you came and gave them a hand but you sort of allowed people to come to the correct answers on their own.*'

This statement concurred with the literature when it stated that knowledge is not transmitted between teacher and student but actively constructed by the mind of the student. Vygotsky (1978) also claimed that learning is a social process and emphasised the need for the instructor to be involved in the internal development process. The students' comments indicated to the researcher the effectiveness and huge benefit that the Socratic Method affords to students by allowing them the time to reflect and to arrive at a conclusion in their own time whilst still allowing the instructor to be involved (Shugan, 2006).

Another purpose of this learning experience was to allow students to interact with a technological artefact for the purpose of achieving a deeper learning experience – both visually and cognitive. When the students were asked what they thought the abaci added to the lesson, one student replied:

> *'Physicality'.*

The students were then asked if they would have found the class as beneficial if the whiteboard or PowerPoint was just used. One student replied:

> *'The visualisation was better and seeing the physical buttons moving helped. Yes we felt we learnt better rather than doing it on the whiteboard'.*

Another student replied:

> *'Your attention was kept by the interactions'*

Kalyuga (2007) claimed that interactive learning environments respond dynamically to the actions of the learners and judging by these comments, it would appear that the students felt the artefact was hugely beneficial and valuable in learning binary/decimal manipulations.

Finally, it was important to understand if the students enjoyed participating in a whole class group session rather than individually and to what degree collaboration between the students had occurred. When asked if they found it helpful doing this activity as a whole class group or would they have preferred to participate individually, one student replied:

> '*Prefer to do it as a class because we can help each other and there is more interaction. If someone gets stuck and someone else knows it they can help them out'*.

Note: This quotation is an example of a code supporting the 'collaboration' theme for data analysis purposes.

It was evident from the students' feedback that they enjoyed the collaborative nature of the activity and it was refreshing to hear the spontaneous willingness of the students to help out a less capable peer. It was also observed by the researcher during the session, that pairings of students naturally formed when working through the problems, without being given direct instruction to do so.

To analyse the success of the session, a post-test exercise sheet was circulated consisting of twenty questions to measure students' explicit understanding of binary to decimal conversion and another twenty questions to measure decimal to binary conversion. These questions measured the students' ability to apply the conversion algorithm to unforeseen numbers which is evidence that learning has occurred.

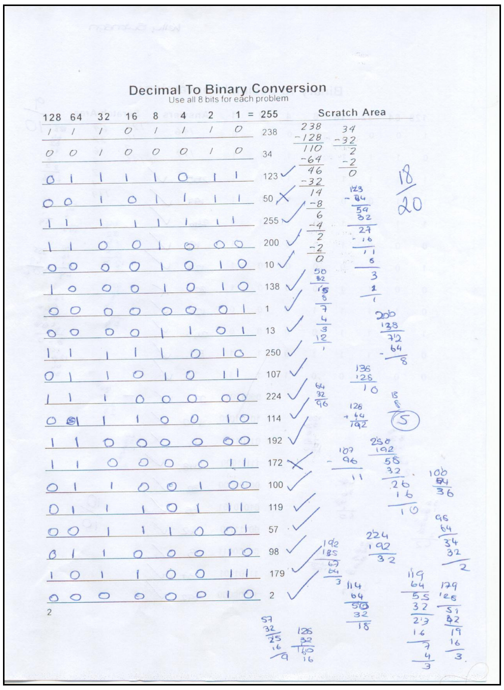

Figure 6: Decimal to Binary Conversion

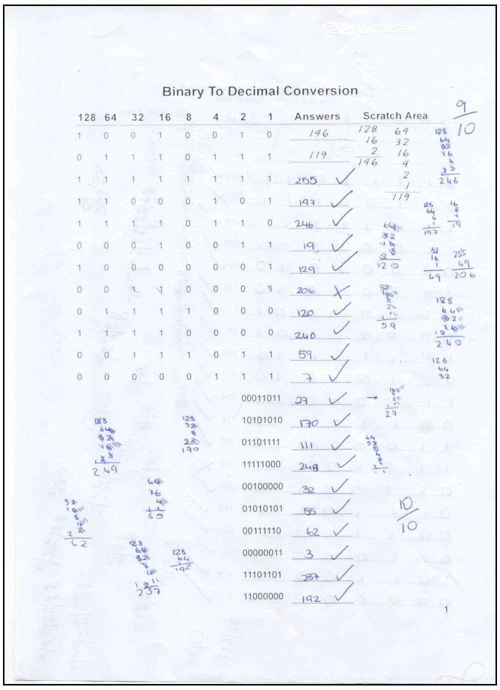

Figure 7: Binary to Decimal Conversion

Twelve students completed the post-test. The results are as follows:

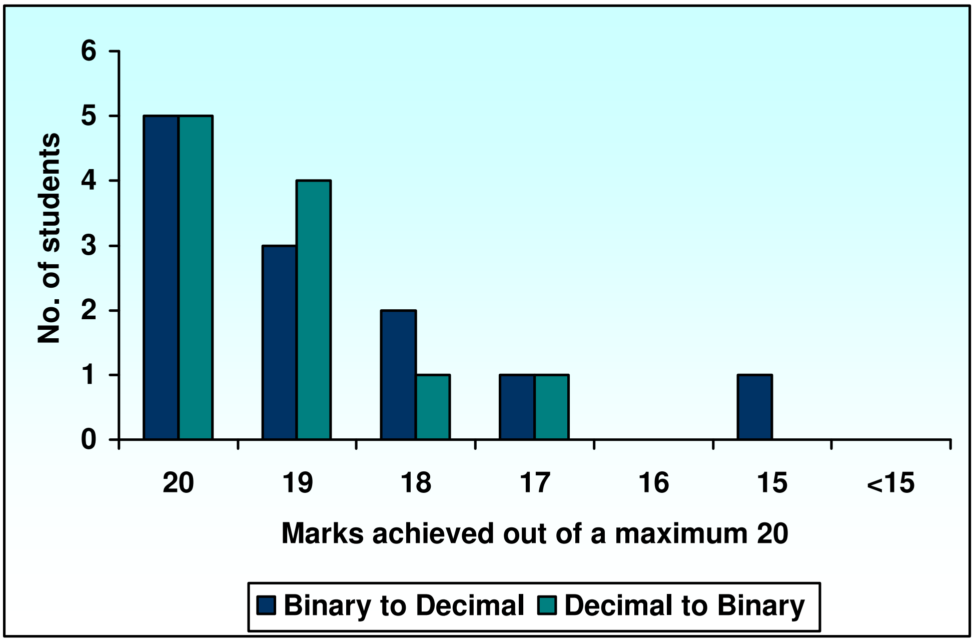

Figure 8: Post-Test Results

Note: One other student achieved 8 out of 8 in the Decimal to Binary conversions but 12 questions were left unanswered due to time constraints.

With the exception of one student who did not complete the exercise sheet, no other student achieved less than 15 correct answers out of a possible 20 in either exercises providing evidence of knowledge construction. It is accepted that teaching students binary positional value in a more traditional way, i.e. pen and paper, might be just as successful, but from experience, this researcher found that the ability to move the buttons on the abaci made it easier for the students to visualise the 0 and 1 positions and to recognise the positional value of each column of the abaci. Secondly the ability to display the number in both binary and decimal helped students understand that a number can be represented in different number bases.

The session ended and everyone was thanked for their participation. From the researcher's viewpoint, the session was extremely exhausting but seeing the upbeat demeanour and smiling faces leave the classroom that day, made it completely worthwhile and particularly when the weakest student in the class announced:

'*Best class so far!*'

Certainly it was felt that the students had deeply understood the concepts taught and had experienced and enjoyed a different method of teaching.

5.4. Enjoyment

This next section highlights one overriding theme which pervaded all learning experiences and as it was not associated with any particular element of this alternative approach, it warranted a section of its own. As outlined previously in Section 5.3, the students' show of hands demonstrated their sense of enjoyment after the first learning experience. Data collected after the second and fourth sessions, indicated that 75% of the students also enjoyed these sessions. This is demonstrated in the table below (see Figure 9). **Note**: This question was not included in the questionnaire after the third learning experience and therefore statistics are not available for inclusion, however based on observations by the researcher and the data analysis it was clear that the students had also enjoyed this session.

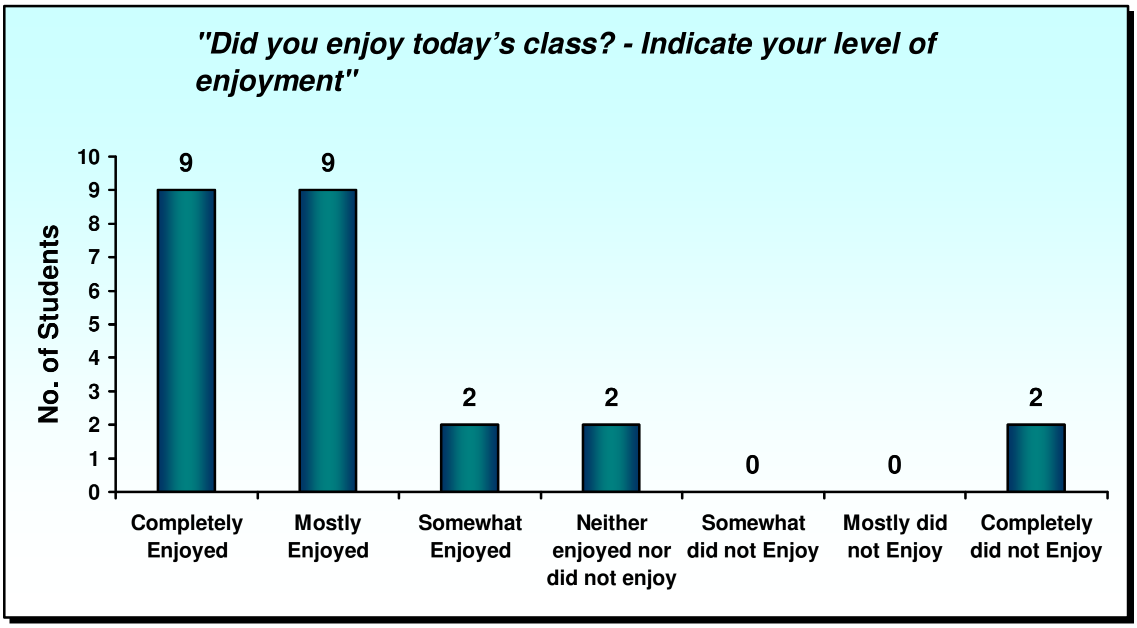

Figure 9: Levels of Enjoyment

From the coding and theming of the data analysis, two different reasons emerged as to why the students enjoyed the sessions. The first reason involved the *group* problem-based activities in which the students enjoyed the collaborative nature of the activities. Vygotsky (1978) believed that students need to collaborate on a social level with others for learning to occur and these group problem based activities allowed this social aspect of learning to happen. As the current structure of the CCNA labs presents the network topology in graphical form, there is no opportunity for students to collaborate with each other and discuss alternative solutions, a concept which Bruner (1966) considers necessary for successful learning. The students claimed that they learned from each other by listening to how a fellow group member might approach the problem.

> *"Because it was good to work in a team environment and see different members' skills and how each one interacted during the task."*

The other factor emerging from the data analysis for the enjoyment experienced by the participants was the fact that the activity required the students to think more deeply and be more active to solve the problem. Again, because of the current CCNA lab structure, the instructions to complete the lab are laid out in a step-by-step sequential format. It seemed the students enjoyed a huge personal gain from having more ownership of the problem. They felt a renewed confidence in their ability to plan, design and configure a network which allowed them the opportunity to increase their zone of proximal development. Setting a challenge for them gave them the opportunity to self-assess their own understanding and achieve satisfaction in solving the problem:

> *"I enjoyed getting the chance to work out problems myself instead of just listening to theory or being told what to do in the labs".*

Interestingly, the two students who ticked "**No Enjoyment**" were two of the weakest students in the class and who subsequently were not successful in passing the CCNA semester exam. The reason given by one student for his lack of enjoyment was that working in a group did not provide the opportunity for individual testing of understanding. The reason given by the other student was that there was not enough time to complete the activity. However, the other four groups had completed the activity with thirty minutes to spare!

The following sections individually analyse the three separate elements of these learning experiences – problem based learning, the Socratic Method and the semiotic tool under the major themes emerging from the data analysis. The analysis was done in this way to understand the degree of importance and value which each element offered or to understand whether a particular element was relevant at all in the final analysis.

5.5. Problem Based Learning

Active/Independent Learning

The data analysis revealed an extreme dislike among the students for the 'spoon-feeding' aspect of the current CCNA labs. Students indicated that merely transcribing commands from the lab sheet to the networking device resulted in a lapse in concentration and deep understanding of the concepts was not taking place. It was necessary to understand if the students felt that problem based learning led to more active engagement (see Figure 10).

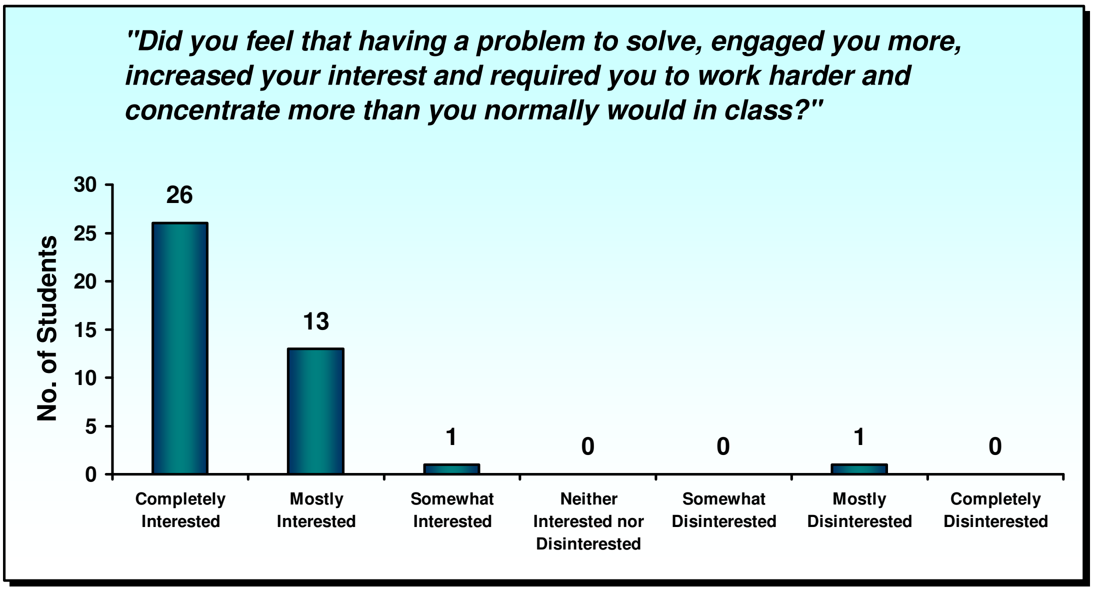

Figure 10: Levels of Interest

The students were then asked what value the problem based scenario brought to their learning experience. The results showed:

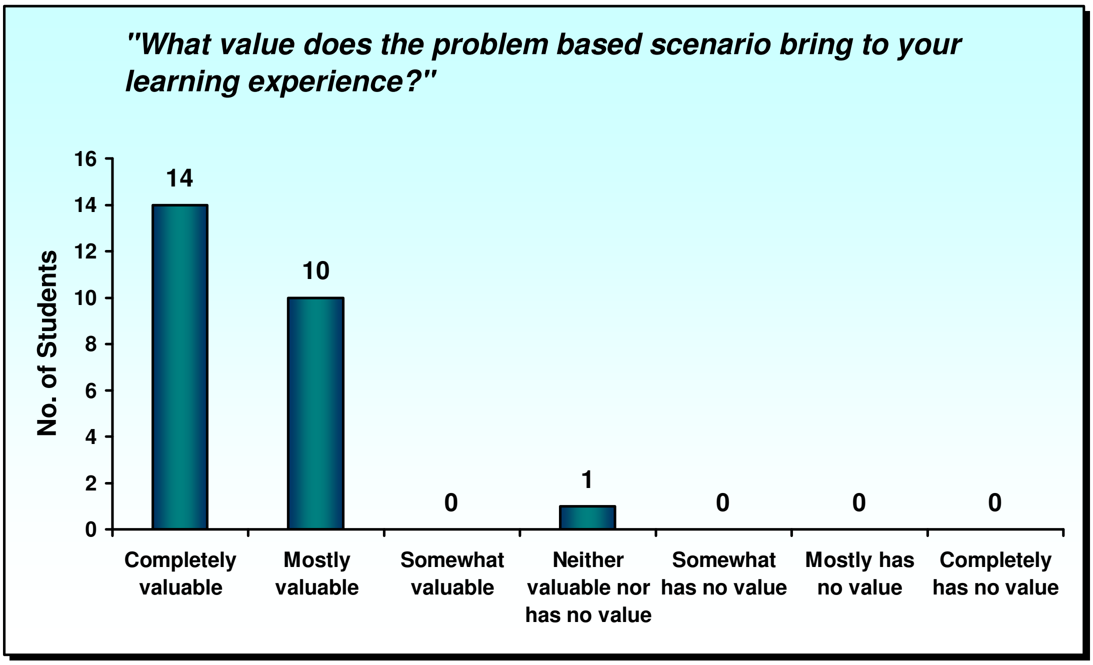

Figure 11: Value of Problem Based Scenarios

Further investigation into this seemingly positive support for problem based learning, highlighted the students dislike of step-by-step instructions and being 'spoon-fed' on the next step to complete when doing a lab activity:

> *"You are not thinking about what you are doing. You are just reading off the screen, you are putting a command in; you are not thinking what the command is doing."*

The students claimed that by having a problem to solve, which required them to use prior knowledge, meant that they had to refer back to their notes or the online curriculum for information to help them solve the problem which in turn made them more proactive in their learning:

> *"The problem had no instructions to follow or even a diagram so I had to think more about the design phase right through <to> how it would effect the configurations".*

The students also found it invaluable to be able to encompass prior knowledge plus the new information gained in this specific chapter into one activity. This challenge gave the students the opportunity to increase their zone of proximal development. When asked what aspect of the activity captured their interest most, one student replied with what he disliked about the CCNA labs:

> *"When we are doing a lab on inter-VLAN routing all routing configurations are done for you except the inter-VLAN routing and then it tells you what to do so you are not learning, you are just going to read it off the screen and you could be thinking of something else"*

Real-Life Context

The analysis revealed that the students considered problem based learning to be more akin to a real-life situation. They recognised that the workplace would expect an analytical type mind to be a successful and effective Network Administrator and problem based learning gave them experience and practice of this skill set. They also recognised the importance of planning out a solution by considering all options, a process which would be expected of them in the workplace, before 'jumping straight in'.

The literature suggests that for students to take ownership of a problem, it needs to be interesting, relevant, meaningful and ill-defined to allow scope for interpretation, just like real world problems tend to be. This ownership gives students' responsibility for their own learning and allows them to become self-sufficient learners (Bruner, 1966). It was necessary to understand if the students found the activities satisfied these criteria and were asked their opinion on the content of the problem based scenarios (see Figure 12).

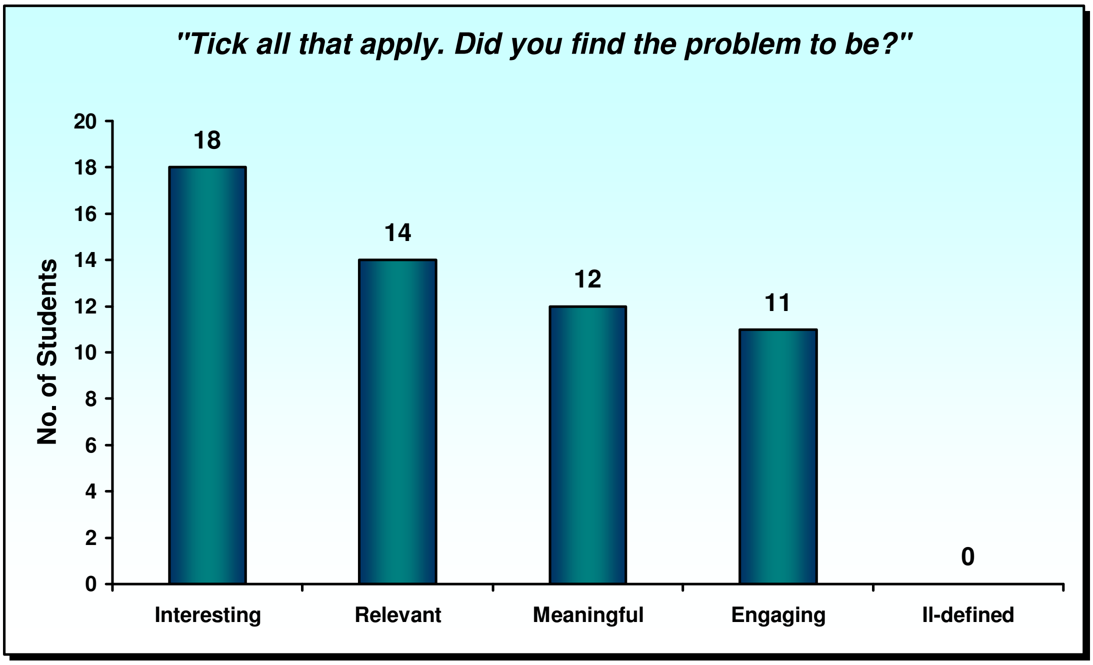

Figure 12: Content of Problem Based Scenarios

From the data analysis, 72% of students deemed the content of the problem to be very important. The current CCNA lab structure appears to be too cut and dried with little uncertainty, a factor which Bruner (1966) considers necessary for activating exploration and this has the impact of denying students the opportunity to consider alternative solutions. Interestingly, the students perceived 'ill-defined' to be a negative attribute rather than a positive, possibly due to their lack of understanding of what an ill-defined problem means. By having the problem ill-defined allowed the students the scope to use any method/resource/knowledge base to solve the problem – a need that the CCNA labs currently do not satisfy. One student replied when asked for his comments on the importance of the *content* of the problem based scenario:

> *"It showed me how I would use what I have learned in the workplace and tested how I would manage the type of problem in the workplace"*

A negative comment was made about the final problem based activity – inter-VLAN routing. While the activity itself was ill-defined, once the solution had been agreed on paper and the main switches had been configured, the rest of the activity involved a lot of repetition in configuring the other switches - approximately fifteen in total! This activity was conducted with the second year students with the help of their instructor and he explained afterwards that he hadn't really considered the repetitive nature of the activity which he had designed. It is a point worth noting on the importance of the *content* of the problem when designing the activities to keep the students engaged throughout.

Knowledge Construction

Obviously one of the most important reasons for doing practical work in any discipline is to give students an opportunity to put theory into practice. As lab work takes up a considerable amount of class time, it is important that students realise value from it. The students were asked if the problem based scenario helped with knowledge construction and retention (see Figure 13).

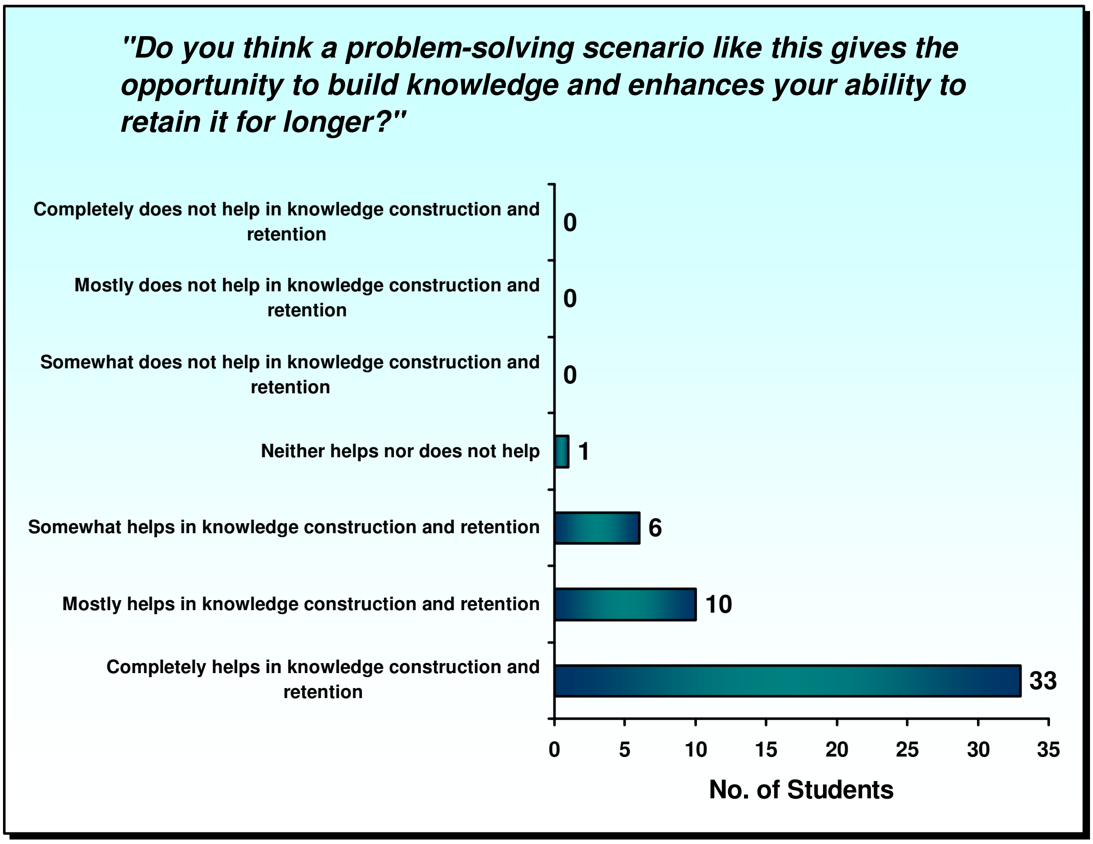

Figure 13: Knowledge Construction and Retention

From the data analysis, 66% of students felt that the problem based scenario completely helped with knowledge construction and retention. The students recognised that they learn from making mistakes but unfortunately with the instructional design of the CCNA labs, this simply means that one step was omitted from the configuration and careful examination of previously typed commands would reveal the omission. Bruner (1966) claimed that instruction must facilitate the exploration of alternatives and based on the students' comments it would appear that the problem based scenario provided this means. They commented:

> *"Building practical ideas to be implemented and seeing if those ideas from your knowledge base are logically sound or not and learning from it"*

> *"Because I didn't read if off a sheet – I had to use my memory and could easily recall what I done rather than reading the steps off a sheet"*

5.6. Socratic Method

This is the second element of the proposed alternative approach and forms the basis for the teaching/learning strategy which was adopted throughout the problem based activities. The Socratic Method gave students the opportunity to reflect and be supported on both the content learned and the learning process. Vygotsky (1978) believed that rather than a learner independently solving a task, they must rely, at least initially, on a more able other to succeed and it was proposed to use the Socratic Method to facilitate this end.

The natural impulsive reaction for an instructor is to reply to a student's question with the answer. However, it was evident from the data analysis that the Socratic Method allowed students the opportunity to think solutions through for themselves which facilitated knowledge construction and increased students' knowledge retention capabilities. The students were asked on their personal experience of the Socratic Method being used as the teaching strategy (see Figure 14).

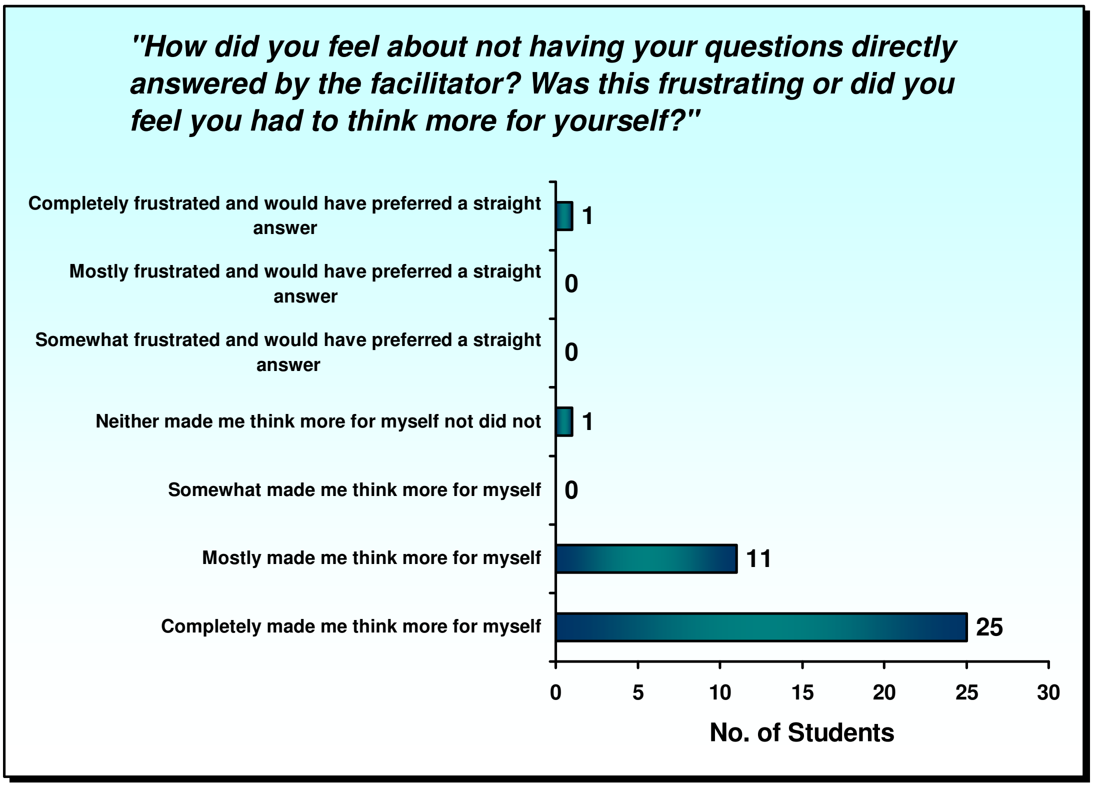

Figure 14: Perception of Socratic Method

However, while 94% of the students highlighted the benefit which the Socratic Method afforded to them, it did not turn out to be as important a factor in the final analysis as was initially envisaged. Very little use was made of the instructor as the more capable other, because the students sought answers to their questions from other sources, i.e. each other, the curriculum, books etc. On reflection, this was seen by the researcher as a positive effort by the students to become truly independent learners by not relying on the instructor as the only source of information. However, it is possible that in other circumstances, e.g. a younger student base, the students might not be as independent or as proactive as these students were and therefore the Socratic Method should still be considered as an important element of this alternative approach to overcome surface learning.

Active/Independent Learning

Students saw the Socratic Method as once again another opportunity not to be 'spoon-fed'. They considered it to be another challenge which if conquered would increase their confidence in their ability to solve a networking problem. The students also considered it as another positive mechanism for testing their own knowledge base to understand if they had the necessary knowledge to solve the problem:

> *"I don't like being 'spoon-fed' answers; I want to find out for meself why, if I am not sure about something, I will go back and read up on it, rather than just have someone tell you well that's it, and then you will probably forget it the next time anyway"*

Once again, they felt they were more active in trying to source a solution from their books or the curriculum without being given a direct answer.

> *"It was good to be able to do it all on my own and make my own mistakes and working out what they were and correcting them myself or with the help of my group instead of a teacher correcting them".*

Knowledge Construction

The students found that by not having their questions answered, forced them to try and source solutions for themselves. It also helped them to reinforce what they had already learnt which aids retention of knowledge:

> "*I needed to find solutions instead of asking for them"*

From the instructor's point of view, the Socratic Method puts the responsibility of learning back in the students' shoes and gives them complete ownership of the task. The only student who ticked the "Completely frustrated and would have preferred a straight answer" box, commented that:

> *"Sometimes a straight answer is needed in order to solve the problem".*

This somewhat limited and simplistic view of problem based learning would strike this researcher as a student who is lacking in the knowledge necessary to solve the problem even though the material would already have been covered in class or is a lazy worker who does not really want to make the effort to be more active to solve the problem. As another student stated:

> *"If your knowledge base is what is involved in the challenge, it would not be frustrating!"*

During the first learning experience the Socratic Method worked very successfully as the students had no prior knowledge of the binary numbering system and the Socratic Method was instrumental in the successful transferral of students' prior knowledge of the decimal numbering system. Through the manipulation of the abaci and Socratic dialogue, the instructor could maximise the potential of the semiotic tool to help students construct knowledge. Possibly using the Socratic Method as a mechanism for recalling prior knowledge and using this knowledge to construct new knowledge is where the Socratic Method is at its strongest.

5.7. Semiotic Tool – Network Simulator

The semiotic tool used in the latter three learning experiences was Packet Tracer™ - the network simulator. The literature claims that a visually interactive multimedia artefact can provide rich dynamic experiences which maximise the opportunity for learning but for an artefact to be used as a semiotic tool it needs to be able to create a channel of communication between the teacher and the student. It was anticipated to use Socratic dialogue as this communication medium to allow the instructor to exploit the mediating function of the artefact and be involved in meaning making for the students.

However, while little use was made of the instructor as a more able other during the activities, it was obvious through observing the students in their groups that they were mediating with each other through the simulator. This was evident from the continuous pointing at the screen whilst suggestions on alternative solutions to the problem were being discussed. Through implementing the solution on Packet Tracer™, the network topology became the result of a thought process which embodied the students' ideas.

By using Packet Tracer™, the students were able to design a network topology which could be discussed, refined and reviewed. It was important to understand the students' views on the use of the network simulator and whether it brought any benefits to their learning experience (see Figure 15).

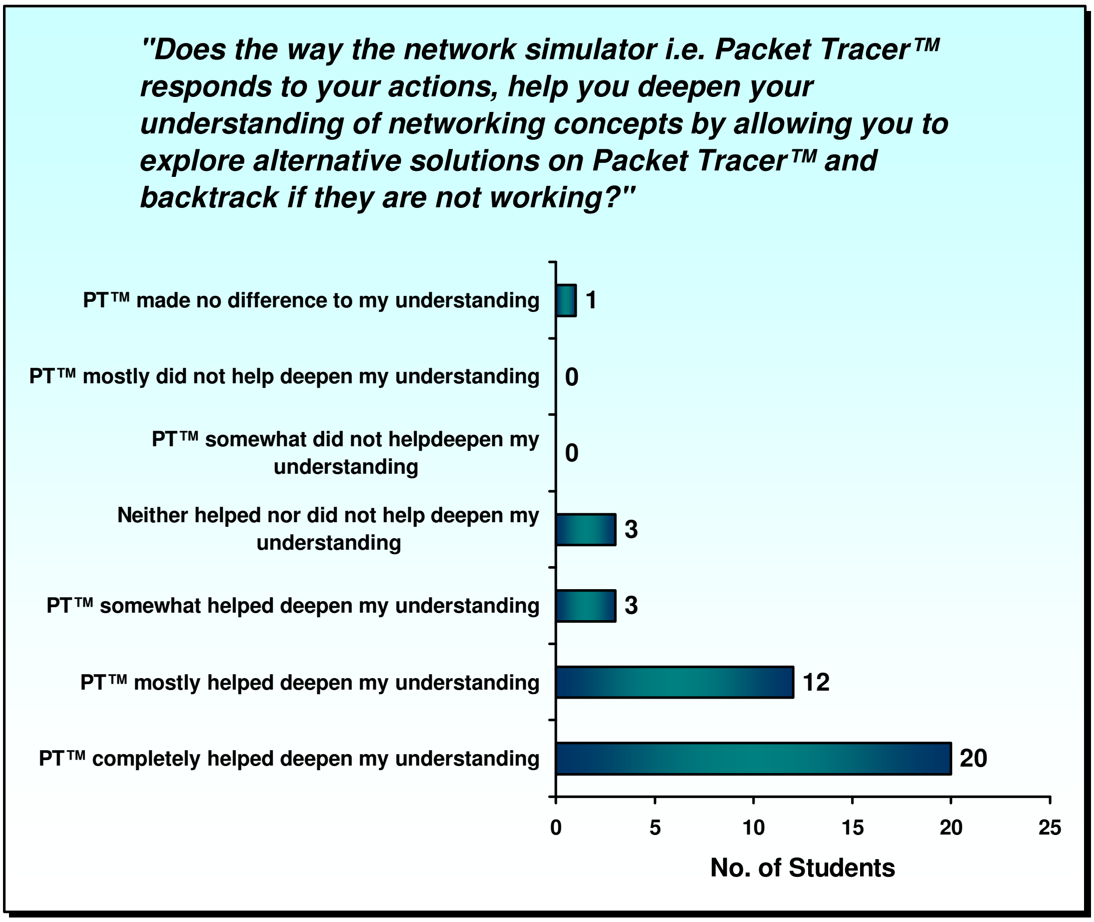

Figure 15: Value in way Packet Tracer™ was used

Active/Independent Learning

From the data above it appears obvious that the way Packet Tracer™ was used was instrumental in helping students deepen their understanding of networking concepts. Rieber et al. (2004) claimed that an important consideration in the design of computer simulations is how to provide meaningful feedback to the learner. Bruner (1966) and Gredler (2004) also claimed that feedback at a timely manner is essential for learning. Students claimed that Packet Tracer™ made it very visible to them, both graphically and textually, if their network design/configurations were incorrect due to the display of the link lights between the devices and configuration information. Through its ease of use and adaptability students are able to review their initial configuration choices, which is one of the factors why Osborne & Yurcik (2002) claim simulators are better than the real thing. Again, this tool made it easy for students to explore alternative solutions and backtrack if they were wrong (Bruner, 1966).

Whilst the researcher had little involvement in exploiting the mediating function of the artefact using Socratic dialogue, the feedback which the students received from the simulator allowed the individuals in the groups to successfully mediate with each other, enabling them to be active independent learners.

> *"It was beneficial because if it didn't give you feedback you couldn't know if there is a connection"*

Knowledge Construction

One of the major benefits of using Packet Tracer™ is the ability to visualise packets as they move from source to destination. It is possible to view source/destination MAC addresses as well as the source/destination IP addresses as they move through the various internetworking devices to reach their destination. The students were asked if this visualisation process was beneficial to them (see Figure 16).

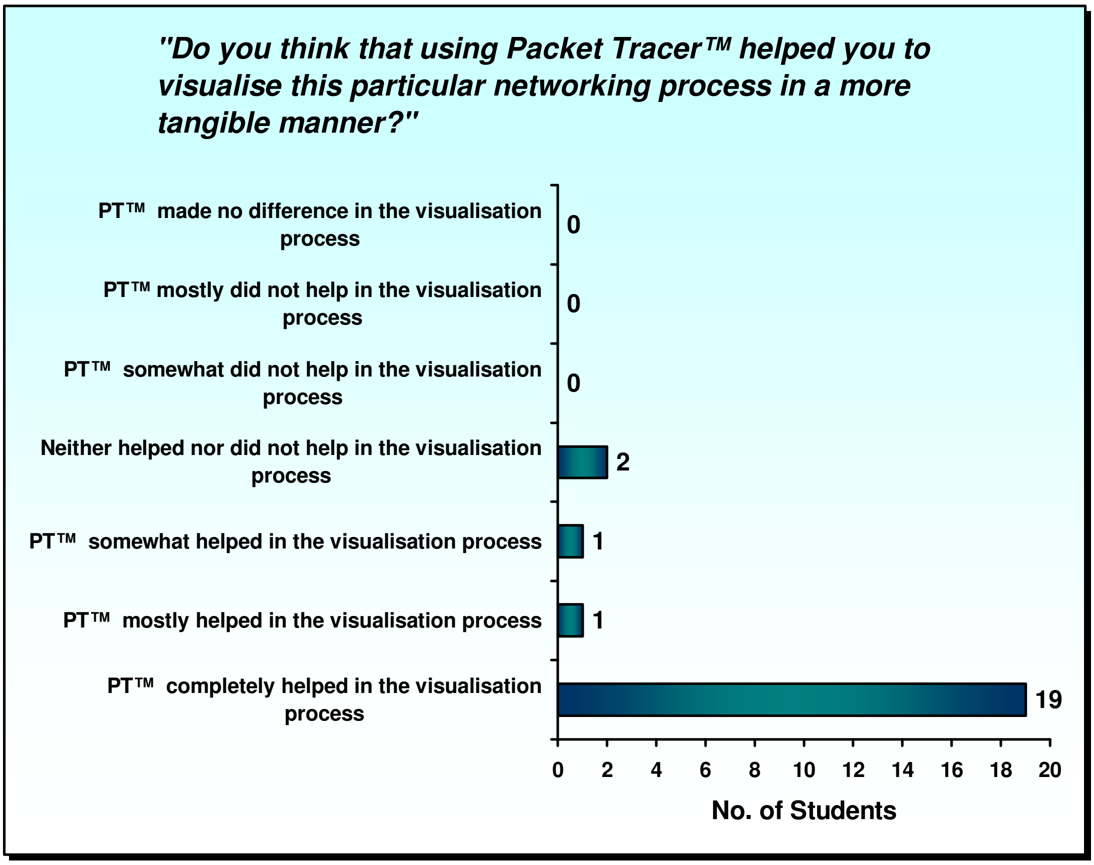

Figure 16: Visualisation Aspect of Packet Tracer™

Eighty three percent of the students found that the visualisation aspect of Packet Tracer™ was hugely beneficial to them. The students claimed that the visualisation process helped with knowledge construction through having the ability to interpret the packet header information at every internetworking device between source and destination. This helped students to understand these processes which would not be possible on physical equipment, a factor which Park et al. (2009) and Goldstein et al. (2005) consider advantageous when studying networking.

The data analysis revealed that 93% of students placed a high value on being able to complete a network design from planning through to implementation which would not be possible on physical equipment due to the lack of adequate resources. This was one of the criticisms by the students of the current CCNA lab structure, in that it presents the network topology completely configured except for one small part. Implementing a complete solution allowed students to discover any gaps or weaknesses in their knowledge base and gave them confidence in their understanding and a sense of achievement and satisfaction, when they solved the problem:

> *"After the completion of the problem, I actually felt like a real consultant and I strongly think I have added value to myself as regards networking"*

However, students also recognised the limitations of Packet Tracer™. The range of devices available on Packet Tracer™ is limited and if students have a requirement for higher specification devices these options may not be available in Packet Tracer™. This denies students their optimum device choice when planning a network design. In the fourth activity on inter-VLAN routing, the students ended up using fifteen switches to configure the network, as the maximum number of ports available on the Packet Tracer™ switches is twenty four, whereas much larger switches are available in industry.

5.8. Collaboration

Three of the learning experiences were group activities. The findings revealed that there were very opposing opinions on the benefits or otherwise of group work. As outlined in Section 5.4, the collaborative nature of the activities was a reason given by some students as to their *enjoyment* of the sessions.

On further investigation into the preference for group work, it emerged that students liked 'bouncing ideas off each other' and felt they learnt from their peers' ideas, perspectives and plans on how to approach the problem. A negative reaction to group work stemmed from the fact that one student's miscomprehensions/misinterpretations can confuse other group members.

Concentrating better seemed to be a common reason why students preferred working individually. Also the challenge for an individual is more satisfying when the activity has been completed by oneself, due to the immediate feedback a correct solution yields, on the adequacy of one's knowledge base. Another reason for individual preference, which became evident from the analysis, was control over the pacing of the activity. As an individual, it can be taken at a pace in which one is comfortable and has an understanding of everything that is being done.

5.9. Another Viewpoint

In the fourth learning experienced with the second year networking students, their instructor was present as he had devised the problem based scenario. This was an opportunity to discover another CCNA instructor's view on this proposed alternative approach. He stated that he realised that the Cisco labs took the 'paint by numbers' approach but it wasn't until he actually saw how the students worked and interacted with each other during the activity that he realised its full potential. While admitting that setting up the problem based activity took time, he felt it was well worth the effort as the students seemed to engage with the material immediately.

When asked his view on the Socratic Method, he felt he was weaker using this strategy than he had expected because he is so used to answering questions directly but recognised the advantage it offered the students. Overall he was surprised at how well this alternative approach worked both for him and the students. He felt the students engaged with the course material and seemed to enjoy taking responsibility for their own learning. While admitting he won't replace all in-class lab work with this approach in the future, he said he will definitely use it regularly.

5.10. Other Instructor’s Viewpoints

It was hoped to gather data from other CCNA instructors to be in a position to compare and contrast their experiences with teaching CCNA. Unfortunately the timing of the instructor surveys happened at the busiest time for CCNA instructors – semester exams. This resulted in only six completed survey forms out of a possible thirty, which meant that being able to generalise their experiences was not possible.

However, the surveys did reveal some interesting data. Amongst the six replies, lab work was performed in groups by all instructors, but the underlying reasons given were different. One reason given for conducting group lab activities was purely down to lack of time and equipment to allow individual participation. Only two of the six instructors indicated that group work was preferable due to the stimulation of discussions within the group, development of team working skills and the use of peer learning to reconcile any miscomprehensions that may have been acquired.

None of the six instructors felt that the students were deeply learning the material but felt students were more concerned with achieving the required grade in the chapter exams. To discourage students from solely focussing on the chapter exams, one instructor reduced the weightings of these exams down to minuscule numbers or deferred the exams altogether until near end of term and then used them as a mechanism to ‘force’ students to revise and reread the earlier chapters or as a study aid. Another instructor drew a diagram and asked students to set up the network from the diagram without any further instructions, something similar to what this study is trying to achieve through problem based learning.

5.11. Generalisation

Shavelson and Towne (2002) claim that knowledge can only advance when the findings can be reproduced and applied in a more global setting and a range of times and places. The findings from this study are not exclusively applicable to a networking curriculum and it is possible to allow generalisations to be drawn to other curricula around the benefits of problem based learning facilitated by the Socratic Method and an external artefact as a tool of semiotic mediation.

Firstly, the core of this study is around problem based learning, so in any situation where tasks to be performed can be embedded within a problem based activity make it a good candidate for this type of approach. It is important to recognise the skill level of the participants before introducing pure problem based activities as Kalyuga et al. (2001) concluded that learning from examples is a better strategy when learners have little domain knowledge of the task at hand. Certainly a choice between example-based learning and pure problem based learning could be adopted to appeal to the individual capabilities of the students ranging from novice to expert. The important underlying factor is to give students the opportunity to engage their high order thinking skills which problem based learning or its derivatives readily provides.

Socratic dialogue is a very effective way of exploiting the semiotic mediation of an external artefact allowing students total control over the pacing and level of instruction. The Socratic Method is adaptable to most learning situations and it is the proficiency of the facilitator which will dictate the success or not of this teaching strategy. Like any new skill, practice and repetition is required to achieve a level of competency to enable it to become a valuable teaching resource.

Kafai & Resnick (1996) claim that students construct knowledge when they interact with an external artefact which can be reflected upon and shared with others. While this study had the benefit of both the digital abaci and Packet Tracer™ as its semiotic tools, there is no reason why the artefact needs to be technologically based. Many teaching resources today make use of instructional tools and any of these could facilitate knowledge construction and be a tool of semiotic mediation. The fundamental factor for this alternative approach is the ability of the artefact to be used as a semiotic tool, which the instructor can exploit through having knowledge of its potential, to help students achieve the target concept and this could be, for example, a burette in a titration experiment within a Science curriculum.

5.12. Answering the Research Question

Based on the evidence yielded in this limited study and notwithstanding the impact of the novelty factor, it would appear that the students both enjoyed and benefitted hugely from the problem based activities. By incorporating many of the educational theorists recommendations for ‘good’ learning, into the problem based activities, gave the students the opportunity to be more active in their learning, engaged their high order thinking skills which in turn facilitated deeper learning and challenged themselves which allowed them to self-assess their own understanding and identify gaps or areas of weakness. The students also derived personal benefits from the activities which should help them in their future careers. These benefits included - development of team working skills, increased self-confidence in their abilities, development of the professional attributes which should help them in their role as Network Administrators and gaining experience of using particular processes and tools that may aid their employability.

In answer to the research question and based on the evidence yielded from this study, this alternative approach to conducting the practical part of the CCNA did enhance the students’ learning experiences by requiring them to engage their high order thinking skills thus discouraging them from surface learning. Some final comments from the students epitomises their feelings on the value of this learning experience:

> *“I found the experience to be very enjoyable and educational”*
>
> *“It was an excellent way of learning. I hope most learning is done this way”*

6. Conclusion

Most students enjoy a challenge which can introduce a fun and competitive element into the class while at the same time allowing students to become more active and increase their zone of proximal development. Evidence of learning occurs when the students solve the problem and this is more satisfying when the students receive feedback from an external artefact, rather than from the instructor. This alternative approach certainly places the instructor in a facilitatory role rather than simply a transmitter of knowledge and allows the students to become truly independent learners.

The College where this study was conducted have a review day for all its students and their respective tutors to understand the students' progress and their likes/dislikes of the course in general. One of the questions on the Student Feedback form is:

"In your opinion what could be done to improve the Course?"

One student commented:

"Doing the Cisco class the way <researcher> did in her experiment"

And another student commented:

"More hands-on labs without handouts – only problem solving scenarios"

This epitomised for this researcher the impact this alternative approach had on the students when out of nine modules covered in the course, of which CCNA is just one, introducing problem based scenarios facilitated by Socratic dialogue and an external artefact were seen as the most effective way of improving the entire course.

6.1. Limitations

It is accepted that the findings from this study are limited in number and are subject to researcher bias. It is also accepted that the novelty factor introduced by the problem based scenarios played a part in the positive reaction by the students to the learning experiences. The findings are weakened due to the first year students not being in a position to conduct a fair comparison on which approach they would prefer for conducting the practical part of the CCNA curriculum as they have not been exposed to the Cisco prescribed approach for a significant period of time. The study would have been strengthened if the second year students were more available as a purposeful sample for research as they were in a prime position to compare and contrast both teaching approaches. The research could also have been strengthened if more time was available to interview a greater number of the students about their personal experiences with this alternative approach rather than gaining these insights through questionnaires.

6.2. Further Research

The findings suggest great disparity between the benefits or otherwise of group work. The more able students seemed to prefer individual tasks as they felt there was nothing to be gained out of group work whilst the less able students felt they would have learnt more if they had performed the activities alone. Further research could investigate this phenomenon to understand which student base or perhaps neither, gain more benefit from group work.

Continuous assessment is a significant part of the CCNA curriculum. Some strategies that CCNA instructors use to remove students' sole focus from achieving seventy per cent in the chapter exams is to reduce the weightings of these exams or defer them until the end of the semester. Further research could investigate whether this continuous assessment has a negative impact on students' focus for learning. Is the focus simply to achieve seventy per cent in the chapter exams or is the main focus for students to understand the concepts and processes of networking to take with them to the workplace?

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8. Appendices

8.1. Appendix I – Second Learning Experience

Activity 2 –Implementing a Local Area Network in a Small to Medium Business

Format: **Small groups of 3 – 4 students**

Description:

Michael Foley has decided to set up a small insurance company using his own home as his company headquarters. He needs assistance in planning and implementing this network and has employed the services of your Networking Consultancy Company.

Initially Michael will employ one office administrator, one receptionist and three salespeople. The office administrator's PC and the receptionist's PC will be stationary devices. The three salespeople will use wireless-enabled laptops when travelling on the road and they will also need to be able to access the WLAN when they are in the office. Security on the wireless links needs to be considered as it is extremely important that the confidentiality of the Company's clients' information is safeguarded.

The following considerations need to be taken into account when designing the network:

1. The receptionist's computers will be assigned a static IP address in the 172.17.10.0/24 network and will connect directly to a multi-function device.
2. The office administrator's computer will also be assigned a static IP address in the 172.17.10.0/24 and will connect directly to a multi-function device.
3. The three salespeople's computers will connect wirelessly to the multi-function device and obtain their IP addressing information from DHCP.
4. The multi-function device must have security features enabled and the default settings must be changed.
5. The WAN interface of the multi-function device will be assigned a static IP address from the ISP.

The following considerations need to be taken into account when configuring the devices:

1. Name the multi-function device **WRS1**
2. Name each wireless client's laptop as **Sales1_LP, Sales2_LP, Sales3_LP** respectively
3. Name the receptionist's computer as **Recp_PC**
4. Name the Office Administrator's computer as **Admin_PC**
5. Set up a static Internet connection on the multi-function device with:
    a. IP address of 172.15.88.25
    b. Subnet mask of 255.255.255.0.
    c. Default gateway of 172.15.88.1
6. Set the multi-function device's internal IP address to 172.17.10.1 and subnet mask 255.255.255.0
7. Enable the router as a DHCP server and create a pool that will deliver 25 addresses starting at 172.17.10.50
8. Allow for mixed devices connecting to the Wireless Network
9. Change the shared network name to **insurance**
10. Do not advertise the network name if this option is configured
11. Choose the most secure security mode for this Access Point
12. Use a preshared key with a value of **123ABC789D**
13. Choose the strongest encryption method available
14. Set the router password to **foley**

Your task, within your group, is to build and test the above network using Packet Tracer ™. When the network is complete, ensure that all the devices, both wired and wireless can communicate with each other. Complete the following table when the activity is complete.

Device	IP Address	Subnet Mask	Gateway
WRS1 WAN Interface			
WRS1 LAN Interface			
DHCP Address Range			
Sales1_LP			
Sales2_LP			
Sales2_LP			
Recp_PC			
Admin_PC			

8.2. Appendix II – Third Learning Experience

Activity 3 – Design and Prototype a Network in a Small Office/Home Office

Format: **Individual**

Description:

Dr Mary Kelly and her husband Dr Andrew Kelly have purchased a new home with a view to relocating their private medical practice to this residence. As well as accomodating the two doctors, a nurse will be employed with responsibility for blood tests, minor injuries and general nursing duties. Two days a week, a physiotherapist will see patients at the surgery and will need access to these patients' medical records. Both doctors will need Internet access for research purposes and for exchange of information between other doctors and hospitals. As the confidentiality of the patients' records is of the utmost concern to the Kelly's, security considerations on the network are of the highest priority.You have been asked to advice the Kelly's on the set up of a network and implement a prototype of your solution on Packet Tracer™.

The following considerations need to be taken into account when designing the network:

1. The nurse's computer will be assigned a static IP address and will connect directly to a multi-function device.
2. The two doctors' computers will be assigned a dynamic address and will also connect directly to a multi-function device.
3. The physiotherapist's laptop will connect wirelessly to the multi-function device and obtain its IP addressing information from DHCP.
4. The nurse's computer will eventually host the company website so all requests from the outside network for web and ftp services should be forwarded to this machine.
5. The WAN interface of the multi-function device will be assigned a static IP address from the ISP.

Based on the above information, draw a physical network diagram of the planned network below, showing all network devices, PCs and cabling. Identify all devices and interfaces.

Physical Network Topology

On Packet Tracer™, develop a prototype of your recommended solution. Connect the WAN interface of the multi-function device to port 23 on the Switch. When the network is complete, ensure that all the devices, both wired and wireless can communicate with each other. The following considerations need to be taken into account when configuring the devices:

Multi-function Device

1. Change the admin password to **K1llester0**
2. Set a static IP address on the WAN interface - 200.98.20.1/27
3. Set a static IP address on the LAN interface - 172.16.10.1/24
4. Activate DHCP on the LAN interface and create a pool that will deliver 50 addresses starting at 172.16.10.20
5. Change the default SSID to **Kelly**

Nurse's Computer

1. Name the PC - **Nurse PC**
2. Set a static IP on the nurses's computer of 172.16.10.2/24 and an appropriate default gateway.

Physiotherapist's Computer

1. Name the PC - **Physio PC**
2. Create a profile that will enable you to associate with the multi-function device.
3. Configure the wireless host to use the SSID as configured on the multi-function device
4. Configure the wireless client to obtain an IP address from DHCP.

Test Connectivity

Verify connectivity by pinging from the:

- Wired hosts to LAN gateway
- Wired hosts to ISP gateway (209.98.20.30)
- Wireless host to LAN gateway
- Wireless host to ISP gateway (209.98.20.30)
- Wired hosts to each other and wireless host

Note: Do not proceed to the next step until you have full connectivity from the wireless host to the ISP gateway 209.98.20.30.

Configure Security on Wireless Host

1. Disable SSID Broadcast.
2. Configure a static WEP key of **CBA987FED5** on both the multi-function device and the client
3. Enable MAC address filtering to allow only your wireless client to connect to the network.
4. Disassociate from the wireless network and then re-associate to ensure that the wireless security features are in use.
5. Test connectivity by pinging from the:
    - o Wireless host to LAN gateway
    - o Wireless host to ISP gateway
    - o Wireless host to wired hosts

Configure Port Forwarding

The nurse’s computer will host the company web server. External Web and FTP access to this machine must be enabled.

Enable port forwarding on the multi-function device so that any requests for web or FTP access made to the IP address of the WAN interface will be directed to the nurse’s machine.

Documentation

Complete the table below with the IP addresses, subnet masks and gateway information of the multi-function device, the wired and wireless hosts.

Device	IP Address	Subnet Mask	Gateway
Multi-Function device WAN Interface			
Multi-Function device LAN Interface			
DHCP Address Range			
Dr Mary Kelly’s PC			
Dr Andrew Kelly’s PC			
Nurse’s PC			
Physio’s Laptop			

In the space provided below, draw a physical network diagram showing all network devices, PCs and cabling. Identify all devices and interfaces according to the interface chart above and indicate the IP address and subnet mask for each interface, based on the entries detailed above.

Physical Network Diagram

8.3. Appendix III – Fourth Learning Experience

CCNA 3 : LAN Switching and Wireless Module 6 : Inter-VLAN Routing **Challenge Lab Activity**

International company 'MoneyManage' have bought a small office block in Dublin city centre with a view to setting up a small office for their money laundering facilities. It is highly illegal so security is of paramount importance. You are required to submit a simulation of their network model in Packet Tracer™. This simulation will be used as part of your application to get the contract for the installation.

The needs of MoneyManage are as follows:

The MoneyManage Dublin office will be split into four departments.

1. Cheques
Employees: 43

2. Bank Drafts
Employees: 90

3. Credit Cards
Employees:146

4. Cash
Employees:11

The employees will be physically adjacent in some cases on the office floor, but logically they must be separated.

Calculate the addresses needed for the departments from 172.16.0.0 / 16.

The departments, although separated for security reasons, will need to be able to communicate to share resources. This must be included in the configuration.

Test connectivity between networks. All pings should be successful.

Advanced Configuration

- The employees of CreditCard and BankDraft need access to a remote server called TravellersCheques with an IP address 220.15.15.200/28 . The other two departments must not be able to contact this server.

8.4. Appendix IV - Information Sheet

There is a belief that the more information a student has, the better his learning experience will be and the more information he will retain for future recall and reuse. Students today are presented with large amounts of rich thick content in many multimedia formats. It is believed that by presenting students with this thick data in a variety of formats, which should appeal to individual learning styles, their learning experience will be optimised. However, sometimes an over-abundance of information related to one specific topic can cause cognitive overload.

Using the Cisco Network Academy Curriculum, a rich thick form of content is available, comprising of online course notes, books, animations and hands-on laboratory exercises which can be completed on Packet Tracer™, a network simulator provided by Cisco. However, the availability and usability of this rich media can obliterate the need for students to engage in high order thinking and problem-solving activities, as the overly-scaffolded exercises result in students merely typing in the appropriate commands. This is referred to as surface learning with the students putting minimal effort in to complete the task. This results in students not using their high order thinking skills and not formulating the necessary cognitive linkages to allow new knowledge be constructed.

Socrates believed that the purpose of teaching was not the provision of information but through questioning and active dialogue, students would develop their knowledge from within. The role of the instructor is that of facilitator and rather than imparting information by direct instruction, questions are asked to prompt and guide student thinking. Using Socratic questioning should allow the student the opportunity to exercise critical thinking of their own prior knowledge.

This research proposes to investigate ways in which a Socratic led teaching and learning strategy, using problem based learning, can improve the effectiveness of the CCNA networking curriculum by requiring the students to engage in more high order thinking processes.

It is proposed to introduce four problem-based activities to the CCNA class at various times over the next three months to allow students the opportunity to use their high order thinking skills. These activities will take the form of binary/decimal conversion arithmetic, IP addressing problems, network topology problems and troubleshooting activities. These activities will be conducted in a variety of sessions including individual activities, activities with groups of three to four students and activities which involve the class group as a whole. Packet Tracer™ will be used for the problem based networking activities.

In order to draw conclusions from this research, data needs to be collected and analysed. A variety of data collection instruments will be used comprising of questionnaires, open forums with students and one audio/video recording of one of the activities.

The participation in these activities is completely voluntary and students can withdraw at any stage if they so wish, as well as omitting answering questions from the questionnaire if so desired. Anonymity and full confidentiality is guaranteed to all participants in the analysis, publication and presentation of the resulting data and findings. Audio/video output will not be made public but will be used to form generalisations which will in turn inform the research. However, in the extremely unlikely event that illicit activity is reported to me or recorded during any activity I will be obliged to report it to appropriate authorities.

If a student wishes to opt out at any stage, any data collected in which he/she has partaken will be edited to exclude their participation and contribution. Also, for a student who chooses to opt out of the research, arrangements will be made in the class for the student to attend the session but be excluded from the research. On completion of the research, findings will be presented back to the participating students and debriefing sessions will be available for any student who wishes to avail of them.

Bernadette Garry

8.5. Appendix V – Request for Permission Form

To Whom It May Concern:

Thank you for participating in this study. This study is for part assessment for the Masters in Technology and Learning in Trinity College. This research proposes to investigate ways in which a Socratic led teaching and learning strategy, using problem based learning, can improve the effectiveness of the CCNA networking curriculum by requiring the students to engage in more high order thinking processes.

Anonymity and full confidentiality is guaranteed to all participants in the analysis, publication and presentation of the resulting data and findings. None of the recordings, i.e. audio or video will be identifiable or made public unless prior written permission has been given to do so. The purpose of the research is to collect and assess the necessary output from the problem based activities to investigate whether high order thinking skills have been used. Please do not name third parties in any open text field of the questionnaire. Any such replies will be anonymised. Please sign below giving your consent to partake in these activities and also to allow these activities to be observed.

Student Agreement

I confirm that I am 18 years or older and competent to supply consent. I understand that partaking in this exercise is completely voluntary and I can opt out or terminate it at any time. I understand that the data is being collected for research purposes and I give my permission to use any data collected for these purposes. I also give my permission for my participation in these activities to be observed for the purpose of data collection. I agree that my data is used for scientific purposes and I have no objection that my data is published in scientific publications in a way that does not reveal my identity. I understand that if I or anyone in my family has a history of epilepsy then I am proceeding at my own risk.

Student Signature: ________________________________

Researcher Signature: ________________________________

Researcher Contact Details: bernadettegarry@eircom.net

8.6. Appendix VI – Observation Protocol Form

Date: **Time:**

Activity: **Setting:**

Group: **Duration:**

Observed by:

Time:	Description	Reflective Notes

8.7. Appendix VII – Sample Questionnaire

Questionnaire for Activity 4

1. Did you enjoy today's class? Indicate your level of enjoyment.

- ☐ Completely enjoyed
- ☐ Mostly enjoyed
- ☐ Somewhat enjoyed
- ☐ Neither enjoyed nor did not enjoy
- ☐ Somewhat did not enjoy
- ☐ Mostly did not enjoy
- ☐ Completely did not enjoy

2. Why or why not was it more or less enjoyable than other classes you have had?

____

____

____

3. Did you feel that having this problem to solve engaged you more, increased your interest and required you to concentrate more than you normally would in class? Indicate your level of interest.

- ☐ Completely interested
- ☐ Mostly interested
- ☐ Somewhat interested
- ☐ Neither interested nor disinterested
- ☐ Somewhat disinterested
- ☐ Mostly disinterested
- ☐ Completely disinterested

4. Why do you think the problem increased/decreased your interest?

____

____

____

____

5. What value do you think presenting a problem-based scenario, which required you to use the knowledge which you have acquired so far, brought to your learning experience? Indicate the value of this problem-based scenario.

☐ Completely valuable
☐ Mostly valuable
☐ Somewhat valuable
☐ Neither valuable nor has no value
☐ Somewhat has no value
☐ Mostly has no value
☐ Completely has no value

6. Explain the value or lack of value that the problem-based scenario gave to you?

____

____

____

____

7. Did having to solve a problem force you to use different skills than if you were receiving direct instruction on how to solve the problem? Indicate the degree of difference in skills used to solve the problem.

☐ Completely used different skills
☐ Mostly used different skills
☐ Somewhat used different skills
☐ Neither used different skills nor did not use different skills
☐ Somewhat did not use different skills
☐ Mostly did not use different skills
☐ Completely did not use different skills

8. If you used different skills, explain what they were?

____

____

____

____

____

9. Tick all that apply. Did you find the problem to be:

- ☐ Interesting
- ☐ Relevant
- ☐ Meaningful
- ☐ Engaging
- ☐ Ill-defined

10. How important is the **content** of the problem scenario in helping you to build knowledge and engage your interest?

____

____

____

____

11. Do you think a problem-solving scenario like this gives you the opportunity to build knowledge? Indicate the degree in which a problem-solving scenario helps you in knowledge construction.

- ☐ Completely helps in knowledge construction
- ☐ Mostly helps in knowledge construction
- ☐ Somewhat helps in knowledge construction
- ☐ Neither helps nor does not help in knowledge construction
- ☐ Somewhat does not help in knowledge construction
- ☐ Mostly does not help in knowledge construction
- ☐ Completely does not help in knowledge construction

12. Why or why not would the problem-based scenario help in knowledge construction?

____

____

____

13. Do you think a problem-solving scenario like this will help you to retain the knowledge you have, better and for longer? Indicate the degree of retention of knowledge from this problem-solving scenario.

- ☐ Completely helps in knowledge retention
- ☐ Mostly helps in knowledge retention
- ☐ Somewhat helps in knowledge retention
- ☐ Neither helps nor does not help in retention
- ☐ Somewhat does not help in knowledge retention
- ☐ Mostly does not help in knowledge retention
- ☐ Completely does not help in knowledge retention

14. Why or why not will the problem-based scenario aid knowledge retention?

____

____

____

____

15. Do you think that you were more active today than you usually are? Indicate your level of activity.

- ☐ Completely more active
- ☐ Mostly more active
- ☐ Somewhat more active
- ☐ Neither more active nor not more active
- ☐ Somewhat not more active
- ☐ Mostly not more active
- ☐ Completely not more active

16. If you were more active, what benefit do you get from being more active?

____

____

____

____

17. Do you think being active helps you to concentrate more and learn better rather than just passively listening?

- ☐ Completely agree that activity enhances learning
- ☐ Mostly agree that activity enhances learning
- ☐ Somewhat agree that activity enhances learning
- ☐ Neither agree nor disagree that activity enhances learning
- ☐ Somewhat disagree that activity enhances learning
- ☐ Mostly disagree that activity enhances learning
- ☐ Completely disagree that activity enhances learning

18. Why do you think that is?

____

____

____

____

19. Did you find working in a small group beneficial? Did one person do all the work or did everyone participate and contribute equally?

- ☐ Completely agree that group work is beneficial
- ☐ Mostly agree that group work is beneficial
- ☐ Somewhat agree that group work is beneficial
- ☐ Neither agree nor disagree that group work is beneficial
- ☐ Somewhat disagree that group work is beneficial
- ☐ Mostly disagree that group work is beneficial
- ☐ Completely disagree group work is beneficial

20. Explain your experience of working in a group.

____

____

____

____

21. Do you think you would have learnt more doing this exercise individually?

- ☐ Completely would have learnt more doing it individually
- ☐ Mostly would have learnt more doing it individually
- ☐ Somewhat would have learnt more doing it individually
- ☐ Neither would have learnt more doing it individually or in a group
- ☐ Somewhat would have learnt more doing it in a group
- ☐ Mostly would have learnt more doing it in a group
- ☐ Completely would have learnt more doing it in a group

22. Explain your answer.

____

____

____

____

23. How did you feel about not having your questions directly answered by the facilitator? Was this frustrating or did you feel you had to think more for yourself?

- ☐ Completely made me think more for myself
- ☐ Mostly made me think more for myself
- ☐ Somewhat made me think more for myself
- ☐ Neither made me think more for myself nor did not
- ☐ Somewhat frustrated and would have preferred a straight answer
- ☐ Mostly frustrated and would have preferred a straight answer
- ☐ Completely frustrated and would have preferred a straight answer

24. Explain your preference.

____

____

____

____

25. Does the way the network simulator, i.e. Packet Tracer™ responds to your actions, help you deepen your understanding of networking concepts by allowing you to explore alternative solutions on Packet Tracer™ and backtrack if they are not working?

- ☐ Packet Tracer™ completely helped deepen my understanding
- ☐ Packet Tracer™ mostly helped deepen my understanding
- ☐ Packet Tracer™ somewhat helped deepen my understanding
- ☐ Neither helped nor did not help deepen my understanding
- ☐ Packet Tracer™ somewhat did not help deepen my understanding
- ☐ Packet Tracer™ mostly did not help deepen my understanding
- ☐ Packet Tracer™ made no difference to my understanding

26. Explain your answer.

____

____

____

____

____

27. Do you think that using Packet Tracer™ helped you to visualise this particular networking process, i.e. inter-VLAN routing, in a more tangible manner?

- ☐ Packet Tracer™ completely helped in the visualisation process
- ☐ Packet Tracer™ mostly helped in the visualisation process
- ☐ Packet Tracer™ somewhat helped in the visualisation process
- ☐ Neither helped nor did not help in the visualisation process
- ☐ Packet Tracer™ somewhat did not help in the visualisation process
- ☐ Packet Tracer™ mostly did not help in the visualisation of process
- ☐ Packet Tracer™ made no difference in the visualisation of process

28. How does this visualisation help in your understanding of this topic?

____

____

____

29. Did you find it beneficial that Packet Tracer™ could give you feedback if the devices could not communicate each other?

- ☐ Completely beneficial
- ☐ Mostly beneficial
- ☐ Somewhat beneficial
- ☐ Is neither beneficial nor not beneficial
- ☐ Somewhat of no benefit
- ☐ Mostly of no benefit
- ☐ Completely of no benefit

30. How did you find this feedback beneficial?

____

____

____

____

31. Did you solve the problem – could all devices communicate with each other?

- ☐ All devices could communicate with each other
- ☐ Some of the devices could communicate with each other
- ☐ None of the devices could communicate with each other

32. Could you apply your prior knowledge to solve this unseen problem?

____

____

____

____

33. If you did not solve the problem, what factors impeded your success?

____

____

____

____

34. If you did not solve the problem, what could have helped you to solve this problem?

____

____

____

____

35. Have you anything else in general to say on this learning experience?

____

____

____

____

8.8. Appendix VIII – CCNA Instructors Questionnaire

Name of College: ____

Course Content and Delivery

Number of hours dedicated to CCNA per week: ____________

Of these hours, how many are:

Theory: ____________

Practical: ____________

What mode of instruction is used for delivering the theoretical part of the curriculum and why e.g. lecture, tutorial etc.?

____

____

____

Do you request your students to pre-read the chapter, prior to your lecture on it? Please tick one of the boxes below.

Always	**Frequently**	**Sometimes**	**Never**
☐	☐	☐	☐

Please state the reasons for your answer: ______________________________

____

____

Labs

Are all three labs completed for each chapter? Please tick one of the boxes below.

Always	**Frequently**	**Sometimes**	**Never**
☐	☐	☐	☐

Please state the reasons for your answer: ______________________________

____

Are the labs done individually or in groups: Groups ☐ Individually ☐

If they are done in **Groups**, please state your reasons why:

____

____

____

____

To complete the labs, do you use:

Packet Tracer™ ☐ Physical Equipment ☐ Combination ☐

Please state your reasons for the chosen resource(s):

____

____

____

____

Do you find some students simply transcribe the commands directly from the chapter lab sheet, rather than attempting to understand the reasons for a particular configuration command? Please tick one of the boxes below.

Always	**Frequently**	**Sometimes**	**Never**
☐	☐	☐	☐

For the second chapter lab which omits instructions, do you find some students search for the required configuration commands from other sources or do they simply copy the commands from the first lab sheet? Please tick one of the boxes below.

Always	**Frequently**	**Sometimes**	**Never**
☐	☐	☐	☐

On a sliding scale, rate the level of learning which you think the students are engaging in?

Deep Learning		→		**Surface Learning**
1	2	3	4	5
☐	☐	☐	☐	☐

Are there any alternative methods you use, to ensure students are deeply understanding the concepts and not just engaging in surface learning?

____

____

____

____

Assessment

Do the students do chapter exams every week? Please tick one of the boxes below.

Always	**Frequently**	**Sometimes**	**Never**
☐	☐	☐	☐

Please state the reasons for your answer: ______________________

____

____

____

What weightings do you apply to?

Chapter Exams: ____________________

Skills Demonstration: ____________________

Final Theory Exam: ____________________

Do you think the students' main concern is the chapter exams rather than deeply understanding the underlying concepts? Please tick one of the boxes below.

Always	**Frequently**	**Sometimes**	**Never**
☐	☐	☐	☐

Please state the reasons for your answer: ____________________________________

____

____

____

Is there any part of the CCNA curriculum of which you would be critical e.g. labs, assessment etc.

____

____

____

____

____

Instructor Feedback

Are you aware that the Cisco Academy receives feedback on the quality of the instructor through monitoring the student scores in each class to highlight classes where a high percentage of students earn low scores?

Yes ☐ No ☐

Do you agree with this instructor assessment strategy and why:

____

____

____

____

____

____

____

Students also complete an online survey at the end of each semester, which asks them for ratings on the instructor, the curriculum and the course assignments. Are you aware that instructors can learn about their performance by accessing online, the average rating their students have given them?

Yes ☐ No ☐

Do you think that these instructor assessment strategies undertaken by the Cisco Academy might influence the way instructors assess the practical skills demonstration, by inflating student scores so that this might reflect better on them as an instructor?

____

____

____

____

____

____

8.9. Appendix IX –Interview Transcript with Codes & Themes

Transcription of Interview from Activity 4 – Inter-VLAN Routing

CODES	DIALOGUE	THEMES
	R: Okay, so what did you think genuinely, this has to be honest because if it is not honest, it is pointless, alright? So what did you think of the session?	
	P3: Much better idea than the way we do labs.	
	P1: Yes, I found that.	
	R: **Much better idea, why? What was the difference with it?**	
Spoon-Fed	P3: You are not being 'spoon-fed'.	Independent Learning
Considering impact of one action on other elements	P1: Yes, made me think about, when I was configuring one part of the switch I was thinking of how it overlaps with other technologies that are on it and normally I am just following what is on the screen	Active Learning
	P4: Or on the page	
Trying to work things out for yourself	P2: You are not just reading lines one by one and going through a set motion, you are actually working things out for yourself, trying to see what is happening down the line.	Active Learning; Independent Learning
Real-life View – collaborating in a group	P5: It gives you a view into real life, in real life if you are in a work situation the amount of times you have to work in a group and different people have different ideas like how to accomplish the task and sometimes by doing things like this, you see that *P2* starts by doing this with the task like and maybe I should be doing that instead of doing a set list like.	Collaboration ; Real World Context
	R: Yes, absolutely.	
Sharing ideas	P4: Picking each others brains for ideas like.	Collaboration
	R: Absolutely, yes!	
	R: So when you say you prefer doing it than kind of doing the labs and being 'spoon-fed', what difference does it make to you though, like why did you prefer doing it like that?	
Passive Learning Spoon-Fed	P3: When we are doing a lab on inter-VLAN routing all routing configurations are done for you except the inter-VLAN routing and then it tells you what to do so you are not learning, you are just going to read it off the screen and you could be thinking of something else.	Independent Learning; Active Learning
	R: So did you think this makes you think more?	

Passive Learning; Spoon-Fed	P2: Yeah we find out if you are forgetting something or where you are going wrong because you like will see it in front of you rather than like if you are just reading a list of instructions then you can't go wrong because it just means you missed a step somewhere if you did.	Independent Learning; Active Learning
Learning from Mistakes	P1: Yeah, by making a mistake I found like I made a mistake there and I wont forget that, it has clicked now.	Active Learning; Knowledge Construction
Looking for 100% completion Follow steps – Passive Learning Spoon-Fed	P5: Sometimes on Packet Tracer™ you are looking at like what score I am at like and if it is 100% you go - the task is done, that's it like. Maybe you might take stuff away from that. Like *P3* was saying earlier on, with a task like this, you start from the start then follow certain steps like, you don't just have a lab like and all you have to do is follow certain steps like	Active Learning; Independent Learning
Not thinking about what you are doing Reading off screen - Passive Learning	P6: You are not thinking about what you are doing. You are just reading off the screen, you are putting a command in; you are not thinking what the command is doing	Active Learning; Knowledge Construction
	R: But you know the second lab that you do, it doesn't give you all the commands	
	P4: That is the challenge lab.	
	R: Well there are kind of three usually.	
	P4: They give you the basic challenge. They give you the 'Show Run'	
	R: The second one is kind of the first one without the commands to tell you what to do, do you not find this is the same type of thing?	
	P2: They more or less have the same type of commands.	
Show you commands used - Passive Learning Spoon-Fed	P4: They give you the output of the switches like say the 'Show Run', they show you the commands that were configured so then if you look at it you can just go, oh that is I all I have to do. Basically you are looking at the bottom corner waiting for it to go 100%.	Active Learning; Independent Learning
	R: And then you are done?	
Satisfaction Challenging	P4: And once you hit 100% you are done, whereas if you were doing something where there is no tick the box you are just giving the scenario, you are going to finish it right down to the tee like until you are satisfied yourself	Active Learning Personal Gain; Independent Learning;

Self assessment of knowledge	P1: You are going to get to the end and then you like will be thinking back, did I do everything. That's what I find. Instead of just being told oh Congratulations it is like I am done, now is everything ok with it.	Active Learning; Personal Gain; Independent Learning;
Gives you task step-by-step – passive learning Spoon-Fed	P3: Even the second lab that doesn't give you the instructions, it still gives you the task step-by-step	Active Learning; Independent Learning
	R: It does yes, it breaks it down	
Spoon-Fed Tells you what to do	P2: And it still tells you what ports you have to use and what addresses you have to use rather that you having to work it out again for yourself.	Active Learning; Independent Learning
	R: Do you think a problem like this helps you to recall back basically what you have done before? Do you know what I mean? Did you have to think about stuff you covered…..?	
Encompasses prior knowledge	P5: It helps with the eh….you are reading a book…. the book we are on now like there is Chapters 1 to 7 like and a task like this everything works together like	Knowledge recall
	R: Right. Great.	
Encompasses prior knowledge	P5: So you are basically restudying stuff from two or three chapters before like	Knowledge recall
Referring back to theory covered	P1: Yes, I found, instead of just focussing on this chapter, like I was kind of going back to Chapter 1.	Active Learning; Knowledge recall
Encompasses prior knowledge	P6: This lab helps you go through old stuff. You had to look at the design before you could write anything, obviously Chapter 1 the design	Active Learning; Knowledge recall
	R: Ok. So it expected you to go back and think of all the things you have learnt so far. It sort of brought it all together	
Spoon-Fed	P1: Without telling you you had to do that	Independent Learning;
	R: Ok. The interesting thing was that only your group <indicating a specific group> were the only group who had their books out. Did none of the rest of you feel you needed to open up a book?	
	P4: No.	
	R: You didn't need to or ….	

Group Discussion	P5: No, because like by talking to the four people in the group, everyone started with a certain….	Collaboration
	R: But for the configuration even, the commands themselves……	
	P3: No. Probably would have needed the book after a while maybe	
	R: So you just didn't get to that point. But *you* did (pointing to a specific group)	
	P5: I thought our group didn't need it	
Thinking about and working out Refer to book	P1: Yes, like I was working out kind of, I was thinking about adding how many switches and then I was thinking about working out the throughput and then I had to go to the book to figure out that part of it	Active Learning; Independent learning
	R: Yeah! Would you ever have to do that when you are doing the Cisco labs? Would you ever have to open up the book?	
Spoon-Fed Following what is on screen – Passive Learning	P1: I wouldn't think about going back to the book cos I would just be following what is on the screen.	Active Learning; Independent learning
	R: So basically, it made you make more of an effort, to find something that was going to help you with the solution	
	P1: Yeah	
	R: Would the rest of you done that?	
	P4: If we really needed to, yeah.	
	P2: If you didn't know something, yeah.	
	R: But you wouldn't have had to do that using the Cisco labs?	
Spoon-Fed	P2: No, you don't have to do it.	Active Learning; Independent Learning
	R: It is all there in front of you. No it is good; I was delighted to see that you did, because that is the whole purpose of it, to force you to try and source this stuff. Ok where will I get the answer to this question? So rather than sitting there and not doing anything, it is good that you actually decided lets open up the book or the curriculum and find something from there. So that was really good! Ok so what else have I got?	

	R: Yeah, did you use different resources than you would use if you were using the Cisco labs, did you find? Do you know what I mean, the fact that you did have to use the book? What about working with each other, like did you find that you kind of tapped into each others brains?	
Group Discussion	P5: I think that's what you were saying with P1, he used the book like. But with our group we all discussed it before.	Collaboration
	R: They did too actually.	
	P5: I am not saying that they didn't.	
	P2: We didn't use the curriculum at all.	
	R: You didn't need to use it.	
	P2: We had it open but ….	
	R: Ok, you didn't have to refer back to it	
Discussion about process	P5: We all gave each other a certain time, what do you think of the problem, what steps should we take and wrote them down and then we broke into two groups like.	Active Learning; Collaboration
	R: What about doing it as an individual and doing it as a group. Now I know obviously there were issues over here <pointing to a specific group> with it.	
	P4: (member of squabbling group). No but the only thing is…….	
	R: No genuinely be honest.	
Real World Scenario Group Conflict	P4: The only thing is, we did have issues yeah, in our group like in the way that some of us prefer to do things differently than others but at the end of the day like, I think it was better that that happened in this group because it gave us a chance to see like say a real world scenario like where these issues probably would come up between network administrators	Real World Context; Collaboration
	R: But did you think you approached it right like you know.	
	P4: I think we did because in the end we all came	
	R: But P7 (student who wanted to work as group) didn't think you did.	
	P4: No, this is at the start.	
	R: Oh well I am talking about at the start, genuinely, these two groups kind of worked together on paper and thought about a process, like you guys decided to separate and P7 didn't really want you to do that.	
	P4: Well not separate in a way.	
	R: Well you did, you three of you worked individually	
	P3 (strongest member of squabbling group): We had three separate ideas of how it should be done	

	R: But could you not have kind of worked together	
Conflict in group	P3: We could have spent an hour arguing about over a piece of paper with scribbly drawings	Collaboration
	P4: Yeah!	
	R: You see you could not see it as an argument it is kind of constructive discussion over what is the best solution, if it is group work	
Individual Solution	P3: I know but the three of us did three different designs on paper, rubbed things out and all, it is not looking right. The three of us spent ten minutes just a quick illustration of what it looks like on screen and then you can say, that looks better, that looks better, that looks better	Collaboration
	P4: Exactly and we chose…..	
	R: It is not really how group work should work	
No perception of benefit in group work	P3: In a group, everyone is not going to do the same job	Collaboration
	R: No but P3, do you not see, you are a group member, you need to work together, collaborate together, discuss things together, as opposed to, it is a bit of a cop out, ok you do your own thing and we will come together at the end and see what came up.	
	P3: No, I don't think it was!	
	P4: No, not really, no.	
	R: You are saying there P3, that you prefer working on your own. Do you not see the benefit of working with a group ever no? Genuinely?	
Preference for individual work	P3: I do yeah, but what I mean that this one, there wasn't just working individually. It wasn't saying to work individually. I was just saying for a minute, until we get each other, because we were arguing over the ideas, put a switch here, put a switch there and the piece of paper was starting to look like a child's scribbles after five minutes.	Collaboration
	P8 (student from other group): I think you need to be able to choose to be in a group or individual	
	R: Well I suppose, the whole idea………..	
	P8: Some people want individual work	

	R: Oh that's fine, well I think it's funny like and *P3* I am being honest here, you know what I mean, you are so good at this kind of stuff, you can help other people with your knowledge and that is one of the benefits of group work, its to kind of help, do you know what I mean, and it also helps you to thrash out in your mind what you are doing. You know, I understand what you are saying that some people do prefer to work individually but in terms of learning, group work is fantastic for learning, for all people involved in the group, genuinely. I don't know how you feel about that, whether you would all agree or not. I know *P3* doesn't agree, *P7* obviously does agree and thinks group work is beneficial.	
Preference for individual work	P3: I don't completely disagree; I agree, you don't have to always work everybody together as a group to work as a group, you can also work at different tasks	Collaboration
	R: But this is the one time I asked you to work as a group. Genuinely, do you know what I mean, this isn't something I do with you every single week, like this is a once off kind of a thing.	
	P4: I know where *P3* is coming from though. We just drew a rough sketch each and brought them in together and then discussed our rough sketches like as a group and then came up with an idea of which one we were going to use like	
	R: What did the rest of you think about that? You approached it differently!	
Group Work – Assignment of roles	P1: Yeah, we started off with the subnetting and *P9* was doing it and I thought we should bring in like scaleability into it so, I decided to start doing the subnetting again, introducing scaleability and while I was doing that *P6* and *P9* were working on other parts of the project. But they went back to mine and just double checked it to make sure it was ok.	Active Learning; Collaboration
	R: What you had done, ok. You basically did separate tasks. You guys did the same didn't you, you agreed to do separate tasks but working on the overall thing together.	
Group Work - Assignment of roles	P5: It was after us discussing what we were going to do. We set each other different tasks.	Collaboration
	R: Ok, so you agreed first of all.	
	P5: It wasn't the case that one person was in charge, the four people were in charge. We said right youse are designing that, we are going to do the IP addressing.	
	R: Perfect, great.	

	P5: When we were both finished, we came together	
Group Work – Assignment of Roles	P2: We set out as a four to see what we needed to do and then split that in two, two people do one thing and two people do the other thing	Collaboration
	R: What are you saying?	
	P3: That's what we done; it was just that we designed…….	
	R: Ah but you guys separated out P3.	
Reluctance to work together	P3: Because we can't put three computers beside each other	Collaboration
	R: But you should have worked on one computer. That was the other interesting thing, these all worked on one PC (pointing to other two groups)	
	P3: But we did after we had designed it out. That's what we wanted to do, we just wanted to get a design in our head	
	R: It should have been done on paper though!	
	P3: You should have seen the paper; it was like a child got a marker…	
	All P: <laughter>	
	R: Anyway it is just a different approach. Would you like that to be the way you always do the practical work of CCNA? Obviously not P3 but it doesn't mean that you couldn't individually <laughter> no but genuinely I have done it with individuals.	
Real Life Spoon-Fed	P5: I think the overall thing that is coming out of it even if you are working individually or as a group is that it is better not being 'spoon-fed'. If you are given a task and say get that done and get it done it is more like real-life.	Real World Context; Independent Learning
	R: Yes	
Spoon-Fed Passive Learning Learn from mistakes/ lack of progress to solution	P5: It is like school – just well done you got that done. But you are after being given the answers. You are better off just, there is your task, get that finished. And if there is a problem area, then that is what you need to brush up on.	Active Learning; Independent Learning; Knowledge Construction
	R: Do you think you enjoyed the class more than you would if it was just doing the labs?	
	P2: Yep.	
	P5: Yes.	

Seeing where you are going wrong Learn from mistakes	P2: It doesn't matter whether you are working as a group or individually, you have a better grasp of what you are doing and learning from what you are doing and you are seeing what bits you are going wrong in. It doesn't matter whether it is a group or individual.	Active Learning; Knowledge Construction
	R: It doesn't, because you could have done the same thing as an individual, each of you could have done this	
Spoon-Fed	P2: It is just as *P5* said, not being 'spoon-fed', line by line, what you are going to be doing	Active Learning
	R: So do you think that will make you remember it more? Do you think you will have learnt more as a result of doing it like that?	
	P2: Yeah, I think so.	
Made me think more	P1: It made me think a lot more.	Active Learning
	R: Okay.	
	P5: It gives you the sense of the design of it; it gives you the sense of……	
	R: What about Packet Tracer™. How important do you think that was in helping you? Say for example if we did not have a network simulator? If you didn't have any technology in doing this?	
Get to see a problem or the way the packets go through the devices Can manipulate the path	P4: Packet Tracer™ helps a lot because you get to see, you know, if there is a problem and you get to see the way that the packets go through all the devices likes for inter-VLAN routing. You get to see where it is going or even which path that it's taken along the network like and if you want to manipulate the path to see if it is actually working or not for you and all that stuff. So Packet Tracer™ is good in that sense but it can be tempermental sometimes you know, cutting out on you…	Visualisation
	R: I know that. But if you look at your topologies, most of you had at least fifteen switches. Impossible to do that on physical equipment!	
	P4: Of course yeah!	
	R: Never, particularly for an individual, you just never could do it!	
Lot of repetition	P1: That was one thing I found kind of that I didn't really like about the lab, there was just a lot of repetition.	Content of problem

	R: Yeah! I don't think <Instructor Name> meant you to go to the extent that you did – a port per person. He said that in hindsight he probably should have kind of just; you know, designed a subnet and basically just had one port for say fifty people. He didn't really want it to go to that level, that's why we kind of stopped it because you know what I mean; you weren't going to get any more out of it. Once you had configured one switch, the rest of them were going to be all the same anyway.	
	P1: Yeah!	
	R: But he didn't want it to be too cut and dried either which was good like because did you find it was open enough for you to interpret it whatever way you wanted.	
	P4: Yeah!	
	P1: Yeah!	
	R: So it wasn't a very defined problem – this is what you need to do to solve it! And he had the actual ACL (Access Control List) at the end as well, if anybody finished it. So there was lots of complexity built into it which was hopefully trying to appeal to everybody's level, if you like, which is important as well.	
Context for knowledge acquired to date	P5: It is just the bringing it all, as I said before, together - the books, the chapters and all, you actually see a network working properly then. Instead of seeing individual chapters	Knowledge Recall and Retention; Visualisation
	R: But do you not do that, do you not find that the labs make you do that, you know, build in all the previous chapters?	
Spoon-Fed	P5: No but an awful lot of the labs, I think P3 mentioned before, when P3 said an awful lot of when they go from 2 to 3 to 4 like when you go to do a certain lab like, it already has that configuration done and uses…	Active Learning; Independent Learning
	R: Oh I know what you are saying. So basically you are building on what this chapter is providing	
	P1: And you don't touch on that again until the final chapter	
	R: So this made you go back to Chapter 1 and use what you learnt in Chapter 1 and bring it all the way up to Chapter 6.	
Problem with retention	P1: Yeah, cos a lot of the time you get to the end of the book and you can't remember what chapters were what numbers.	Knowledge Recall and Retention
	R: I know, I know. So would it be safe to say you all did enjoy it more?	
	P1: Yeah!	

	P2: Yeah!	
	R: Did you think it forced you to be more active instead of just sitting there and typing?	
	P2: Yeah!	
	P1: Definitely!	
	P5: Yeah!	
	R: And do you think that is a good thing?	
	P1: Yeah!	
	R: Anybody anything else to say?	
	P7: I was thinking I never use Packet Tracer™. I go through the labs and do everything myself. I think it does the same thing.	
	R: Do you not find what the guys were saying that it does tell you too much information?	
	P7: This book tells us exactly what you should do	
	R: But do you not find this <activity> makes you think a little bit more, by basing it on a problem?	
Time constraint with Curriculum	P7: Oh yes, this type of lab yes.But I think as well the Cisco labs. Always they are very active. Every chapter, something new, you don't have time to do something else.	Content of Problem
	R: Say for example, we stopped doing the labs and we just introduced a problem that covers all of the labs and covers all of….. I mean you could have completed that lab in three hours that would have brought in all of the stuff on inter-VLAN routing plus all of the other five chapters instead of just zoning in on Chapter 6, the configurations.	
	P7: No, no, that is perfect, good. What I am saying like is nowadays we have every Friday one exam, one week for one chapter, so sometimes we just have time for normal labs. Do you understand?	
	R: Yes, I know what you are saying.Activity can be…. just because you are sitting at the computer typing in commands from the lab doesn't mean you are really active, it just means you are typing	
	P7: No, no, most of the time you are talking about the chapter	
	R: I just mean more active in terms of you have to think more, you have to go looking for material, you basically have to be more involved	
	P7: Most of the time I print the lab and do it by myself	

	R: Anybody anything else to say. I think I have asked all the questions. The other thing I noticed actually, sorry, what was really interesting, the way you used Packet Tracer™ to look at the actual configurations of the switches and the router. Have you ever done that before? Do you know what I mean, so you needed a switch with a particular number of ports and you actually used Packet Tracer™ itself to see, okay, if I use this switch I am going to get that, if I use this switch…... Normally again the Cisco labs tell you use this particular switch.	
Made us think	P1: Oh yeah! That made us think like kind of for the core switches and the distribution	Active Learning
	R: To understand the different switches and what they had. So 2960 will give you this, 2940 will give you that. Did you ever use that before, Packet Tracer™ for that reason, did you ever have to?	
	P1: Maybe, only for assignments.	
	P2: Only myself, when you are going through assignments, we normally just use like the one that they mention in the curriculum – the Catalyst 2900 or 2690.	
	R: That's it, yeah! But this time you were actually looking on Packet Tracer™ to see which switch is going to match, which was new, like I had never seen you do that.	
	R: But the fact that you actually had to go looking to see which of the switches is going to help you as opposed to, as P2 said, Cisco telling you use the 2900. Now you know a little bit more about the models.	
	P5: I think this project that you gave us this morning was a bit like, <Instructor name> gave us out a case study as well to do like, involved this just a set of lists and he is not giving us much info, he is telling us to come up and ask him questions on it like. It's just as you say, he is not 'spoon-feeding' us like.	
	R: Okay	
Encompassing Prior Knowledge	P5: And it is combining the routing protocols with like the LAN configurations on the switches as well like.	Knowledge Recall
	R: Great! Good! Did you find it difficult that we weren't answering your questions directly? Did you find that frustrating or were you alright on your own.	
	P4: No.	
	P2: No I prefer that.	
	R: You prefer that! Why?	

Spoon-Fed	P2: I don't like being 'spoon-fed' answers; I want to find out for meself why, if I am not sure about something, I will go back and read up on it, rather than just have someone tell you well that's it, and then you will probably forget it the next time anyway.	Active Learning; Independent Learning
	R: So it helps you remember by……	
Challenge	P2: You want to go back and figure it out	Active Learning
Need Knowledge Already	P4: But if you are given something that you don't know……	Negative of Socratic Method
	R: Oh well of course, but that wouldn't be fair because you couldn't be expected to.	
	P4: That would be frustrating!	
	R: Ah yeah! But that's the point, as long as you cover the material.	
Spoon-Fed	P4: If you've covered it then, you don't want to be 'spoon-fed', cos you know it.	Active Learning
Surface Learning	P1: That's something I found. Sometimes I wouldn't do much reading at the start of the week, we'd come in and do one of the Packet Tracer™ labs and I'd fly through it, but em, just because I am doing what is to be done. But em like, if I didn't read the Chapter much and I was to do this, I'd have to go back and read. It forces me to…..	Active Learning
	R: Ok, so it forces you basically to have covered the material first.	
Surface Learning	P5: Sometimes you can do a Packet Tracer™ and say that's me study done. Like grand!	Active Learning
	R: Yeah!	
	P1: But you don't know what's going on.	
	P2: You haven't read it yeah!	
	P5: You haven't read it really like.	
	R: Sure! Anybody anything else?	
	P4: There is one more thing about the challenge labs and all that stuff like you know the labs in Cisco?	
	R: Yeah!	
Worry about not completing labs	P4: Well most of the time they introduce new, em, new commands when you are doing the challenge lab or even just the basic or whatever, there's new commands which you don't actually have. They don't actually tell you about them in the curriculum and they could bring them up during exams and stuff like that so that's kind of where they would be very useful to keep them as well	Content of Problem
	R: But do you always do the challenge labs?	

	P4: Yeah, nearly all the time for the chapters like, cos it helps a lot more. Troubleshooting as well is pretty good. Yeah, but if you incorporate like you know you could nearly do that stuff at home, you know and em, come in here and then it would be better, more practical for to give us a challenge like you know like do this and we can collaborate with each other as well like you know.	
	R: Yeah! So you did find it a useful way of doing the practical side of the curriculum? Did you, all of you? Is that fair to say**, or is that too general a statement to make? Is there anybody that didn't and would prefer to do the Cisco labs the way they currently are?**	
	P1: No	
	P5: Prefer that!	
	P6: More beneficial in the long run!	
	R: Okay, great, good. Guys, thanks a million. I know it has been a long morning. Thanks a million, I really appreciate what you did today and filling out the questionnaires – I know they are a bit laborious and talking on the machine and all the rest. So, thanks a lot and sure we might do it again, we will see in January, we might do it again, okay? We will see how it goes.	