

**Using Low Interactive Animated Pedagogical Agents in Online Learning:  
An Exploratory Study of Singaporean Pre-Service Teacher Preparation**

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# **USING LOW INTERACTIVE ANIMATED PEDAGOGICAL AGENTS IN ONLINE LEARNING: AN EXPLORATORY STUDY OF SINGAPOREAN PRE-SERVICE TEACHER PREPARATION**

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## **ABSTRACT**

The aim of the study is firstly, to investigate the effectiveness of low interactive Animated Pedagogical Agents (APAs) in aiding learning for a sample of 378 Singaporean pre-service teachers taking a full-time Post-Graduate Diploma in Education course in a case Institute; and secondly, to gauge how favourably the pre-service teachers perceive learning through such instruction. The sample is chosen because it represents the largest cohort of students from the case Institute. The study also explores whether the effectiveness and favourability in regard to APAs are affected by learners' sensory preferences. Because APAs are lifelike characters that can be embodied in a computer display to interact with learners, many APA-based lessons are designed with high interactivity to simulate intelligence; this type of APA however, is costly to develop and difficult to customise, making it less attractive for instruction. This study, in contrast, proposed that APA-based instruction should be designed with low interactivity, which is supported by sound pedagogies to help alleviate the above problem. To test this hypothesis, the study employed a quasi-experimental approach with a 2 x 4 factorial design to conduct the inquiry. Two learning conditions, the experimental and control conditions, and four sensory preference levels, the Strong Visual, Mild Visual, Strong Auditory and Mild Auditory levels - made up the factorial design. The two learning conditions were respectively learning with low interactive APAs (aka LIAI) and learning with a conventional online method (aka CI). Perceptions of LIAI were measured by three aspects of opinion: (1) extent of learning, (2) presentation of the instruction, and (3) interest in the instruction. At an overall level, 50% of learners on average were very positive in all three aspects of opinion; about 10% were very negative and the remaining 40% were mildly opinionated. At an individual level, extent of learning received the greatest satisfaction, followed by interest in the instruction and lastly presentation of the instruction. For effectiveness, LIAI produced moderately better learning performance than CI. Strong auditory and visual learners were found to learn best in their preferred modality. Mild visual learners learned well in their opposite modality and mild auditory learners did not benefit from either modality. The study also discussed implications of these findings and provided some recommendations for future research.

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## **CHAPTER ONE**

### **INTRODUCTION AND STATEMENT OF THE PROBLEM**

This study focuses on online learning as part of the teacher training experience for pre-service teachers at a teacher training institute (hereafter called the case Institute) in Singapore. Online learning has grown rapidly in Singapore, as elsewhere in the developed world, in the past few years. What makes online learning so popular is the freedom to learn without the constraints of space and time for the learners and the ability to reap good Return-of-Investment (ROI) for the course providers (Oliver & Herrington, 2001). Many corporate companies and educational institutions have realised the advantages of using online learning and have begun to offer their courses in the online mode. As online learning is still relatively new in Singapore, the scale of online delivery for companies is normally confined to short programmes that are targeted at a very specific domain or at best, to provide enrichment training for staff development. In other words, the online learning is usually used to play a complementary role and the training is normally conducted in-house. But for educational institutions like the case Institute at the centre of the present study, which has a large and distributed clientele together with a very specific role to fulfill, the use of online learning takes on a slightly different course and meaning.

Being a teacher training institute, the case Institute's main mission is to prepare untrained teachers to become qualified school teachers at both primary and secondary levels. Most of these trainees quickly become skillful and knowledgeable in their subject matter and pedagogy, but are also savvy in applying technology to enhance learning. Pre-service teachers in the case Institute usually learn technology for education by attending face-to-face classes and online lessons. They also need to design instruction for lessons to be delivered in these two modes. Providing an immersive environment to learn the technology and a hands-on

opportunity to apply the technology to design lessons is the key to experiential learning (Kolb & Kolb, 2005). Experiential learning is a useful method for new teachers without much practical experience like the pre-service teachers to learn in an authentic environment.

Not long ago, the Singapore Infocomm Development Authority (IDA) launched a massive island-wide project called *iN2015* with the aim to turn Singapore into a fully-wired nation with super-fast broadband communication speed (IDA, 2007). The impact of this project on the case Institute has been that it needed to upscale its present number of online courses in order to capitalise on the faster broadband speed. This implies that more courses will go online as compared with the conventional face-to-face delivery. It also means that students will learn the online courses with reduced or little human interaction. The case Institute is concerned about whether a switch to more learning by online methods will compromise its quality, and is thus keen to ensure it does not.

Just about a decade ago, a new technology using Animated Pedagogical Agents for learning appeared. An Animated Pedagogical Agent is a lifelike character that embodies itself on a computer screen and can co-exist together with any display in the background. The agent can emulate human behaviour such as gesture, locomotion, facial expression and speech. These properties are promising attributes that could be used to fill the gap due to the missing social elements that are commonly associated with fully online learning conditions. But making such agents effective in providing humanlike instruction requires them to be highly interactive, which is an area that cannot be achieved without high-technology and expensive investment. Ironically, such highly interactive agents do not always produce results that are commensurable with their intended outcomes. In addition, they are also difficult to be customised which makes them unfavourable to some smaller course providers.

The present study argues that the complexity brought about by the requirement for high interactivity together with the over-emphasis on the provision of technology could have diverted the necessary attention on the need to consider factors related to good pedagogies. Seeing it in this light, this study proposes looking for an alternative Animated Pedagogical Agent learning system with low interactive features that are more practical and perhaps also just as effective for the context stated earlier. To verify this, from the case Institute teacher training institute a sample of one of its cohorts of pre-service teachers was chosen to carry out the research. The research first involved constructing a representative low interactive Animated Pedagogical Agent learning system and then ascertaining its favourability and effectiveness for learning using the sample of pre-service teachers. Because learning with Animated Pedagogical Agents involves learning with virtual objects in simulated environments, not all learners are accustomed to learning under such conditions. Therefore this study also wants to know if there are any particular student characteristics that might affect the effectiveness of such learning. It is hoped that the findings of this study will shed light on the use of an alternative agent learning system for online learning and also provide a possible solution to address the problem faced by the case Institute.

### The Research Problem

Triggered by the onset of the Internet and the advancement of network technology, the use of online learning is picking up fast especially in the area of adult learning and training (Hiltz & Turoff, 2005). The growing popularity of online learning among adult learners is due primarily to its flexible mode of delivery and cost-effectiveness (Inglis, 1999; Oliver & Herrington, 2001, p.1) which is a crucial factor to consider for many working people. Being flexible, online course developers have to contend with the constraints of not being able to provide a teacher (or instructor) to interact with the students as in a face-to-face classroom. Although technology may be deployed to reduce this constraint by, for instance, using voice

or video conferencing technique, the human presence is still restricted by the need to pre-schedule the conference time and the hassle to set up the necessary communication equipment.

To compensate for this, many technologists turn to the field of Artificial Intelligence (AI) with the purpose to create a learning system that is intelligent and can offer the kind of interaction similar to a real teacher. Since then, there have been a lot of resources and energy put in to design systems that can adapt to human learning behaviour. One of the spin-offs from such effort is the “Intelligent Tutoring System (ITS)”. Basically an ITS adapts to human learning by having a sub-system built within the main system that contains all the heuristics of an expert when solving problems. Such sub-system is called the “Expert Model” (Beck, Stern & Haugsjaa, 2004). The main system also needs another sub-system whose responsibility is to track a learner’s behaviour, very much like a real teacher, during the learning process and compare data recorded for the behaviour with that in the Expert Model. Similarities or differences in the two sets of data will be sent to a third sub-system called “Pedagogical Module” (Beck, Stern & Haugsjaa, 2004). This module handles the pedagogy and will make decision on what instructional step to take next. Once the decision is made, the Pedagogical Module will communicate with a fourth sub-system, the “Domain Knowledge” (Beck, Stern & Haugsjaa, 2004), to determine what relevant domain material to retrieve and how it is to be presented to the learner together with the necessary instructions. The synergy of the four sub-systems is to provide the adaptivity and hence the interactivity of the learning system so that it resembles how a real teacher handles instruction in a classroom. The more the system is able to interact with the learners, the more it is regarded as intelligent. A point to note is that the ITS only tries to make the computer look intelligent, it does not make explicit the presence of a human teacher in the process. In other words, the interface for learning is still very much machine-driven. Even with this, the ITS is considered an incredible success to have man-made intelligence reaching such a level. But the intelligence does not come without

a price, it is costly, technologically demanding, needs training to get used to it and most importantly, it has inherent problems for customisation and scalability.

Of late, a new form of technology called “Animated Pedagogical Agent (APA)” has emerged. Its presence has changed the way people perceive a computer. The APA has a humanlike appearance and is able to embody itself on a computer screen together with other objects to perform functions such as talking, gesturing and providing facial expressions. The main effect is to mimic human behaviour. The anthropomorphic nature of the agent is quickly recognised by education technologists as great potential to fill the gap due to non-human presence normally exist in online courses. Therefore, beginning in the late nineties, much research has begun to incorporate APAs in the architecture of ITS to build systems with APAs possessing adaptivity and interactivity (Gulz & Haake, 2006; Wissick, 2002). But building such a system is not as straightforward as it appears. Consider when an APA is embedded in a learning situation, because of its unique ability to mimic human actions; it becomes the centre stage of the learning process, which inadvertently, poses a great demand on its ability to interact spontaneously like a human. The result of this is that an APA now has to shoulder the responsibility of being intelligent whereas for its predecessor, the ITS, the intelligence is distributed to its machine. The need to possess conducive behaviour and high level of interactivity by an APA has made its design more technologically demanding than an ITS, and very often, has gone beyond the ability and scope of an instructional designer whose key responsibility is to ensure the instructional integrity and quality are not compromise in the designing process. The greater emphasis on using technology to render instruction could have repercussions for online course developers who may not favour large investment in high-technology.



The reason why highly interactive agent systems are not always popular with smaller online developers is that running such a system will require building a very complex system and incurring higher overheads, which runs counter to the online business model. It also results in greater difficulty in customisation to meet curriculum changes readily. An APA is unlike a real human who has the kind of fluidity when it comes to managing changes, it needs re-engineering and re-programming that are normally done by a team of people consisting of graphic designers, content experts and Artificial Intelligence engineers. Making changes to any existing APA learning system is therefore limited to team effort and is practically not suitable for the job of an instructional designer. Many of the online course providers are small-timers which includes school teachers, they do not have the resources for a huge project team like what has been described above; they do not have Artificial Intelligence experts but mainly instructional designers. Because they are small, they also need to be very responsive to the market changes in order to stay competitive. As a result, they tend to give the complicated APA system a miss and continue to use text and graphics to be the main form of course presentation. This is not only disadvantageous to the learners, is also detrimental to the long-term development of small scale online course providers if they continue to shy away from advanced technology. The above issues also cause concern to the case Institute because knowing how to design proper online lessons forms part of the pre-service teachers' curriculum. Therefore it appears that the inadvertent technology-divide between the more resourceful companies and the less-able communities will remain for a while until a suitable alternative that relies less on sophisticated technology is found.

One of the ways to address the above issue may lie in the need to view the use of technology under the lens of design, in particular, the concept of *Affordance*. Briefly, the term “affordance” means “opportunity for action” (Kirchner, Strijbos, Kreijns, & Beers, 2004, p. 49) or “the interactions between users and tools” (Wijekumar, Meyer, Wagoner, & Ferguson,

2006, p. 192). Affordance offers to look at technology from the user's perspective. In the paradigm of affordance, technology is just a tool that offers opportunities for the user to interact with a specific set of features belonging to the technology to fulfill a certain task. The key is that the technology only offers the opportunity but not necessarily will result in an action by the user. Whether or not the user will use the specific features of the technology and whether after using the features will help to fulfill the task will depend on the user's background characteristics such as his/her prior experience with the tool, age level, past domain knowledge, culture and most importantly, intention (Wijekumar, Meyer, Wagoner, & Ferguson, 2006; Gaver, 1991). In other words, it is the user who determines if the technology is useful and not the technology per se. Therefore, users' characteristics are considered as determinants to the use of technology in the instructional design.

In the many research studies that have been carried out in the past decade, few have managed to produce consistent findings on how APAs affect learning (Clark & Choi, 2005; Dehn & Mulken, 2000; Wang, Johnson, Mayer, Rizzo, Shaw, & Collins, 2008). There are probably two reasons for this: first, is that very few studies have included users' characteristics (Note: students are the users in this study, therefore the term will also be called student characteristics thereafter) as determinants of the learning outcome. As explained by the affordance paradigm, this could have caused a mismatch between the technology intention and the students' desire. Next, is that many of the studies are eager to find ways to use the agent technology to produce learning conditions that can situate a learner in an as-real-as-possible environment. This is probably caused by the over-zealous enthusiasm of the pursuance of "artificial reality" apparent in the industrial and commercial sectors. However, the focus in education can be quite different. In education, the emphasis is very much on process but in industry and commerce, the emphasis is normally on product. Product is more deterministic whereas process is dynamic and probabilistic. Although the field of Artificial

Intelligence for APA research has grown leaps and bounds in recent years, it is still unable to produce true adaptivity to handle learning processes that are mostly complex and indeterminist. This is to say that if Artificial Intelligence cannot help APAs to attain the necessary level of adaptivity and hence the required intelligence commensurable with the ability of a real teacher, then learning from such an APA system is likely to encounter problems that are induced by the mismatch between the system's "artificial competency" and the learners' expectancy. The condition may be termed "technology backfiring".

It seems clear that focusing the effort on making the APA approach human reality may not pay off (Hook, 2000); and it might as well remain simple just as its very own name suggests - an agent, which is someone who merely provides the service for another person who cannot or is unable to do a certain task by himself or herself; and to remain in a non-supplantive role in the whole process. This is to suggest that an APA should be designed as only a tool, like any other technology tool such as PowerPoint and Weblog, but not to approach the sophistication of a human being. This also implies that the APA should not rely solely on its adaptivity to interact but remains as a simple tool which allows more effort to concentrate on usability. The notion of a tool concept lies fundamentally on the paradigm of affordance and that seeing technology as a tool makes the matching with the students' characteristics easier. But just how to design such an APA system to do such a job? Is it possible to produce such an APA system? There is clearly a justification for research. This study is initiated to undertake such research. It hopes that through the research process, more understanding about low interactive systems can be learnt which will lead to the eventual development of a low interactive APA learning system. Such a system will be tested for its favourability and effectiveness. Any student condition that could interfere the outcome will be determined and examined. The findings will be reported and implications will be discussed.

### Purpose of the Study

Based on the above discussion, this study will first explore, with the help of a literature review, an alternative APA technology whose affordances are less technically demanding and suitable for customisation by instructional designers and school teachers. Following this, a corresponding learning system will be built and its favourability and effectiveness tested against a sample of pre-service teachers from the case Institute using quantitative methods. This study will also examine if there is any student characteristic that may interfere significantly the learning outcome by using the low interactive APA system. It is expected that the less technologically-demanding APA should help to address the issue of customisation brought upon by complicated APA systems; and a better understanding of how the aforesaid conditions affect the efficacy of APA learning should give better insight into ensuring appropriate affordances are met when designing an APA learning system.

### Context of the Case Institute Taking Part in this Study

School teachers employed by the Ministry of Education (MOE) of Singapore need to undergo professional training at the case Institute before they can be considered qualified to teach in a school. As such, the case Institute has to constantly update and upgrade its curricula in order to keep pace with the changing needs of Singapore as well as to meet the global demands within a knowledge-based economy.

The case Institute offers two categories of programmes, namely, Postgraduate Programmes and Initial Teacher Preparation Programmes. The Postgraduate Programmes are for participants who want to upgrade their professional qualifications to a higher level. They range from Masters level to Doctoral level. As for the Initial Teacher Preparation Programmes, their main mission is to equip pre-service teachers with the necessary skills and knowledge not just in subject matter and pedagogy, but also proficiency in designing instruction that

incorporates appropriate Information Technologies (IT) to provide engaged learning (MOE, 2006b). To achieve this, pre-service teachers need to undergo courses in instructional design that incorporate Information Technologies. They learn this in two ways. First, they need to attend both face-to-face and online lessons. Next, they need to design instruction for classroom use and online delivery as part of the requirements of their course. To know how to apply online technology is one of the goals of the Singapore Ministry of Education's initiatives - the IT Master Plan II (MOE, 2006b).

The case Institute takes in pre-service teachers with different pre-requisite qualifications and prepares them according to their academic potential. Hence the Initial Teacher Preparation Programmes can be further divided into three more programmes: the Diploma in Education (DipEd) Programme, the Bachelor in Arts/Science (BA/BSc) Programme and the Post-graduate Diploma in Education (PGDE) Programme. Of these, the PGDE Programme has the largest intake which amounts to about over 1000 pre-service teachers every year. Because this cohort is very large, the training quality for this group of teachers will be significant and very important for the case Institute.

Pre-service teachers can have two tracks of specialisation in the PGDE Programme depending on their background training and their choices. The two specialisation tracks are the secondary school track and the primary school track. The former is designated as PGDE (Secondary) and the latter is called the PGDE (Primary). Between the two tracks, PGDE (Secondary) takes up about 70% of the entire PGDE teacher population.

In terms of demographics, PGDE (Secondary) teachers also offer the widest range of student characteristics in terms of age, race and other personality traits, in particular, the background training. Many of them join teaching as their second or third career and they vary a lot in

their ex-professionalism. So they bring along unique backgrounds which help to increase the heterogeneity of student characteristics. The rest of the PGDE (Secondary) students are usually fresh graduates from universities. All PGDE (Secondary) students possess at least a basic degree in their area of subject specialisation.

Besides the abovementioned programmes, the case Institute also offers specialised training to the industrial and commercial sectors. Most of these courses are tied to the domain of instructional design. Since instructional design is also part of the core curriculum for all Initial Teacher Preparation Programmes, the case Institute has to ensure every student, full-time or part-time, do well in the subject of instructional design. This means that the case Institute has to optimise its provision of courses in order to cater to the different types of clientele.

In general, courses from the case Institute are run in a few modes - via online, face-to-face or a combination of both. When online delivery is combined with face-to-face instruction, it is called blended learning (Hiltz & Turoff, 2005).

While the present study is based on a cohort of initial teacher trainees in a Singapore higher education Institute whose course required them to use on-line learning as part of their programme, it is instructive to set the context to the study within the development of online learning more generally in the international, national Singapore and case Institute.

Recently, online learning has received increased attention worldwide. This is due partly to the proliferation of Internet usage that makes connectivity between people easier and partly to the greater demand for the workforce to remain knowledgeable in their field in a knowledge-based economy. Hiltz and Toroff (2005) consider four elements as the main driving force behind this popular mode of learning, they are:

1. Students – more and more workers and professionals understand that if they want to remain employable and competitive, they have to embrace life-long learning and to keep learning (as a student) where online learning is one of the ways to help them achieve this.
2. Instructors – using online learning instructors can prepare and deliver their courses at a single go because the online mode of instruction can be easily mass-customised.
3. Institutes – some automated procedures in online courses help to cut down repetitive administrative chores and free up more resources for other more demanding areas. Also the intense competition among higher institutes of learning to offer courses that can attract students by their easy accessibility also helps to proliferate the use of online learning.
4. Pedagogy – some students regard the use of online methods for instruction as more effective even than the face-to-face (only) method and hence lend support to the online mode of learning.

From the above, it can be seen that online learning has its own advantages and appeal to certain groups of students, so if an institute is to take advantage of such a learning mode, then it must know how to maintain a good balance between the four elements and face-to-face learning. But what is a good balance? It will depend on the context and individual needs of each institute. Some institutes prefer to offer fully-online courses for learners who cannot afford to travel to the course venue due to geographical constraints. The University of West Florida (UWF), for instance, offers over 400 fully online courses at undergraduate and graduate degree levels as well as credit-earning certificate programs (UWF, 2010). Other institutes run courses that concentrate on face-to-face (only) and adopt a decentralised approach to allow course providers to make their best choice. This is because some subject matter is highly hands-on oriented and the instructor needs to interact with the learners in real

time and space to provide guidance. Other institutes, on the other hand, choose to be flexible and prefer to adopt the blended mode of learning (Bach, Haynes & Smith, 2007). For example, Barroso and Cabranes (2006) reported in a study that adult students in Portuguese ranked blended approach as their most favourable mode of learning as against the face-to-face or fully-online learning. Also Bonk, Kim, Zeng, Son, Teng, & Oh (2006) in their study pointed out that blended learning in all training in the United States hit about 30 percent in 2005 or about double that of 2004. A similar trend also reported in Taiwan that 46% of the respondents surveyed indicated that they used blended learning in their organizations for training (Teng, Bonk & Kim, 2006). Singapore is no exception to this global trend. It is also moving increasingly towards the use of a blended approach because Singapore's e-learning movements are largely mandated and pioneered by the Infocomm Development Authority (IDA) of Singapore which not only sets the direction for the development of e-learning but is also a main driver for all ICT-related initiatives (IDA, 2010). But IDA is more concerned about how ICT as a whole can be used effectively to benefit the economy of the nation. For this, IDA sees building a culture of lifelong learning as the way to sustain a knowledge-based economy (KBE). One good way to achieve this is to leverage on e-learning (or online learning) and to use it pervasively in manpower training (IDA, 2001). But IDA does not want to stifle the innovative use of e-learning by dictating a national policy so it adopts a decentralised approach to allow the industries including education to implement their e-learning plans according to their own needs (Lim, 2006). This means that companies or universities have the autonomy to choose between fully-online learning or blended learning or a combination of both. They are also free to decide on the platform of the delivery, that is, whether to outsource or to customise it in-house. For higher education institutions in Singapore, including the case Institute, they use well-established platforms such as Blackboard, IVLE (Integrated Virtual Learning Environment) and WebCT etc. for course management and they customise their own contents and methods of instruction (Lim, 2006). In other words, there are no pre-defined



models or standardised ways to delineate how much online content is to combine with how much offline content to make a blended approach. As such, the term blended learning in the context of Singapore is used quite loosely among the higher education institutions.

But whatever the mode of delivery is, be it fully-online, face-to-face or blended, the type of interaction involved in any of the approaches is either by the mediation of technology or by a real human. This has implication for an institute's business model. From a strict economic point of view, it is perhaps desirable if the institute can deploy less manpower in its operation to cut down overheads, using fewer human tutors to teach a course; but from a sustaining educational quality perspective, it would mean the opposite because human tutors are seen as more amenable to changing conditions and can meet the students' needs more readily than using technology. How to juggle between the two opposing conditions remains a challenge to many institutions.

The case Institute besides being a teacher training institute in Singapore has also the mandate to propagate national policies that have impact on the country's general education. The *IT Master Plan 3* (MP3) is one such policy. The IT Master Plans are a series of national policies that provide guidelines and directions for schools to integrate technology in their curricula. The first IT Master Plan (MP1) initiated in 1997 was to provide computer hardware and fundamental IT training for schools and school teachers to get ready for using ICT in their lessons (MOE, 2010a). This was followed by the second IT Master Plan (MP2) launched in 2003 where the aim was to ensure schools use ICT as educational tools to make lessons more engaging (MOE, 2010b). The IT Master Plan 3, implemented in 2009, has an extended mission to see that ICT is not only used to support teaching and learning but also to facilitate the learning of the 21<sup>st</sup> century skills which include self-directed learning (SDL) and collaborative learning (CoL) (see MOE, 2010c). SDL basically means to give the students the

autonomy to decide on their own learning goals and chart their own path to achieve the goals whereas CoL refers to equipping students with the social skills to work fruitfully in a group setting.

The implementation of the IT Master Plans have prompted schools to use more online applications such as web pages to gather information, blogs and wikis for students to monitor and report their progress of learning and online discussion forums for them to work collaboratively to brainstorm ideas and seek consensus (MOE2010c). In other words, the use of online learning is now expected to play a bigger role in schools and is to be used more extensively than before.

Responding to such demands from schools, the case Institute needs to adjust its curricula to provide teachers-in-training with adequate skills and knowledge to apply online tools and manage online learning; this has a strong impact on the department in which the researcher is working because it is the main department in the case Institute to teach the subject of Educational Technology which is a core and compulsory subject to all pre-service teachers.

The new Educational Technology curriculum has an increased proportion of online lesson training as compared to the more traditional face-to-face counterpart. The online lessons include self-directed learning on how to use online tools and how to design ICT integrated instruction. This means that learning of basic pedagogy is carried out more in the online learning mode and the other more complex tasks such as hands-on and developmental work are done in face-to-face classes.

Although the increase in the proportion of online learning helps to better prepare the pre-service teachers to meet the IT Master Plans' requirements of the government, the case

Institute is also concerned whether the reduction in using face-to-face teaching of content might compromise learning quality. This worry is not unfounded because based on a report published by the National Bureau of Economic Research; courses using online learning can cause students to miss out on important body language of the lecturer and other classroom cues which can be detrimental to students' performance (Lohr, 2010). The case Institute is therefore interested to know if there is a method to compensate for the absence of human presence during online instruction. Its concern is also shared by the researcher; and it is also the central problem that this study is trying to investigate. The present researcher agrees that APAs have the potential to plug the gap due to the missing human presence in online learning but posits that the complexity behind the APA systems may be more problematic to solve than is thought. This study therefore looks for an alternative system that might work better. The prospect of an alternative system could probably be a solution to the no-human online issue and hopefully could also offer the case Institute more leeway to concentrate its manpower on courses that need more face-to-face guidance. For this matter, the case Institute has kindly granted the researcher permission to use one of its cohorts of PGDE (Secondary) students – the largest cohort of all the programmes to carry out the intended research. Having a large sample to work on is beneficial to this study because of the need for collective consensus of the Institute to verify the effectiveness of the proposed alternative system. It also needs to know how the effectiveness is related to learners' characteristics. Therefore it needs information from sources that are as heterogeneous as possible to ensure that the findings are representative of the pre-service teachers. A large sample is certainly an advantage under these conditions.

### Personal Statement

As the researcher of this study I work at the case Institute as a lecturer. My main duty is to teach courses on educational technology and multimedia. I grew up in an era where paper and books were the essential learning materials in schools. So in my later years, I became very fascinated by the use of technology in education.

My personal view about technology is that it is a double-edged sword, with its own pros and cons. Though we have benefited a lot from the help of technology, we have also been handicapped by our over-reliance on it in both our work-life and leisure-life. For example, at work, we use email almost invariably as a communication tool, but we tend to miss out the human smiles and body signals that could help us understand our interlocutors better. At leisure, we use digital cameras that have full automatic features to help us take pictures. But gradually, we also tend to forget the art of photography. The same applies to the APAs, we rely on the autonomous functions of the system to help us teach the students; if such a trend were to become prevalent in the future, will we also tend to forget the art of teaching?

I believe that the correct way to go should be to look for a good balance between relying on ourselves and relying on technology. Where to draw the line is a subtle and intractable issue and in most cases, it depends on the context in which the question is asked. This is the case with this study.

Highly interactive APA learning systems certainly have their own players and markets. But for others who may not want to pay the price or are more nostalgic about old skills and practices, there should be a compromise somewhere where the old skills can meet new technologies and co-exist harmoniously to complement one another. Indeed, there are already some examples in other walks of life such as the dual-gear-shift mode used in some high-technology cars. In such a car, the driver can choose between an automatic gear shift and a

manual gear shift at a flip of a hand movement. In automatic gear mode, the car tracks the driving behaviour of the driver and uses it to regulate the availability of engine power, but in a manual gear mode, it is the driver who decides the amount of power that is needed. This shows that old technology does not need to be totally replaced by a new one but the two can co-exist to offer users a choice. It also points out one important thing, that is, a person's personal preference often is the determining factor behind the choice.

I am hopeful that a similar condition might be established for the APA systems in that some APAs are fully interactive while others might be less interactive, so that users can have a choice of their own depending on the context and needs.

### Limitations of the Study

The findings of this study are exploratory, based on a sample of pre-service teachers specialising in secondary school subjects. Though their age group, in the range of twenties to forties, may be a reasonable representation of the more general adult students of the case Institute who are also online learners, the background qualification of the sample is nonetheless less representative because the subjects are all university graduates. Taking this into consideration, the scope of generalisability from this study may be restricted to graduate adults in the case Institute.

The main intention of this study is to explore the possibility and efficacy of using a low interactive APA system for online learning set in the context of an initial teacher training course in the case Institute. Given the uniqueness of the sample – a group of Singaporean trainee teachers, it is questionable as to how representative are the findings to other populations using online learning systems with low APA interactivity. For this, generalisation

of the findings with regard to the system in this study must be done with caution and in respect to the distinctiveness of the sample of Singaporean teachers.

### Significance of the Study

It is hoped that findings from this study will provide insight at two levels:

1. At the curriculum level for the pre-service teachers, the study provides an opportunity to construct and test a low interactive APA system used to reduce the problems brought about by the complexity of a highly interactive APA system. The experimental system will provide information on whether low APA interactivity is effective in online learning and whether it is acceptable to the learners. This helps curriculum planners and educational policy makers decide if such an approach can be implemented for a full-scale online learning.
2. At the pedagogical level, this study looks at how learning via the low interactive APA system may be related to a particular student characteristic. The result should help to cast a more refined picture in addition to the more global view of how students learn from the system. Student factors that are favourable or unfavourable to learning would inform instructional designers and the like in regard to appropriate approaches to take when designing instructional events. It would also mean that instructional designers may want to be more selective in their target learners, based on what findings this study offers. The findings thus have implications not just for designers but also the system implementers and the users.

### Research Questions

The research problems discussed in previous sections are transformed into the following research questions which will then be used to frame the research design and methodology for this study. The main research questions indicate the core issues to be addressed in this study

while the sub-questions allow the issues to be analysed in greater details so as to provide more comprehensive answers to the main questions.

1. How favourably do learners perceive instruction using low interactive APAs?
  - a. What are the opinions of learners on instruction using low interactive APAs?
  - b. Do their opinions differ with respect to differences in sensory preference? If yes, how do they differ?
2. How effective is instruction using low interactive APAs in terms of helping learners learn?
  - a. How do learners' achievements from instruction using low interactive APAs compare with that from more conventional online instruction?
  - b. Does the achievement vary in accordance with learner's sensory preferences? If yes, how does it vary?
  - c. In view of the answers to 2(a) and 2(b) above, what is the joint impact of types of instruction and sensory preference on achievement?

### Definition of Terms

There are three terms which need further definition. They are the main components forming the title of this study. The first term is “low interactivity”, the second term is “Animated Pedagogical Agent (APA)” and the last term is “online learning”. They are highlighted here because they represent meanings that are unique to the context of this study.

#### *Low Interactivity*

Interactivity has a similar meaning as interaction and they are often used interchangeably (Su, Bonk, Magjuka, Liu, & Lee, 2005, p. 2). Therefore interactivity can be explained in terms of interaction which is a more familiar term better known by many. According to Su et al. (2005),

interactivity means “the degree of interaction that certain communication channels provide” and interaction in Wagner’s (1994) notion is “reciprocal events that require at least two objects and two actions”. Combining the two, interactivity therefore means “the degree of provision for several objects to reciprocally communicate with one another”.

By extending the above explanation to the case of APA-enabled instruction, low interactivity therefore has the meaning of using “limited degree of provision for the APAs and learners to reciprocally communicate with one another”.

#### *Animated Pedagogical Agent (APA)*

It is easier to look at the term “Animated Pedagogical Agent (APA)” as being formed by two parts – the first part is “agent” which is a kind of entity and the second part is “animated pedagogical” which describes the entity.

It is a challenging task to give a definition to the term “agent” due to the fact that “agent” is an umbrella term that has no exclusive ownership by any area of domain (Nwana, 1996). It is also because “agent” in different domains assumes different roles for different tasks, so to define it will need to find a description that is semantically encompassing enough so that it represents as many aspects of agent activities as possible. To this end, the definition given by Nwana (1996) is deemed helpful because it embraces all the key properties possessed by almost all common agents. Nwana’s definition of an agent is “a component of software and/or hardware which is capable of acting exactly in order to accomplish tasks on behalf of its user” (p. 5). Notice that the definition does not explicitly include any physical form of an agent so the agent can be visible or non-visible.



For the second part “animated pedagogical”, two pieces of work are used to derive a meaning for it. Consequently, “animated pedagogical” is used to describe an agent such that it is to be visible and exists in an animated form, either humanlike or otherwise (from Craig, Gholson, & Driscoll, 2002) and “operates in an educational setting to guide students’ learning processes” (from Clarebout & Elen, 2006, p. 211).

However, a slight modification is needed to make the definition less restrictive. The researcher of this study finds that the word “humanlike” should be deemphasized and substituted by “lifelike”. This is because the use of non-humanlike characters such as iconic or cartoon-like characters are just as favourable as the humanlike counterpart as reported by a number of studies (e.g. Anderson, Corbett, Koedinger, & Pelletier, 1995; Buisine, Abrilian & Martin, 2004). To sum up, the final meaning of “animated pedagogical agent” used in this study will be “a motional lifelike character which operates in an educational setting for supporting or facilitating learning”.

### *Online Learning*

Online learning refers to “any class that offers at least part of its curriculum in the online course delivery mode, or as a transmission of information and/or communication via the Internet without instructors and students being connected at the same time” (Richardson, 2003).

The online learning will take place using the case Institute’s courses and students. To have maximum research generalisability, the case Institute has granted this study to use its entire cohort of PGDE (secondary) pre-service teachers as the student sample. But because this is not a small sample and the impact which the study produces will significantly affect the students’ progress into their next phase of programme advancement, the level of disruption

due to this study must therefore be kept to the minimum. The researcher after due discussion with the case Institutional authority has decided to use APAs to help students learn multimedia design principles at rudimentary level. Keeping the domain of learning to basic level helps to bring down learning complexity so that the effects of APA in the learning process can be more readily identified. In addition, pre-service teachers are also more amendable to trying out new technology when the content of learning is less demanding. This is very important because they must agree to taking part in the study if a large sample size is to be retained for generalisability. With this provision, the context of online learning will be to learn basic multimedia design principles.

### Structure of the Thesis

The main body of the thesis will consist of six chapters. They are largely arranged in chronological order. Below is a brief description of the chapters:

Chapter One provides an outline of the research problems culminating in research questions that give the scope and direction for the study. Chapter Two is a targeted literature review based on the research aims and questions given in Chapter One. Its purpose is to engage in a critical review of relevant previous publications so as to obtain clues and ideas about how the present study may be designed to address the research questions. This review of the literature should also aid in developing an argument in respect of addressing the research questions. Following this, Chapter Three describes the research methodology, including an explication of the research design and method, nature of sample, identification of variables and the kind of data to collect in order to provide evidence to support the claims or arguments made in Chapter Two. Research validity, reliability and pilot-testing of instruments are also discussed in this chapter. Chapter Four focuses on data collection processes and the methods for analysing the data.

From this, results of the data are consolidated to offer research findings. Chapter Five concentrates on a discussion of the findings in relation to the research questions. Chapter Six is the final chapter and provides conclusions, implications and possible recommendations for future work.

## **CHAPTER TWO**

### **LITERATURE REVIEW**

In Chapter One, two main research questions with specific sub-questions were framed to guide the research. They are given below:

1. How favourably do learners perceive instruction using low interactive APAs?
  - a. What are the opinions of learners on instruction using low interactive APAs?
  - b. Do their opinions differ with respect to differences in sensory preference? If yes, how do they differ?
2. How effective is instruction using low interactive APAs in terms of helping learners learn?
  - a. How do learners' achievements from instruction using low interactive APAs compare with that from more conventional online instruction?
  - b. Does the achievement vary in accordance with learner's sensory preferences? If yes, how does it vary?
  - c. In view of the answers to 2(a) and 2(b) above, what is the joint impact of types of instruction and sensory preference on achievement?

In this chapter, literature is reviewed on what constitutes the interactions provided by APAs and how the extent of interaction may influence learners' perceptions and their performances when learning with APAs.

#### A Brief Background

Online learning has become very popular in the past decade because of the support of new technology and its ability to reach out to large studentship with reasonable investment cost. Many online course providers call the use of small investment to reach out to a large scale

market the economies of scale (Inglis, 1999; Oliver & Herrington, 2001). Online learning is also more convenient than traditional face-to-face learning because it reduces the constraints of time and space and is especially beneficial to adult learners and course providers which have curricula that require self or independent learning (Richardson, 2003). Besides these advantages, online learning remains aloof and “cold” to many because of its lack of human presence.

The emergence of APAs has given hope to overcome this weakness of a lack of human presence. The use of lifelike characters in APAs and their ability to allow learners to interact with them can contribute to what researchers called the *persona effect* which briefly means “the presence of a lifelike character in an interactive learning environment” (Lester, Converse, Kahler, Barlow, Stone, & Bhogal, 1997). But the effort to embody a virtual character in such a learning environment does not come cheap and easy. It needs the help of Artificial Intelligence (AI) and computer engineering which demand sophistication of system support and therefore incurring high technology cost (Beck, Stern & Haugsjaa, 2004; Ong & Ramachandran, 2003). Also because the design of delivery is always associated with emulating human behaviour, the pedagogical construction and design of such a system is usually complex and not easily customisable especially for small time course developers. This causes concerns from many online course designers including school teachers who mostly have to work individually and independently for economical reasons to design such a system. Therefore, there remain issues and questions with regard to the worthiness of investment in APA-based systems and the effectiveness of such systems.

Many of the studies on educational technology have pointed out that what truly influences the efficacy of instruction, be it with or without technology, is the choice of pedagogical approach and its appropriate application in the context of the learning (E.g. Clark, 2002, 2005; Driscoll,

2000). Technology alone cannot be the sole determinant for the success of the learning (Clark, 2002, 2005) but it does help to facilitate the learning process if used appropriately and meaningfully. Therefore, it points to the fact that the design of instruction using technology and creating conducive learning environment are more crucial than the technology itself.

The use of APAs has a similar issue in that not only the delivery of instruction is dependent on sound pedagogy; the rendering of the APAs' behaviour also requires the understanding of a certain minimum level of technological know-how. Many traditional instructional designers including school teachers are not trained and equipped with such skills and knowledge to meet the requirements. This makes designing APA learning environments difficult and confined to only a small group of APA professionals. This condition is undesirable because it impedes the widespread use of such technology in schools and institutions if teachers and instructors are prohibited from designing the APA-based instruction themselves.

There are clues and indications from research to suggest that using simple technology is equally if not more suited to supporting teaching and learning than to using high-technology learning systems (e.g. Benyon & Murray, 1993; Brusilovsky 1999; Clarebout & Elen, 2006; Thomas, 2005; Swartz, 2003). Such findings provide an alternative to looking at the use of low-end technology. More and more research is also making the call to consider technology as a tool and design it from the concept of "affordance" (e.g. Wang, Woo, & Quek, 2009; Woo, 2009, 2010). The idea of affordance basically means to consider using technology as a tool to extend human capacity. In a sense, affordance plays down the 'bells and whistles' of technology but heightens the need for usability. This opens up a new avenue for reconsidering APA design and the possibility of using less technology-dependent techniques to emulate agents' interactivities.

The review that follows is to look at how an APA learning system which relies fundamentally on sound pedagogical approaches rather than sophisticated interactions may be designed. As in any classroom learning, the importance of good course design and delivery in online learning cannot be understated (Vonderwell & Turner, 2005). This calls for an alternative design approach and reconsideration of design priorities.

The following literature review is divided into eight sections. The first section provides a discussion on how technology can be integrated properly in instruction and how this affects instructional design. The next three sections concentrate on examining the roles of interactivity in relation to online learning and APAs, from which an interaction design framework that is based on the interactive relationships can be established. The framework is used as a basis to guide further literature review in order to address the research questions. A further three sections discuss the types of interaction and their implications in detail, in particular, how the extent of APA interactivity might influence perceptions of learners and their level of learning. The last section gives an overall summary which consolidates the findings and implications of the review discussed previously.

### Pedagogy, Technology and Online Learning

Technology has a strong influence on our lives. It affects almost every aspect of our daily activities, such as communication, entertainment, work and learning. Because of this strong influence, educators can no longer ignore the role of technology when considering a student's learning experience (Mason & Rennie, 2008). This means that instructional designers, in particular those dealing with online courses whose lesson delivery relies heavily on technology, have to be aware and conscious of how pedagogy is impacted by technology and what considerations must be taken into account when designing instruction with technology.

Before proceeding further, it is important to know what ‘design’ means and what instructional design entails. Smith and Ragan (2002, p. 4) define *design* as “a systematic or intensive planning and ideation process prior to the development of something or the execution of some plan in order to solve a problem”. They call it, in short, the capacity for “domain-specific problem solving” (p.4). In other words, design is not an exact science or art but an activity that one engages in to arrive at some solutions. Using this notion, instructional design in the context of this study means “a planning and ideation endeavour to find solutions for some instructional issues or problems”. As most educators would agree, the process of instruction is hardly a straightforward one and to obtain a successful instructional delivery, there are usually problems to overcome. Hence it is appropriate to concentrate the discussion on problems that involve the design of online instruction using technology.

Usually, to design instruction with technology, an instructional designer (such as a university lecturer) besides having to know the subject matter and the basic pedagogy of instruction such as how to specify learning outcomes, identify learning activities and decide on the mode of delivery (Mason & Rennie, 2008), would also need a good understanding of the functions of the technological tools and the conditions under which those tools could most effectively and appropriately be applied (Land & Hannafin, 2000). The knowledge of all these put together is what Mishra and Koehler (2006) call, the *Technological Pedagogical Content Knowledge* (TPCK). The TPCK framework came about because little research had been done on what entails knowledge for integrating ICT in teaching and learning (Koehler & Mishra, 2005; Mishra & Koehler, 2006). Sharing this sentiment, Mason and Rennie (2008) point out that some course designers use technologies simply to pander to the fancy of the net generation. The TPCK is a very popular framework used by many researchers to help teachers and others to integrate technology in their instructional design (e.g. Grandgenett, 2008; Hughes, 2008; Niess, 2007). But the intertwining relationships between the design components are difficult



to understand (Cox, 2008). To get around this, Mishra & Koehler (2005) conducted a study by using design as a methodology to let education graduate students learn technology integration for online learning. The gist of the study was to have student teachers design an online course and give their perceptions towards the design process through surveys. Mishra & Koehler (2005) found that the context for the design is important and must be clearly explicated. Also the design process propelled the designers to give more subtle considerations to the nuances of the technology suitable for integration. What is also implicit in the findings is that learners get a deep understanding of a tool in relation to how it may aid pedagogy only through their intense interaction with the tool. This means activities with purposeful interactivity set in a right context are likely to facilitate learning.

The work of Mishra and Koehler has been inspiring, but their TPACK framework appears to lean more towards explaining the intricate relationships between technology, pedagogy and content, than towards providing details to illustrate how the framework can be applied in a practical situation using design language. In other words, the framework tends to be more descriptive than prescriptive – perhaps due to the fact that the participants in the study were graduate students with some experience in using technology with instruction. It would be ideal if such a framework could eventually evolve to include design principles which are more operationalisable and ‘instantiable’ so as to allow novice learners, and in the particular case of the present study, pre-service teachers, to also benefit from using such a framework in their designs.

Despite the lack of practical orientation in the TPACK framework, the “learning by design” concept does provide a linkage to another popular framework commonly used in the design world, namely, “affordance” (e.g. Brown, Stillman, & Herbert, 2004; John & Sutherland, 2005; McGrenere & Ho, 2000; You & Chen, 2007). Affordance has its root in ecology

(Greeno, 1994) but was introduced to the field of computer interface design by Norman (1988). By 'interface' is meant the interaction between the functions of the technological tool and the user. Hence affordance requires the design to take into consideration the responses of the user. This has close resemblance to pedagogy in which a learner's behaviour is considered a decisive factor in the instructional process. Reinforcing the same point, Wallace (2003) agrees that technology integration is highly related to Pedagogy and Content Knowledge (PCK). Others like Gaver (1991), Woo and Wang (2009), also contend that a tool must provide functions when working in a certain condition to allow a user to feel its usefulness. In other words, the practical usability of the tool is far more important than the mere features of the tool alone. Though affordance provides guidance on how a tool should be designed to increase usability, it falls short of offering a connection to the pedagogy of instruction. This could be due to affordance being a general concept or theory for design, rather than one targeting education per se.

From the above discussion, it can be noted that using influential frameworks like TPCK and affordance can provide a basis for using technology in instruction. However, they do not contain sufficient operationalisable information on how technology can be designed as an integral part of instruction. The emphasis here is integrating technology and not using technology.

The lack of a proper design framework for technology integration is even more pronounced in online learning. This is because instruction in online learning is mainly mediated by technological tools and delivery platforms; furthermore, these two are also limited by types of network and the network's bandwidth. As a result of these constraints, some traditional pedagogies may find themselves hindered or less effective. For example, conversation in traditional face-to-face instruction is in real-time and responses are immediate, but in online

learning it is either in synchronous or asynchronous mode. Each mode has its own pros and cons depending on the context of learning and the purpose of instruction. Hence contextualising a design before evaluation is important if the integration is to be effective and useful.

In the previous section, it was mentioned that an APA online learning system relying on low interactivity has to be designed and constructed and then evaluated for its effectiveness. But because a technology integration design framework is generally not available, in particular in the context of APA integration, it becomes clear that this study will need to locate its own boundaries and devise its own design framework.

In the following sections, discussion will focus on how interactivity plays its role in the process of integrating APAs in instruction and how a design framework based on interaction can be formulated from such interactivity. The interaction design framework will become the cornerstone of this study and will be used to guide the rest of the discussion.

### Online Learning and Interactivity

Online is the mode of learning used in this study and, according to Horton (2000) and Oliver & Herrington (2001), interactivity is the key to learning. Interactivity also forms an essential part in this research study. It is therefore important to understand the role of interactivity in online mode of delivery and how it impacts learning.

Online learning, Twigg (2003) argues, can differ in many ways depending on the discipline involved, the type of students and the preferences of faculty members conducting the course. But generally, the design of online courses can be grouped into five models with each representing a different degree of course flexibility. They form a continuum ranging from

fully face-to-face mode of delivery to fully online interactions with students. The five models are: *Supplemental*, *Replacement*, *Emporium*, *Fully Online* and *Buffet* (Twigg, 2003). These models differ in terms of interactivity which is of prime concern to this study. To understand the relationships between interactivity and these models, only two of these models will be used for illustration. They are picked from the two extremes of the continuum and any other models will fall between these two models. The first to look at is the Supplemental model. This model retains most of the face-to-face activities but places some of the learning tasks online. Examples of learning tasks include short online lectures, online discussion and quizzes. It offers the least flexibility and interactivity and is often known as the traditional model (Twigg, 2003). It is this traditional model that is used by the case Institute as its model of delivery for online learning.

The next model is the Buffet model (Twigg, 2003). It is the opposite of the Supplemental model. It is designed to provide individualised learning experience for each student. Students have a choice to choose the learning elements such as a video presentation or to take part in an online discussion depending on the student's learning goals and individual preferences. The system will track the student's performance and offer alternative learning strategies when necessary. In other words, the system has the capacity to adapt to the student's learning behaviour through its interaction with the learning elements. This model has the highest level of flexibility and interactivity. It also depends extensively on the system's adaptivity.

The five online learning models mentioned above offer different degrees of flexibility for students. They also imply flexibility has different demands of interactivity among the learners, instructors and learning materials (Twigg, 2003). It can be seen that the relationship between course flexibility and interactivity is almost positively proportional.

While Twigg sees online interactivity as a form of continuum, Benyon & Murray (1993) regard online interactivity as comprising of two domains: *External Interactivity* and *Internal Interactivity*. External Interactivity refers to the interaction undertaken by the user and the system's interface. As such, this mode of interaction is very much governed by the field of Human-Computer-Interface (HCI). HCI strives to understand humans' nature on managing an artefact and provide the best input/output mechanism to facilitate this operation. It has a theoretical underpinning of human psychology and computer science engineering (Carroll, 1997).

Internal Interactivity means the decision-making process using the system's knowledge to analyse, infer and then provide a decision as to what to do next in the learning process. This is very much like a teacher using his/her instructional expertise to orchestrate learning activities in a classroom. The difference is that for online learning, this process is carried out by a system whereas for classroom learning, this is done by a real teacher. So the Internal Interactivity is more about pedagogical decisions and is underpinned by learning theories and Artificial Intelligence (AI) techniques (Ong & Ramachandran, 2003). AI, basically means "the activity of providing such machines as computers with the ability to display behaviour that would be regarded as intelligent if it were observed in humans" (McLeod, Jr. & Schell, 2001, p. 265). AI is an emerging field of technology and is a much specialised area by itself. To provide humanlike interaction with the learners will imply a synergy of the specialities from the two disciplines. This is both costly and challenging.

Twigg's as well as Benyon and Murray's notions of interactivity are more functionally oriented; they tend to regard interactivity from a system's architectural perspective. But some other researchers (e.g. Canales, Pena, Peredo, Sossa, & Gutierrez, 2007; Chou, 2003; Wang & Woo, 2009) adopt a more student-centred approach and study the interactivity from an

instructional point of view. They use the learner as a point of reference. Typically, these researchers agree that an online learning system can be considered as being made up of four types of interactivity, namely: learner-to-content, learner-to-tutor, learner-to-learner and learner-to-interface. Learner-to-content interactivity is concerned with how learning materials are to be presented and organised to produce the best impact in the learning process, it is an area that can be best described by cognitive theory. Learner-to-tutor and learner-to-learner interactivities are about communicative interactions between the tutor and peers, it aims at maximising social support to facilitate learning; it may be best studied under the social constructivism paradigm. The last one, which is the learner-to-interface interactivity, is about the mechanism used by the system to provide a means for interaction to support the first three types of interactivity; this would be an area in the field of Human-Computer-Interaction (HCI).

Despite the different views on online interactivity described above, they all seem to indicate one common phenomenon. Higgison (2000) sums this up when he recognises that the provision of interactivity during online learning is an important but enormous undertaking. The number of different disciplines involved in the process of rendering interactivity cuts across specialised fields ranging from a highly humanistic domain like cognitive psychology, traverse the interdisciplinary domain of HCI, to a highly technical domain like AI. This is not only labour-intensive but also cost demanding. It is also difficult to be designed by online learning practitioners like instructors in higher institutions and teachers in the schools. This creates a disconnect between the designers and the users. Design literature has frequently cautioned the need for design from a user's perspective if the design is to be useful and effective (see for example, Brown, Stillman, & Herbert, 2004; Maeda, 2006). It will help to enrich best practices if users can play a part in the design process. This requirement, together with the need to have proper interactions in online learning as suggested by the literature,

provide a good basis for the researcher of this study to conceptualise a design framework that can incorporate APAs.

### Online Learning and APAs

Traditional online learning has often been seen as a cost-effective way to deliver instruction to a large group of learners who want flexibility of time and space (Oliver & Herrington, 2001). But it has also been criticised for its lack of human elements and social presence in the learning process (Richardson, 2003; Woo, 2009, 2010). Of late, a new form of technology using computerised characters called Animated Pedagogical Agents (APAs) which are capable of mimicking human behaviour has emerged. Johnson, Rickel & Lester (2000) for example, believe that because of its anthropomorphic property, it offers promises to better learning experience through its social interaction with the learners. Since then, research has become interested to know how APAs may improve the affect of students and whether it also leads to better cognitive performance.

Much research associates the study of APAs with multimedia. For example, in Moreno's (2005) review of works on the use of APAs, she formally integrated APAs in Mayer's (2001) theory of multimedia learning with a proposed new cognitive model for multimedia learning with APAs. This is because an APA by itself, is a visual display of its own image, facial expressions and gestures. It also produces voice and in the case of multiple agents, they engender dialogue among themselves. All these properties fall in line with the definition of multimedia which, according to Mayer (2001, p. 2) is defined as "a presentation of material using both words and pictures". Based on this definition, the APA is indeed a manifestation of multimedia.

What happens when APAs are embodied in online learning? First, there is a need to look at the format of presentation in online learning. Clark (2002) claims that course providers of traditional online learning generally agree that using multimedia is a good means to help achieving effective learning when it is combined with sound instructional methods. Therefore, it is not uncommon to see online content embedded with multi-forms of media such as graphics, animations, videos and text to support its content presentation (Oliver & Herrington, 2001). When such an online learning is delivered through an APA, the multimedia properties of the APA will overlap with that of the multimedia from the content and the resulting setting may be considered to be an integrated multimedia learning environment. As a result, the number of media elements involved in the environment will become very complex, especially when these elements produce mutual interactions among themselves. This is a great concern to instructional designers.

Many multimedia instructional designers are aware of the learning consequences due to the need to interact with too many multimedia elements (e.g. Atkinson, 2002; Ayres & Sweller, 2005; Clark & Feldon, 2005; Moreno & Mayer, 2000). Clark & Feldon (2005) point out that the main problem of interacting with many multimedia elements is the concurrent attention needed to engage all the elements if they are unintelligently presented either spatially or temporally. Very often this causes the problem of split-attention effect (Ayres & Sweller, 2005) which overloads the learner's cognition (Clark & Feldon, 2005; Mayer, 2001). Mayer (2001) explains that the split-attention effect is "impairment in learning that occurs when a learner must mentally integrate disparate sources of information" (p. 92).

This has implication for Research Questions 1(a) and 2(a) both of which question whether low-interactive APA systems can give rise to favourable perceptions of learning among users and how effective they are as learning agents. The embodiment of APAs appears to increase



the learner-content interactions by their own animation; however, it could be that these same ‘virtues’ propagate the split-attention effect and cognitive overload issue. Although research has proposed some strategies to allow APAs to function effectively in an interactive environment, for example, Mayer’s (2001) seven principles of multimedia design and Moreno’s (2005) critical analysis on multimedia learning with APA, issues on the positive impact on learning by APAs remain unresolved (Craig, Gholson & Driscoll, 2002; Woo, 2009). The issue of multimedia integrated with APAs is further complicated by an effect which Sweller (2002) calls the “intrinsic cognitive load”. Sweller (2002) associates intrinsic cognitive load with the element interactivity found in the content. The higher the interactivity level, the higher the intrinsic cognitive load is required by a learner. He further points out that learning with high element interactivity material may be made easier by sound and well-thought-through instructional methods. Also, new content should not contain too many high interactive elements (Sweller, 2002, 2005).

Based on the above findings, there is an indication that APAs situated in a highly interactive learning environment can impose high cognitive demand on the learners, resulting in a need for sound instructional design to compensate for the extraneous cognitive effort needed by the process. This suggests that an alternative solution to the problem may lie in the possibility of reducing the interactivity of the media elements. This was suggested in early discussion of the inclusion of interactivity in online learning; the review here suggests the scope of the interactivity should be low for APAs. The review also indicates a relationship between interactivity and cognitive load. What kind of low interactivity can APAs assume without compromising the quality of pedagogy such as not to have cognitive overload? This brings us to the next part of discussion where the relationship will be further explored.

### APAs and Interactivity

This section attempts to explore the relationships between APAs and interactivity and to know how they are related to pedagogies.

A review of research on APAs (Baylor & Kim, 2004; Gulz & Haake, 2006; Jitjaroen, 2008; Lester, Converse, Kahler, Barlow, Stone, & Bhogal, 1997; Piwek, 2003; Wang, Johnson, Mayer, Rizzo, Shaw, & Collins, 2008; Woo & Wang, 2005) found that the findings are multifaceted. Practically, every aspect of an APA such as look, speech or even its ethnicity is a researchable item. This gives rise to a very wide spread of research topics but at the same time, a lack of common themes for more in-depth inquiry. The present researcher reckons that in order to understand the effects of APAs in a more holistic manner, a framework needs to be in place to help organise the research findings in a thematic fashion. In particular, a framework is needed of the themes that delineate the interaction properties of APAs when used in online learning. Such a framework is also useful for providing strategies for the design of APA instruction. However, as explained at the beginning at this chapter, there is no such framework available from any known literature. The researcher needs to devise one himself.

### *Interaction Framework for APAs in Online Learning*

In formulating an interaction design framework for APA, Chou's (2003) general interaction framework for online activities cited in previous sections was useful in providing a basis to begin with. In Chou's framework, four modes of interactions were proposed; they aim to cover most online activities. Three of the interactions apply well to the types of APA interactions, except the learner-to-learner interaction which portrays activities involving only the learners and is therefore excluded from considerations. The remaining forms of interactions are: student-to-APA, student-to-content and student-to-interface. Their relationships are reconstructed to take into considerations the role of APAs in the learning process. Figure 2.1 gives the interaction framework for APAs when used in online learning. A

point to note about the framework is that the term “student” is changed to “learner” to include the general learners that are outside the institution or school settings. The term “tutor” used in the original framework is also replaced by the term “APA” to reflect the central role assumed by the APA.

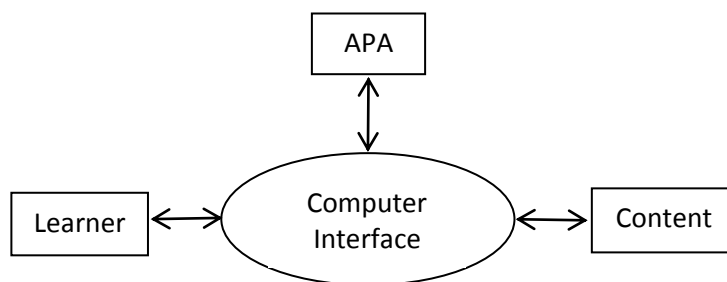


Figure 2.1 Interaction Framework for APAs in Online Learning

In Figure 2.1, Learner, APA and Content are the sources of interaction and they all must interact through the computer interface. For example, the APA has to talk to the learner via the computer speech interface which is a speech synthesizer. Or the content may call upon the learner to respond to a text-based answer by clicking on a hyperlink where it is also an element of a computer interface. So the Computer Interface acts as a mediator to facilitate all interactions that are required in the learning process.

Using this framework, research findings can now be organised around the three types of interactions, namely, Learner-Content, Learner-APA and APA-Content.

Learner-Content interaction though not directly linked to APAs, provides a good grounding on how content and its presentation can affect the learning process and from which the impact of APAs may be inferred. This type of interaction also forms the basis of conventional online

learning which helps to compare the effectiveness of conventional instruction with that of low interactive APA-based instruction.

Learner-APA interaction, on the other hand, focuses on how an APA may forge social connection with learners through its lifelike affordances. But because this study proposes using low interactive APAs, the findings in this section might well shed light on whether artificially mediated social interactions could alter a learner's perception on learning. The knowledge gained here helps to frame Research Questions 1(a) and 2(a).

APA-Content interaction closes the loop the tripartite interactions given in Figure 2.1. This interaction fundamentally seeks to know what research has found in terms of how an APA presents the learning content and whether the method of presentation is highly interactive. Together with the knowledge of how an APA interacts with a learner from the previous section, how the APA uses the content to present instruction in this section, and also from knowing what learners expect from the learning content (from the section on Learner-Content interaction), an overall picture of what entails an effective learning and its corresponding interactivity may be understood. Such knowledge will allow any unanswered portion in the literature review to be re-examined and reworked to arrive at research questions for this study.

### Learner-Content Interaction

In this type of interaction, because an APA is absent, the focus will be on conventional online learning. Understanding research in this aspect of learning has two purposes: first, it helps to lay the foundation for understanding learning in a general sense so that APA learning may be built upon it as an extension; second, such interaction is a possible part of an APA learning strategies in which a learner is instructed (by the APA) to self-learn some parts of the content.

For long, online learning has been known to lack face-to-face interactions that are commonly found in ordinary classroom situations, it therefore has to rely on good instructional methods and technological affordances to compensate for the shortcoming. Clark (2002) suggests that online learning should consider three important components: the instructional methods, the instructional media (e.g. the use of computers) and the media elements (e.g. text and pictures). Instructional method determines the type of media as well as the media elements which in turn influence the interactions between the content and the learner. But effective instructional method has to be grounded on good understanding of learning, hence, it is clear that understanding what constitutes learning helps to understand the interplay between instruction and learning and the interactions they entail.

Researchers generally agree that learning is the result of cognitive processes that respond to external stimuli from the environment (e.g. Goldstein, 2008). Much of the understanding about learning is derived from the field of cognitive psychology. Cognitive psychologists concede that human cognition involves processing information in three “memory stores” that are called the sensory memory (SM), the working memory (WM) and the long-term memory (LTM). They form the human cognitive architecture. Information picked up from the environment is first processed in the SM and transferred to WM which may draw upon the information previously stored in LTM to form new knowledge, and the newly created knowledge is then put back into the LTM for future use. The entire episode of information treatment is analogous to the information procession used in computers (Schunk, 2000). In fact, some cognitive psychologists argue that the information processing mechanism was originated from the computer architecture used in machines (Wingfield & Byrnes, 1981). But ironically, the same concept was later found to have reapplied to computers that control Artificially Intelligence (AI) to emulate human thinking (Schunk, 2000). The intertwined relationship between structural modelling and human thinking probably is a first indication

that human cognition can be understood by decomposing it into explainable structures. This assumption is reflected clearly in several well-known theories and models such as Sweller's (2002) Cognitive Load Theory and Mayer's (2001) Cognitive Theory of Multimedia Learning. The commonality among these theories is that learning is a process involving passing information from one memory "store" to another. This means understanding of how learning works should begin with the memory stores. The first memory store to discuss is the Sensory Memory (SM).

### *Sensory Memory (SM)*

SM may be considered to be the frontline component in a learning process because it deals directly with the information coming from the learning environment. All information to be learnt is filtered through our sensors like the ears and the eyes and is immediately captured by the SM for a brief moment. Driscoll's (2005) research found that visual information stays for about a quarter of a second and auditory information stays a little longer for up to four seconds. It appears that such quantification of memory limits is hardly challenged. Sperling's (1960) famous experiment on persistence of vision effect and Darwin, Turvey & Crowder's (1972) experiment on persistence of auditory information - a follow-up of Sperling's experiment, are the two most cited studies to support the limited memory phenomenon (e.g. cited in Driscoll, 2005; Goldstein, 2008; Ormrod, 1995). Research also found that the SM has the tendency to store information in the form in which it is sensed, that is, visual content is in visual form whereas auditory content is in auditory form. Researchers call the memory associated with visual and auditory storages respectively the *iconic* memory and the *echoic* memory (Goldstein, 2008). This means that written words will be processed by the iconic memory but spoken words will be processed by the echoic memory. Believers of this model of information processing are termed having the Sensory Modality view (Mayer, 2001;

Moreno & Mayer, 2007). The influential theory behind this view is Baddeley & Hitch's (1974) model of working memory (Mayer, 2001, Mayer, 2005a).

The sensory modality view does not favour everybody. Some researchers are more concerned about how external information is encoded and represented in the mind rather than how it is sensed. They believe that whatever the format of the information is; a learner is able to use some coding systems to encode the information into knowledge (Mayer, 2001). They therefore adopt what Mayer (2001) calls a Presentation Modes view. Basically, believers of this view associate what is stored in the mind with what is perceived and they classify the perceived data by presentation format. This leads to verbal and non-verbal presentation modes (Mayer, 2001). Verbal means to present content in spoken or written word format and non-verbal means to present content in picture format. In this classification, the written word is not separated from the spoken word as per sensory modality view but grouped together with the spoken word into the verbal mode. As a result, it is not sure how written text should be processed in our human mind. This causes confusion and the difficulty to rely on one single correct explanation.

Then there is the third view which suggests three representational modalities: linguistic, non-linguistic and affective (Marzano, 1998). Linguistic is akin to verbal and non-linguistic is likened to non-verbal. The uniqueness of this view is the additional affective modality which is an attempt to integrate cognitive experience with affective experience into one domain. Citing neuroscience findings, Marzano (1998) argues that the affective characteristics such as feeling, emotion and mood are often tagged to cognitive representations to form a more complete knowledge representation that includes experience. Though not too many cognitive models have formally incorporated affective influences into cognitive processes, Marzano's model may be said to be an unconventional interpretation of affect as a form of modality. This

is also an endorsement of the need to take a learner's learning experience as part of an assessment criterion.

There is also a fourth view, namely that of Mayer (2001), who takes a middle stance between the Sensory Modality view and the Presentation Modes view. The intention is to get the best of both worlds. In his study, he devised a new model for multimedia learning which consists of four parts: multimedia presentation, sensory memory, working memory and long-term memory (see figure 2.2).

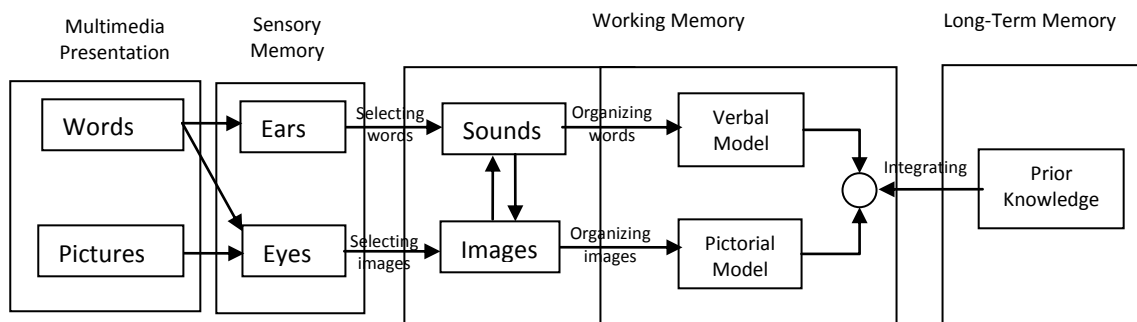


Figure 2.2 Mayer's Cognitive Theory of Multimedia Learning  
(Extracted from Mayer, 2001, p. 44, Figure 3.2)

He argues that sensory memory will follow the modality view where the processing of spoken words and written words are to be based on the sensors receiving them. This is useful for online learning because it implies that “what format of content produces what kind of sensory effect” to the learner. It also allows a more predictable organisation of the content. But for what is to be constructed ultimately as a representation in the working memory (which will be discussed in detail later), he proposes using the Presentation Modes View to integrate image, voice and words into a complex mental model which arguably, is one of the more likely representations of knowledge (Eggen & Kauchak, 2001).



So far knowledge is semantically and spatially represented. However, knowledge can also be temporally constructed. When this happens, it is called an episodic representation (Slavin, 1997). As an example, it can be the episode of a movie which consists of both verbal and non-verbal data connected through temporal and spatial relationships (Baddeley, 2000b). This complex representation, according to Marzano (1998) can differ from person to person with some favouring the pictorial type of representation while the other favouring a more linguistic nature of representation. He cautions that preference for one particular style of modality is possible among learners and is an area related to individual learning style (Coffield, Moseley, Hall, & Ecclestone, 2004; Lovelace, 2005). This adds to a second call to take learner's preferences, specifically, sensory preference for learning, into consideration when designing online instruction. As a result, this review will need to examine the effect of learners' sensory preferences when reviewing the interaction of APAs with learners. This will be discussed in later part of the sections.

### *Attention*

Closely related to SM is attention. It is the ability to “filter” information stored in SM before passing to LTM (Driscoll, 2005). The ability to pay attention differs from person to person. Some experienced learners know how to selectively pay attention to only relevant information in the content and ignore the rest while others are frequently distracted by interference. Bransford (1979) noted that attention is especially crucial if the content to be learnt is new and also difficult. Driscoll (2005) delineates three factors that instructional designers should use to help draw learners' attention. They are:

- (1) make sure that the information is meaningful to the learner. Meaningful learning has always been the key in most cognitive discussions (e.g. Eggen & Kauchak, 2001; van Merriënboer, 2005).

- (2) do not make learners perform two competing but yet similar tasks together. For example, listening to two similar conversations speaking with the same tone and at the same time. Such a problem is also highlighted by Sweller (2005) as the split-attention effect which should be avoided altogether, and
- (3) confine the complexity of the learning tasks to within the ability of the learner.

Sweller (2002) refers to this requirement as the *intrinsic load* which means how well information units (called the elements) can be learnt separately and independently. The more independent the elements, the lower the intrinsic load and the easier the learning will be.

Notice in Driscoll's view, modality such as speech is a concern to cognitive overloading, which has implications for this study.

Attention is very important to online learning because online learners are usually on their own without the advantage of 'just-in-time' guidance. But attention alone is insufficient to ensure a good head start for a learning process because the sensed data are meaningless until they are being processed by another stage called perception (Eggen & Kauchak, 2001, p. 272).

Therefore attention and perception are usually combined together to produce a joint learning effect before the perceived data are further advanced to Working Memory.

### *Perception*

Perception may be approached from two perspectives: one from a cognitive perspective and the other from a designer perspective.

From a cognitive perspective, perception is defined as "the process by which people attach meaning to experiences" (Eggen & Kauchak, 2001, p. 272) and this should be differentiated from "sensation" which is the physiological response one receives from the sensors (Ormrod,

1995, p. 194). Stimuli received by our sensors fade away quickly in our SM and hence they do not leave behind exact replicas of what have been sensed (Slavin, 1997). Because of this short retention stint, the human mind must quickly form a meaning out of the “left-over” information in the SM before it is completely lost. But the meaning-making process is also largely determined by one’s own past experience, knowledge, motivation and other factors (Slavin, 1997) which means perception is very much experience-oriented and learner-specific. According to Eggen & Kauchak (2001), the level of meaningfulness is to a large extent dependent on a person’s ability to make connection between the perceived data and the existing knowledge stored in the long term memory (LTM); in other words, if the connection is easy, then more connections can be made and the result is that the perception will be more meaningful.

But there is always a possibility that a learner may not have or have only insufficient past knowledge available in his/her LTM for making connection in a perception stage such as learning a new topic or understanding some novel materials. According to Sweller (2005), in the absence of past knowledge in LTM to guide the perceptive learners, they will need to resort to trial-and-error to make meanings on their own. Very often this can lead to erroneous perception which can develop into misconception or mistaken understanding. The problem of learning with novices was highlighted in Kirschner, Sweller, & Clark’s (2006) paper that properly designed guided instruction can be a solution to such a problem. It means that content with good organisation and presentation will help novices make ‘right’ meanings and hence the ‘right’ perceptions for learning. But how to design good content organisation and presentation is crucial.

Good content organisation and presentation were well-researched by the Gestalt psychologists in the nineteenth century (Skaalid, 1999). Goldstein (2008), citing Gestalt psychologists’

findings, argues that humans have the innate ability to organise sensed information into patterns according to some rules which they called the *laws of perceptual organisation* (Goldstein, 2008, p. 73). For example, Leflore (2000) argues that people have the tendency to perceive text when placed close to a picture as belonging to a single entity; Goldstein (2008) associates this with the *law of proximity*. Because the text and picture are perceived as belonging to the same entity, the viewer will perceive that the text must be a description used to complement the details of the picture. The implication of this to instructional designers is that any deviation from such an arrangement will create *visual disharmony* (Boyle, 1997, p. 125) and the learner will be confused. To overcome the visual disharmony, a learner will need to expend extra cognitive effort, often leading to cognitive overload.

The law of proximity also applies to objects that are temporally related. Mayer (2001) cautions the need to present narration and visual materials simultaneously by taking advantage of the separate visual and auditory channels in his Cognitive Theory of Multimedia Learning. Because visual elements such as a picture or an animation are being processed in the sensory memory separately from spoken words like a narration, the two processes can proceed simultaneously without creating extra cognitive load. The resultant effect is that a learner can better integrate the two sets of information from the two modalities to quickly form a perception, because the two sets of information are pre-organised by the designer based on pedagogical guidelines, the perception is more likely to be coherent with the learning task and to help in the subsequent parts of knowledge building.

When perception is viewed from a designer perspective, it refers to how well a tool can help a user extend his/her capacity (Woo & Wang, 2009; Woo, 2009). The notion of perception is very much framed by the theory of affordance (see Norman, 1988) which emphasises the relationship between the perceptions created by a tool and the actions it affords the user

(Kirschner, Strijbos, Kreijns, & Beers, 2004). Kirschner et al. caution that a tool must allow its user to perceive it as meaningful so that the user will take action to use it. In other words, the properties of the tool must be designed in such a way that they evoke a sense of usefulness when perceived by the user (McGrenere & Ho, 2000). And according to van Vugt, Hoorn, Konijn, & Dimitriadou (2006), it is the perception of wanting to use the tool that generates interactions between the tool and the user in the form of usage. Accordingly, Kirschner et al. (2004) also suggest that perception is dependent on the users' expectations, prior experiences and focus of attention.

Applying the designer's view of perception on APAs means that the interaction offered by an APA in a learning environment must be such that the APA appears useful to a learner to achieve his/her intended goals which, in turn, depend on the learners' past experience and expectations. This shows that the designer's perspective and the cognitive perspective are in many ways similar except that the designers are more concerned about users' perception on the usefulness of the tool (Moraes & Silveira, 2009) or in the case of this study, the design of the APA learning system.

Attention and perception are certainly crucial as the first stage of a cognition process, but what is their overall implication for the research questions of this study? The review found that perception can be adversely affected when the interactivity of material elements in the content is high which in turn has an impact on APAs, because an APA is a part of the interactive elements embodied in the content. This adversity is especially pronounced if the content to be learnt is new or unfamiliar to the learners. The corollary of the findings is that learning will be perceived as more effective if content material can begin with low element interactivity coupled with good instructional strategies. Good instructional strategies must also have the provisions to guide a learner's attention to move between salient points within

the material. Such a strategy is likely to address issues on what constitutes favourable responses when learning with APAs. This creates the first question for this study which is reflected in Research Question 1(a). In addition, the understanding about the importance of perception on usefulness given by the literature helps to decide which opinions are appropriate to answer Research Question 1(a).

The next part of discussion will focus on the second memory store - the Working Memory (WM). WM is the location where filtered information from the external source and the past information from the Long-term Memory in a person's mind will be integrated and new knowledge representation is worked out, hence the name "Working" memory.

#### *Working Memory (WM)*

The most recognised origin of WM may be traced back to the work of Baddeley and Hitch (1974) where they conceived that human learning involving information processing should be carried out via three sub-memories, the *visuospatial sketchpad*, the *phonological loop* and the *central executive*. The first subsystem is capable of processing spatial elements whereas the second is used to process verbal information (Low & Sweller, 2005; Sweller, 2002).

According to Baddeley (2002a), the two memory subsystems perform functions in accordance to the central executive which decides the transference of information in and out across the two subsystems. But exactly how the central executive manages information retrieval procedure from the subsystems is unclear especially when tasks involved is very simple such as adding two single digit numbers together (Imbo & Vandierendonck, 2007). As a result, Baddeley added a fourth subsystem called the "episodic buffer" to the existing system. This new subsystem is to improve the linkage between the different modes of information with time sequencing. The attempt is to provide a more complete representation of knowledge by integrating spatial, verbal and temporal dimensions into a complete whole (Baddeley, 2002a).

For example, different modality elements in a movie are strung together in time sequence by its episodes. Despite the improvement, critics remain sceptical about the robustness of the system. They found that the system lacks the ability to account for differences in sensory input and is not clear how the verbal subsystem would handle written words and spoken words (Crottaz-Herbette, Anagnoson, & Menon (2004). This is a recurring issue on how written words are to be processed. This issue was also cited previously in the discussion under Sensory Memory. In addition, by not referring to the physical inputs of the content, Baddeley's et al. theory is somehow incomplete because instructional design must start with the content. This may be attributed to the possibility that Baddeley's model was derived from a purely cognitive psychological basis and not for the field of instructional design. Besides this, some other critics such as Sweller (2005) are still concerned about the coordinating role of the Central Executive and question the evidence for its functional existence.

Sweller in the early years was also devoted to the work of cognitive memory but he approached it from another perspective. Sweller is more interested in the processes that take place within and outside the WM whereas Baddeley focuses on the structural affordances of the memory system. Sweller's conception of the WM is that it is very limited in capacity and duration (Sweller, 2005) but like Baddeley et al., he makes no clear distinction with regard to the modality structure of the memory. Although he does not deny the existence of dual modality as a possible form of information treatment and he concedes empirical evidence to support such effect (e.g. Frick, 1984), he prefers to leave the modality effect as "possible but vague" because he is not certain if the two modalities do interfere with one another or they simply function independently (Sweller, 2005).

Despite this, Sweller's CLT is able to resolve the problem of coordinating role for the central executive in Baddeley's model. Sweller argues that the central executive role should instead

be performed by the schemata residing in the LTM. A schema is a “cognitive construct that schematically organises information for storage in long-term memory” (Sweller, 2005, p. 29). Schemata can vary by age (Eggen & Kauchak, 2001) and also by person (Wingfield & Byrnes, 1981) and they are therefore learner-specific. Based on this, it implies that different people will have different ways of processing information in the WM and they produce different knowledge even when the information is the same. The recognition of differences among learners’ cognitive styles is a way of acknowledging constructivists’ way of thinking that advocate knowledge should be independently constructed based on one’s own understanding of the world (Land & Hannafin, 2000).

The literature review from the WM has pointed out strongly the inherent limitation of the human working memory which operates like a “factory” for producing knowledge. The literature also recommends optimising the visual and auditory modalities to cope with the limitation. All these have strong implications for using APAs in instruction. The fundamental use of an APA is to engender interactions to simulate social presence. But simulating interaction would mean adding more visual and auditory elements to the learner’s WM because of the inherent multimodality nature of an APA. This, together with the issue of interactivity of elements used in content (which has been discussed previously), makes integrating an APA with content delivery very challenging. Although some researchers (e.g. Atkinson, 2002; Baylor & Ryu, 2003; Kim & Baylor, 2007; Lester et al, 1997; Moundridou & Virvou, 2002; Mulken, Andre, & Muller, 1998) have claimed that APAs can enhance learning experience, it is not clear if such positive effect would be negated by the extra modality demands brought about by the APA, in particular, when the interactivity is low. This gives rise to the formation of Research Question 2(a). As suggested earlier under the section “Online Learning and APAs”, implementing APAs with high interactivity appears to be problematic and difficult to achieve pedagogical effectiveness.



### *Long-Term Memory (LTM)*

Cognitive scientists generally agree that knowledge formation takes place in the LTM (Clark, 2002; Kirschner, Sweller & Clark, 2006; Schnotz, 2005; Schunk, 2000; Sweller, 2005) although they may differ in what is actually stored in LTM. For example, Schunk (2000) contends that LTM stores knowledge in the form of propositional networks with words as the nodes in the network. Both declarative and procedural knowledge are stored in this form with slight modifications for procedural knowledge. Schnotz (2005) sees propositional representations as only one of the transitory sub-storages where its content needs to be integrated with another pictorial storage to form mental models which is the final form of knowledge representation. A mental model is an abstraction of multiple modalities including visual, auditory or even tactile information.

For Sweller, LTM is seen as storage of some abstract representations called schemata (definition has been described in previous section). When new information enters into WM, the schemata in the LTM will be activated and its relevance will be compared to the new information. If the new information matches closely with any of the schemata, the schema will decide how much more additional information will be required and how less is to be retained in the WM. Once this is coordinated, the schema will be reconstructed and returned to the LTM. In Piaget's term, if the reconstruction is minimally done, it is called "assimilation" (Eggen & Kauchak, 2001, p. 35). But if the reconstruction is largely different from the original one, then it is called "accommodation" (Eggen & Kauchak, 2001, p. 35). Therefore, the schemata control the interactions between WM and LTM and this assumes the role of a central executive (Sweller, 2005). Theoretically, the use of schemata probably gains more ground than the others because the concept of schemata has a strong root in Piaget's theory (Eggen & Kauchak, 2001) which has been proven to be both classical and seminal in

the field of developmental psychology. The acceptance of CLT can be seen by its wide application in many studies. For example, Kirschner, Sweller & Clark (2006) used CLT to justify that discovery style of unguided learning induces more cognitive load and leads to poorer learning than guided learning. On the other hand, Kalyuga (2008) used CLT to draw upon the interactions between a learner's expertise level and the effective use of instructional methods for a successful learning experience. In all, Sweller's CLT can be considered as one of the most influential theory widely used to explain how learning occurs with respect to instructional settings.

Two key features in CLT are considered very useful for the context of this study. The first feature concerns instructional methods. CLT emphasises the need to apply sound strategies to avoid overloading the limited capacity of WM. This has resulted in several important implications for instructional design. They are (a) the split-attention effect, (b) the modality effect, (c) the redundancy effect, (d) the element interactivity effect and (e) the imagination effect. Among all, (a), (b) and (d) are most relevant to the context of this study (Sweller, 2002).

Below gives a brief description of what they are, first, split-attention refers to having to attend to two or more relevant pieces of information which are spatially or temporally isolated from one another. This causes the WM to be overloaded. This has a profound implication for online learning (Ayres & Sweller, 2005).

Second the modality effect. It refers to how well content is presented in such a way to optimise the learner's visual and auditory senses in information processing. Presentation that uses visuals and audios complementarily tends to lessen the cognitive load and facilitates learning (Clark, 2005). The modality effect has a wide application. For example, Moreno

(2002) studied if verbal modality (measured by on-screen text, narration and the combination of both) has an effect on immersiveness of virtual environment (measured by choice of media). Choice of media refers to desktop computer screen, head mounted display while seated and head mounted display while walking. She found that college participants who learned with narration outperformed those who learned with on-screen text alone and with “on-screen text combined with narration” in retention and transfer tests. She concluded that modality effect did affect learning.

Third the element interactivity effect. This refers to whether the elements in the content including embodied elements from the APAs are highly related to one another and whether they can be learnt separately in isolation. Element interactivity has been discussed under “Online Learning and APAs” and “Attention” in earlier sections and hence will not be discussed again. But the fact that it has been mentioned so many times shows that it is a very significant component for deciding the appropriateness of an instruction.

For the second feature of CLT, the main concern is scaffolding. Sweller defines learning as one that processes all relevant elements of information simultaneously in working memory (Sweller, 2005, p. 25). Therefore for learning to occur, some form of assistance from external agents such as guidance from the content or past knowledge in the form of schemata from the learner must first be in existence and is made available. Failing which will render the learner resorting to trial-and error to establish his or her own heuristics in order to learn (Sweller, 2005). This implies that a learner’s past experience must be taken into account in the designing process. This again, is the third indication on the importance of learners’ characteristics.

The fact that schemata in LTM play a central executive role in the entire cognitive process as given by CTL indicates that instruction should be designed to take advantage of the learner's past similar experience or knowledge. When this is not possible such as learning a brand new topic which happens frequently in actual classrooms, then the executive role will be ineffective and must be complemented by external help, such as the guidance of a teacher. Can an APA take over such a role? This is equivalent to asking whether the APA possesses the human's complex ability to manage learning tasks, which themselves are often also complex. Though this may not provide direct answers to any research question of this study, it does raise an important consideration, namely, whether highly interactive APAs engendered by high-technology is sufficient to substitute the quality of a trained teacher? If not, should the pursuit of using highly interactive APAs in learning be reconsidered, or perhaps, APAs' interactivity should go low instead. This calls for the same answer which is to be addressed by Research Question 2(a) already mentioned under "Work Memory".

#### *Overall Implication from "Learner-Content Interaction"*

This review shows that human cognition is a complex process involving intricate interactions between the memory stores. These interactions are to a large extent dependent on external stimuli such as the content, the teacher, the instructional methods and the interactions made by all of them. It seems that the more interactive the learning environment is, the more intense the interactions in the cognitive process will be and hence the greater the challenges for learning. In real face-to-face classrooms, the challenges can be mediated and made easier by the expertise of a trained teacher; but the APA in an online setting might not possess compatible capacity - as the real teacher may - to handle complexity and the different forms of interactions between learners, content and the APA itself. The entire interaction process is further constrained by the individual's cognitive structure evidenced by the short-lived SM, the limited capacity of the WM and the insufficient schemata in the LTM to manage the

interactions between the memory stores when learning new things. It all seems to indicate that subjecting a learner to a highly interactive APA learning system might not be beneficial as a result. Consequently, it may be possible to use simple and not-so-interactive APAs on learning tasks that are appropriate for the chosen interactive level. If the low interactivity proposition works, then both Research Questions, 1(a) and 2(a) may be answered positively and favourably.

### Learner-APA Interaction

As pointed out in the previous section, learning involves paying attention to relevant information (using sensors), forming a perceived meaning of the information (in SM), comparing it with previous knowledge (schemata), making necessary modification of the meaning and creating a suitable mental representation (in LTM) to form new knowledge. If such a process is carried out without any external help, a learner will have to rely on his/her schemata to operate as a central executive control to coordinate the various processes. This, very often, induces learning difficulties due to the lack of strategies to cope with the limitations of human cognition. Common problems include split-attention and cognitive overload.

Therefore the most important role that an APA plays in such a learning process would be as an instructional mediator. It is to help the learner optimise his/her central executive control to manage the different cognitive processes adequately and properly. But mediating is a social act; an APA must also be able to engender a social interaction during the mediating process if the learning is to be fruitful. The following section focuses on how APAs utilise their interactions to enhance instruction and sociality.

### *APAs' Interactions on Learning Outcome and Experience*

Some research studies have shown that interacting with an APA can lead to a more enjoyable learning experience (e.g. Atkinson, 2002; Lester, Converse, Kahler, Barlow, Stone, & Bhogal, 1997; Moreno, Mayer, Spires, & Lester, 2001) but whether this will lead to better performance remains unclear. For example, a classic study by Lester, Converse, Kahler, Barlow, Stone, & Bhogal's (1997) about using an APA called *Herman-the-Bug* to design a plant. Lester et al. subjected participants to five types of agent interaction conditions, namely, fully expressive, principle-based animated/verbal, principle-based verbal, task-specific verbal and muted. Subjects were compared between pre-test and post-test scores to measure performance of problem-solving ability. Subjects were also required to rate their learning experience in terms of likability, believability and usefulness. Lester et al. concluded that fully expressive interaction gave rise to higher learning gains and affective rating than the other four conditions and hence inferred the presence of a persona effect which is the perception of "the presence of a lifelike character in an interactive learning environment" (Lester, Converse, Kahler, Barlow, Stone, & Bhogal, 1997). But this result is not convincing for some. Dehn and van Mulken (2000) pointed out that because it lacks control in the degree of animation and amount of advice given by the agents, the validity of the results needs further justification. Lester et al. also did not provide detailed description on the basis on which speech and gestures were coordinated, lacking such information makes interpretation of the results difficult. In addition, Moreno (2005) also made a similar comment on the same study, she noted that the study did not use a non-agent condition to be a control group in the experimental design and hence she found the finding inconclusive.

It seems that APA research has an inherent issue which is the unit size of the analysis. By unit of analysis is meant "the unit (e.g. individual, family, school, school district) the researcher uses to gather data" (Creswell, 2005, p. 600). APA's animation for lifelikeness cannot go without the voice and body actions such as gestures and gaze which are essential components

in human conversational behaviour. Therefore these modality elements cannot be investigated independently which means the experimentation must employ a larger unit of analysis. The result is that treatment variables often take a composite form and generalisation of findings can only be confined to contexts of similar nature.

The effect of the agent's interaction was revisited by Moreno, Mayer, Spires, & Lester (2001) a few years later. They conducted a similar study but with a tighter experimental control. The aim of the research was to understand if image and/or modality are the main effect(s) for learning and perception. Moreno et al. asked college students to interact with four types of learning conditions for learning science - agent image with narration, agent image with text, narration without agent, and text without agent. Moreno et al. found that subjects did better on retention, problem-solving transfer and interest rating when learning with narration and the result is independent of whether the agent's image is present or not. Consequently, Moreno et al. posited that agent image has no effect on learning or affective motivation and that the advantage of using narrative agents is due to modality effect. Hence Moreno's et al. findings run counter to that of Lester's et al. but Moreno's et al. findings appear to carry more weight because their design is based on controlled settings.

The issue of APAs' presence and modality on learning was again investigated and results reported in Atkinson's (2002) paper. He wanted to know how the presence of an APA and modality used in instruction to solve mathematics word problems could affect learning outcome and learning process. Learning outcome and learning process were respectively measured by ability to solve mathematical problems and subjective responses to two constructs: level of interest and the comprehensibility of the lesson. There were two parts in Atkinson's (2002) study; the first part was similar to that of Moreno's et al. (2001) in terms of experimental conditions (agent with voice, agent with text, voice-only, text-only and control).

The “text” in the text-only condition refers to explanations in written words and the “voice” in the voice-only condition refers to the same explanations but presented in spoken words. The “text” in the agent with text condition also refers to explanations but presented in a word balloon above the agent whereas the “voice” in the agent with voice condition refers to explanation in spoken words using human voice. Finally, the control condition is one that has no agent and no explanation in either spoken word or written word format. A point to note is that all agent conditions incorporated agent gestures and/or gaze.

Atkinson’s findings were consistent with that from Moreno’s et al. (2001) where agent with voice condition produced easier learning experience and higher learning outcome than the control condition in terms of far and near transfer measures. Similarly voice-only condition was reported to outperform text-only condition in terms of ease of learning and near transfer. But because of the small sample size (50 students) used in the experiment, Atkinson (2002) was cautious about drawing any conclusion.

The second part of Atkinson’s (2002) study was designed to partly overcome the above shortcoming. He combined voice, gesture, gaze and the visual presence of an APA to be a composite effect and called it the *embodied agent effect* (p. 425). This allows a simpler experimental stratification but a larger sample size (75 students). The embodied agent effect was to be compared with a voice-only condition and a text-only condition - the same two conditions used in the first part of the experiment. The results showed that instruction with APA’s voice and deictic gestures (with gaze) were useful means to direct a learner’s attention towards salient parts of the content as evidenced by an easier learning experience and a better scores for far and near transfer than its voice-only and text-only counterparts. Atkinson attributed the better performance to a reduction in cognitive load due to modality effect and embodied agent effect. But like the previous two studies, the speech and gestures coordination



were not explicitly explained nor shown to be based on some specific structures. So the exact speech-gesture interaction remains unclear despite knowing their joint effect is positive.

Atkinson's (2002) experiment also produced an unexpected result for which he did not give explanation; that is, the voice-only group was no better than the text-only group in terms of learning process and learning outcome measures. By not forgetting that voice-only means voice explanation over text presentation which is utilisation of both auditory and visual modality, the Atkinson's finding appears to be in direct contradiction to what most researchers have found, that is, the optimisation of dual modality is better than using single modality during cognition (Atkinson, 2002; Craig & Gholson, 2002; Mayer, 2001; Mayer, 2005a, 2005b; Moreno et al., 2001). Although Atkinson went a step further by examining combined data from the embodied agent condition and the voice-only condition and obtained a new outcome that ultimately supported the modality effect, he still did not offer any clear explanation to the new finding. So if Atkinson's data was correct, then his finding prompted a questionable area that needed further investigation, which is, why voice over text is not better than text alone and why the converse becomes true when an agent's animation is included?

This researcher, after taking due consideration of Marzano's (1998) finding on performance for modality, suspects that the unexpected phenomenon observed above could be related to individual differences. Previous discussions have pointed out several times the necessity to include learners' characteristics such as sensory preference (discussed under "Sensory Memory") and past experience (discussed under "Long-term Memory") into the instructional design. In Atkinson's case, the learners' characteristic could be due to individual sensory preference given the similar settings between the case previously discussed and that of Atkinson's (2002). The possible effect of sensory preference will be examined after the next section.

For now, the review focuses on two other areas that could possibly relate to APAs, they being subject matter and cultural differences. Research so far has used either Mathematics or Science as the subject matter in their studies. It is not known whether learning from APAs will be different for non-mathematics or non-science subjects. Baylor and Ryu's (2003) study might help to address this question since the subject matter used in their study is both non-science and non-mathematics and contains settings that are very similar to this study.

Baylor and Ryu (2003) found that APA's image and animation have no effect on pre-service teachers' performance when the subject of learning is instructional design. This contrasts with the findings of Atkinson (2002) and Moreno et. al. (2001). To explain this, Baylor and Ryu (2003) made specific references to the above two studies and from which they drew their conclusion - that it was the nature of the task which is related to the subject matter - that determines whether the APA effect is present. They argue that learning Mathematics or Science entails a more structured learning process which is in turn more predictable and hence allows the role of an APA to be more prescriptive as compared to Instructional Design, where the learning process is less structured and has to depend more on the APA's ability to provide advisement. Sharing a similar viewpoint is Wang, Johnson, Mayer, Rizzo, Shaw & Collins (2008), whose study required that students with a mix of engineering and non-engineering backgrounds learn engineering logistics concepts from an agent-based learning system. They found that students with engineering backgrounds did not benefit from the system, and the converse was observed for those with non-engineering backgrounds. Their explanation was that having relevant prior knowledge to learning engineering logistics made the learning less demanding and hence lowered the need for interaction with the agent. The advantage of having relevant past experience in learning has also been highlighted by Sweller (2005) in previous discussion. For those without prior engineering knowledge, quite expectedly, found

the task challenging and needed more help from the agent. This task demand and cognitive load relationship was also acknowledged by Clarebout and Elen (2006) whose findings are coherent with those above.

In consolidation, the literature review indicates that it is not the subject matter that is key to the effectiveness of APAs, but instead, the nature of the learning task that plays the decisive role and the prior knowledge of the learner.

Baylor and Rhu's (2003) study, in addition to the above contribution, has a further observation that might throw more light on this study – namely, the effect of ethnicity of the learners. Baylor and Rhu's study used participants that were mixed ethnicity, comprising 84% Caucasian, 4% Hispanic, 10% African American and 2% the others. Since the study showed that the learners did not gain any performance benefit from learning with the APA, the corollary of this would be that learners' ethnicity as a whole did not confound the learning. Alternatively, it could be that each individual ethnic effect nullifies others and renders the overall effect neutral. Although Baylor and Rhu did not supply an analysis or conclusion on this, they did suggest further investigation to examine the ethnicity of APA instead of the ethnicity of the learners.

In fact the effect of APA ethnicity on learning is not well researched (Greysen, 2008). This is probably due to the fact that instructional agents are commonly treated like classroom teachers whose ability to teach is far more important than their ethnicity. Reeves and Nass's (1996) famous "Media Equation theory" can be a good testimony to this claim. What Media Equation theory informs us is that humans have a unique tendency to regard media elements situated on a computer screen (e.g. APAs) as social entities. In a similar vein, an instructional APA embodied in a computer system can be equated to a real human instructor and be

accorded all the social expectations that are typical of a real instructor. This phenomenon can be confirmed by using findings from Greysen's (2008) study, where participants were asked to construct an APA interface to support instruction. One of their tasks was to assign the APA with ethnicity and gender. The study observed that participants tended to design the APA with gender and ethnicity similar to their own characteristics. Such stereotyping phenomenon, according to Greysen (2008), is due to cultural influences. Males are historically portrayed to be the role model in many fields such as business and politics, and although women are fast in catching up, they are still not quite in the same hierarchy yet; however their desire to be seen as equally important is manifested in the type of APAs they designed. This cultural influence, as the author of this study concedes, may be even more prominent in the Asian society given the long historical background of male dominance in the past. This has implications for this study as most of its participants are Asians by ethnicity.

Though the influence of cultural biases remains possible, it may not be detrimental to learning after all. Moreno and Flowerday's (2006) noted that the performance of learners, despite having a preference for their ideal APA, was nonetheless unaffected by this preference. In other words, gender and ethnicity of an APA have no obvious effect on learning. But Moreno and Flowerday (2006) also cautioned the possibility of an "experimental effect" which means learners' awareness of the fact that they were in an experiment could have a confounding effect on their behaviour.

It appears that any cultural influences on learning with APAs have yet to achieve conclusive understanding. It is thus advisable to remain cautionary when using APAs that are sensitive to gender and ethnicity in instruction. Perhaps a better way to address this issue is to use non-humanlike APAs so as to avoid unnecessary interference and possible complication. This suggestion is supported by two groups of researchers: the first is Buisine and Martin (2007)

who found cartoonish APAs could produce greater likeability; and the second, from Ruttkay, Dormann, & Noot (2004) who argue that non-humanlike APAs can be more appealing and entertaining (Woo, 2009). Whatever the choice is, the fundamental consideration still lies in knowing the purpose and context of the learning which was highlighted in earlier discussion.

In sum, the review above helps to confirm the advantage of using voice over text for explanation, also the need to know the context of learning and the exact nature of the learning tasks. This gives rise to design directions to make agent interaction simple which helps to address the issues of perception and effectiveness of low interactive APA instruction.

Knowledge about perception is used to frame Research Question 1(a) and likewise, knowledge about effectiveness is used to frame Research Question 2(a), as pointed out in the review. The review also found a possible a cultural dependency whereby different ethnic groups might prefer agents with the same ethnicity. Such dependency may be negated by using ethnic-independent-cum-non-humanlike agents, such as a cartoonish character. Subject matter was found to have no influence on APA instruction. There are two unanswered areas identified by the review, they are: speech-gesture coordination and learners' characteristics. The two areas will be discussed in the next two sections.

#### *a. APA's Speech-Gesture Coordination*

Speech and gesture coordination for an APA is an area that has not been frequently researched due partly to the difficulty of formulating a precise model to delineate the exact manner of coordination. Of special interest and relevance to the topic on speech-gesture coordination is the *Temporal Contiguity Principle* (TCP) proposed by Moreno and Mayer (2000) and also Mayer (2005b). Basically, the principle states that “students learn better when verbal and visual materials are temporally synchronised rather than separated in time” (Moreno & Mayer, 2000, p. 751). Mayer and Anderson's (1992) research showed that when the information to be

shown is in large quantity (called large chunk), then showing a large chunk of animation simultaneously with another large chunk of narration is pedagogically better than showing the same two chunks of information sequentially. However, if the chunks are small, and assuming that they do not exceed working memory capacity, then there will be no difference between presenting the two chunks of information (one narrative and one visual) either sequentially or simultaneously (Moreno & Mayer, 2000). In fact such a need to chunk content into manageable and meaningful lots has been highlighted frequently by cognitive psychologists (e.g. Eggen & Kauchak, 2001; Ormrod, 1995) as a technique either used by a learner or a designer to help overcome the limited cognitive power in humans. The TCP is in fact an extension of such technique.

The implication of the TCP for an APA's speech-gesture coordination is that sentences for speech must be made as short as possible and the visual to be studied should not take too much cognitive effort to interpret. This is because other than the APA's own speech and the visuals from the content, the APA's own image and gestures could also form part of the cognitive load especially with the short-lived nature of the sensory memory. Hence if one can design a presentation meeting such requirements, then it will have the flexibility to present the speech either in synchronisation with the visuals or immediately before or after the visuals.

Perhaps a more thorough understanding may be obtained from Buisine and Martin's (2007) study. They investigated empirically which of three modes of speech-gesture coordination yields better learning outcome and subjective perception of the learning. Learning outcome is measured by written recall and graphic recall whereas subjective perception is measured by quality of explanation, likeability of the agent and expressiveness of the agent. The three modes of speech-gesture coordination used in the treatments are: redundancy, complementarity and control. Redundancy refers to duplicating the information via speech

and gestures whereas Complementarity means distributing the information across speech and gestures. Control group has the agent's speech but gesture is limited to non-semantic type which means not related to any object in the lesson (p. 487).

The results of the study identified that Redundancy was the best mode of presentation which outperformed others in written recall and all dimensions of subjective measures. Buisine and Martin (2007) attributed the superiority of this mode of presentation to the repeated verbalisation when referencing to an object item in the lesson. The result is to help learners encode verbal information. This explains why only written recall is benefited from this mode of learning. As to why redundancy, an uncommon practice in real human conversation, can invite such a good subjective rating, Buisine and Martin (2007) believe that it is because redundancy helps to increase learners' memorisation and hence is perceived as more likeable. This may be taken as an indication that usefulness of the agent's participation in the learning process is the key to favourable perception.

To sum up, it may be said that an APA has the potential to engage a learner through its persona effect which in turn depends largely on its ability to speak and animate to engender an interactive forefront. So the way speech and animated movements are coordinated will impact significantly the extent of interaction a learner receives (Woo & Wang, 2005). The review has put together various findings to provide a simple but yet effective way to use APAs effectively in instruction. That is to use short sentences for explanation and cognitively less demanding visuals to form the basic instructional elements; then coordinate the explanation with gestures to direct learners' attention either in a sequential or concurrent manner. The proposal so described helps to fine-tune the Interaction Framework proposed by this study and provides strategies for designing learning systems using low interactive APAs. But there is uncertainty about how effective such a system will be and whether it will gain the

appeal from the learners. This concern is an affirmation of the need to evaluate any low interactive APA instruction that is designed by using this Interaction Framework. This also confirms the formation of Research Questions 1(a) and 2(a). The review will continue to explore the other unanswered area in the next section.

#### *b. Learners' Characteristics*

Earlier reviews highlighted the need to examine learners' characteristics because learning is an activity that requires learner's past experience and individual differences. The review also pointed out, in particular, sensory preference, as a potential factor to influence a learner's perception of APAs and hence the instruction. This is because an APA, by its make-up, can engender multiple modalities which can have repercussion for learning if they are not coordinated properly. Improperly coordinated modalities in instruction can complicate the interactions between a learner and the instructional elements which, according to Cognitive Load Theory, can cause cognitive load to increase. Multimedia Design Principles also highlighted a close relationship between modality and the sensory functions of a learner where the relationship is commonly described as the Sensory Modality View (Mayer, 2001). Hence, it can be inferred from the literature that how an individual learns will depend on what modalities the APA uses to deliver the instruction and how the learner uses his/her sensory functions to interact with the APA. What is not certain here is whether the use of sensory function is affected by one's preference for a certain modality? In other words, will sensory preference interfere with learning through an APA's modality? This is what needs to be explored in the next section.

#### *Learners' Sensory Preferences and APAs' Modalities*

Literature on how sensory preference is related to APA modalities is scarce, and is even more so for low interactive APAs. While studies have investigated the relationship between



learning styles and software agents in order to address adaptivity and automation issues (e.g. Choy, Ng, & Tsang, 2005; Esmahi & Lin, 2005; Sun, Joy, & Griffiths, 2007), seldom do they refer to embodied agents, in particular, agents with low interactivity. Hence knowledge about learners' sensory preference and modality used in APA instruction remains sketchy and tenuous.

There are many reports suggesting modality in instruction is related to learners' sensory preferences. Higgison (2000), for example, found that about 65% of learners are visual learners who are more adept at processing visual material (Hapeshi, 1993, p. 181; Tanner & Allen, 2004, p. 198). The report from the Learning and Skills Research Centre (Coffield, Moseley, Hall, & Ecclestone, 2004) also cited research findings that about 60% of us are visual learners. Abdelhamid (2003), in one of his studies, obtained similar findings that college students were mostly visual learners and their instructors were also inclined to use visually-enabled methods in instruction. Yet in another study, Zywno (2003) reported a weak but positive correlation between the extent of visual preference of engineering students and the appeal of multimedia in learning. The above observations may be explained in Tanner & Allen's (2004) findings that learning styles are related to the type of instructional modality one is frequently exposed to. For example, the mode of instruction in college education is mostly verbally-oriented, most college students are therefore quick to pick up the skill to process verbal information proficiently (Tanner & Allen, 2004); this explains why college students are mostly visual learners and why they are better at using their visual modality. However, despite the common views shared by the above studies that adult learners tend to use their preferred modality to learn, some researchers such as Coffield, Moseley, Hall and Ecclestone (2004) hold an alternative view to claims related to learning styles.

Coffield et. al. (2004) in their influential report pointed out two common flaws in studies that involve learning styles. First, there is a lack of scientific evidence to prove the existence of style and thus its effects on learning; second, these studies overemphasised the need to match instruction with learners' styles of learning. Agreeing with this view, Pashler, McDaniel, Rohrer and Bjork (2008) proposed an alternative method to mitigate the condition. They pointed out that for learning style effect to be scientifically evidenced, a "crossover interaction" between learning styles and instructional methods must first be obtained empirically. For instance, to show that learning styles A and B have an effect on instructional conditions will require learners in style A to do well in one instructional condition but poorly in the second instructional condition and vice versa for learners in style B, which means learners in style B must simultaneously be shown to do poorly in the first instructional condition but well in the second instructional condition. Pashler et.al. also cautioned that even if a study can demonstrate the crossover interaction condition, its results remain applicable only to that particular classification of learning style because the definition of learning styles varies with settings and purposes of the instruction. Implicit in Pashler et. al. statement is that the nature of the instruction is the major determinant of the learning style effect.

Despite the dissent expressed by Coffield et. al. (2004) and Pashler et.al. (2008), both groups of researchers do agree that there are well-designed learning styles' studies that could produce reliable results to inform teaching and learning. Cited by Pashler et. al., one of the notable studies is by Massa and Mayer (2006) who investigated how verbalised and visualised help-screens were related to learners' sensory preference during a computer-based lesson. The study found learners who received help-screens that matched their preferences did not produce better performances. However, because the study did not specify enough how the help-screens were actually used in the learning process, it is not clear if all the elements in the task are related to the specific sensory preference. For instance, the visualised screen could

contain predominantly pictures, but could also have word labels embedded in it, or it could be that learners were pre-exposed to some on-screen verbal instructions prior to accessing the visualised screen. In either case, the elements in the activity were not all that “visual” but were contaminated with other “verbal” components. In other words, activities that are proclaimed to be visual or verbal by nature may not necessarily be wholly so. This could be the reason why studies which purportedly claimed relationships between learning styles and performance without reporting details of the task, failed to produce convincing results. This phenomenon can be explained by what Carbo (1983; cited in Coefficient et.al, 2004) called “the methodological weakness” of research studies.

Other studies that lend support to the above argument include Miller’s (2005) study on how learning styles impact learning by using Computer-based Instruction (CBI). In Miller’s study, learning styles were measured by using Kolb’s Learning Styles Inventory (LSI) and Gregorc Style Delineator (GSD). LSI measured Accommodation, Assimilation, Convergent and Divergent thinking whereas GSD measured Concrete Random (CR), Concrete Sequential (CS), Abstract Random (AR) and Abstract Sequential (AS). Miller found no interaction effect between performance and learning styles when LSI was used. For GSD, however, they found a significant difference between performances of Concrete Random (CR) and Concrete Sequential (CS) learners with the former outperforming the latter. Miller attributed the null-effect associated with using LSI to not taking into account the format of the CBI. As a result, Miller suggested that future research should take into consideration the compatibility of CBI format with learners’ preferences. CBI format, as referred to by Miller, means the specific elements that the learners interacted with during the instructional process. This again, is testimony to the problem of lacking learning task details and elements for interaction exhibited by some of the studies.

In another supporting study, Chou and Lin (1998) studied Taiwanese university students and how they used hypermedia to learn computer networks. They, like the other researchers, found no cognitive style effect when styles are used as the only measure to relate to learning. But when the study took a further step by looking at how learners interacted with the nodes (hyperlinks) in the hypermedia, they found field-independent learners outperformed field-independent learners on cognitive map tests. Cognitive maps tests are used to evaluate learners' ability to reconstruct relationships among the nodes in the hypermedia. The study also affirms the need to include information on task elements for interaction as a necessary component in the research methodology.

In yet another study, Plass and Jones (2005) also found supporting evidence to demonstrate the *Individual Differences Principle* (IDP) explained by Cognitive Load theory. IDP simply means to provide learners the choice of using visual or verbal information to support learning. Plass and Jones reported that when learners interacted with learning elements such as choosing between visual or verbal annotations to help them learn vocabularies, those who chose annotations that had modality correspond to their preferred learning styles, learned better. They attributed the better learning to a lessening of cognitive load when learners are able to use their preferred styles for learning. Although Plass and Jones' findings did not add new weight to the aforesaid requirement, they help to explain why people have preferences for a certain modality; in particular, they suggested the connection to cognitive load which has already been cited in many previous sections.

At this stage, it seems clear that the relationship between a learner's preference and his/her performance is not straightforward but through the interaction with the instructional elements which include voice, gestures of an APA and size of information presented. This supports the formation of Research Question 1(a) which questions the perceptions of the learners. More

importantly, it also points to the necessity of knowing whether Research Questions 1(a) and 2(a) are also affected by sensory preference. This gives the initial conception for Research Questions 1(b) and 2(b). The relationship between sensory preference and cognitive load will be further discussed in the next section.

### *Sensory Preference and Cognitive Load*

It was suggested in a previous section that cognitive load can be reduced if a learner interacts in a task involving modalities of his/her choice. Why is this so? According to Cognitive Load Theory (CTL) discussed in early sections, constant practising and rehearsing of tasks produce what is called *automaticity* which makes the tasks “require less attention as they become well learned (Shiffrin & Schneider, 1977 cited in Slavin, 1997, p. 202). Less attention means more cognitive capacity may be spared for other secondary tasks in a learning process (Ormrod, 1995). This familiarity effect is especially significant when one is engaged in a task that s/he is not familiar with. For example, Low and Sweller (2005) cited an experiment about shadowing a typist on two different tasks to demonstrate the effect of modality. In the first task, the typist was asked to type from a given text message while simultaneously listening to an oral message; in the second task, the typist was to carry out the same typing task but with the text and oral message reversed order. The experiment found that the typist had no problem performing the first task but had difficulty for the second task because most if not all traditional typists are trained to type from text messages, not from an unfamiliar condition like the oral message which involved unfamiliarity.

In a report given by Gyselinck, Jamet, & Dubois (2008) that has relevance to sensory preference found that modality effect was not an invariant that could be generalised across all users of multimedia. Their claim was derived from not able to get a modality effect in their concurrent-task experiment. In a further analysis to relate the findings to the types of learner,

they found that modality effect applied positively to high verbal learners but negatively to high spatial learners. Hence, they postulated that the effects from the two types of learner could have nullified one another giving rise to the neutral modality effect. Studies that do not highlight the nature of the task normally lack research rigour. But the finding from Gyselinck (2008) et. al. is still important because it reminds us that a task can inadvertently invoke other learning styles which are not called for but can nonetheless be related to modality - like the verbal and spatial styles illustrated in Gyselinck's et. al. study. This brings to light again the need to know how learners interact with the task/instructional elements, which means learners must be given an opportunity to explain how they interact with the task elements. The implication is that instruments used in this study should have provision for freely expressed opinions. In regard to the present study, there are implications for Research Question 1(a) in terms of designing questionnaires to elicit learners' perceptions.

In all, the review of the literature on sensory preference has informed this study in three important ways: (1) Sensory preference can interfere with learning but does so only through the interaction with the task elements; (2) Because sensory preference does not impact learning directly, this study must make provision to elicit learners' responses on how they interact with the task elements; (3) Learners' preference for a certain modality is due to familiarisation of working in that modality. This is because working in a familiar condition requires less cognition to function and will result in a perception of the task as easier. With the knowledge of point (3), the need to query the possible interference of sensory preference is now supported. This gives rise to the formation of Research Questions 1(b), 2(b) and 2(c) which query the confounding effect of sensory preference on respectively learners' perception, low interactive APA instruction and types of instruction.

#### *APAs' Multiplicity and Sociality*

The above discussion so far confines learning conditions to using single APA. But believers of social context learning find that agent sociality may be enhanced by using multiple agents (Hietala & Niemirepo, 1998). This is because multiple agents have the ability to display social behaviour in a group setting which shares similar contexts in many human activities (Beun, de Vos, & Witteman, 2003). Baylor and Ebberts (2003) found that two agents playing two difference roles are better than one with the same two roles because the social cues from two different agents can be distinctively segregated to avoid confusion. Very often, in a real face-to-face learning condition, a teacher has to play many roles such as an expert and a motivator simultaneously. This may be manageable for a real teacher but not for an APA which lacks the kind of subtlety to exhibit the complex behaviour to handle such task (Woo, 2009).

The advantage of using two agents can help to resolve the problem as illustrated in Krenn, Pirker, Grice, Baumann, Piwek, & Deemter's et al. (2002) *eShow Room* project. In this project, they simulated a car sales scenario through the dialogue of two lifelike agents, one acted as a human buyer and the other acted as salesman. A real human buyer is to learn from the enactment of the two agents and then makes informed choice about whether to buy the car or not. The entire learning process is set in a social context which employs the concept of vicarious learning (see Eggen & Kauchak, 2001, p. 238-239; Slavin, 1997, pp. 171-172) to dramatise the presentation (Woo, 2009).

The use of multiple agents appears to be a promising strategy for systems that intend to use modality as the main vehicle for simulating sociality. This, together with the understanding on speech-gesture coordination, will help to design a more effective low interactive APA instruction system which will impact the answers to Research Questions 1 and 2 as a whole.

#### APA-Content Interaction

The interaction between an APA and the content may take several forms such as an APA using its deictic gestures to illustrate a chart, map or sentence or using its speech to explain auditorially or the combination of both. But because such interaction does not make the involvement of content explicit, very often, the interaction is classified as Learner-APA interaction rather than the interaction specified in this section. For this, there is little or no known literature that falls exactly under this form of interaction.

But there is still relevant but indirect literature that can be helpful to this section, for example, the study by Betrancourt and Bisseret (1998). They wanted to know whether presentation of text and pictorial information in illustration learning is most useful when text explanation and pictorial illustration are (1) displayed separately in different locations (split display), (2) placed close to one another (integrated display) or (3) using pop-up windows to substitute the text explanation (pop-up display). Using recall and transfer as the means to measure the learning of a sample of twenty four university students, they found that both pop-up window and integrated group outperformed significantly the split condition group in terms of recall and recognition tests despite no significant difference was observed between the pop-up and integrated groups. They attributed the non-significance observation to a “ceiling effect” which occurs when “the range of difficulty of the test items is limited, and therefore scores at the higher end of the possible score continuum are artificially restricted” (Gall, Gall, & Borg, 2003, p. 427). But in terms of speed of recalling and recognising, pop-up window group outscored the other two groups. However, because of the small sample size used in the study, the above conclusion must be viewed with caution.

Pop-up windows have an additional advantage. Most people would suspect a pop-up window would easily divert a learner’s attention away because of the sudden popping effect, and is the reason to cause split-attention and distraction. But when the popping is done by the learner



just as it was used in the study, the action becomes conscious and deliberate, and the learner becomes alert; this makes pop-up windows a good tool to direct attention and promotes active learning (Betrancourt and Bisseret, 1998; Stark, 1990).

The use of pop-up windows in multimedia learning was again investigated by Erhel & Jamet (2006). They used the same experimental conditions as Betrancourt and Bisseret (1998) which are: separate, integrated and pop-up window although the experiment was not conducted intentionally for comparison. Erhel & Jamet found two contrasting observations between the integrated and pop-up groups. The observation is that they did not find the pop-up condition better than the integrated when the measure of the outcome involved interpreting and reconstructing information into verbal form. Because this measure requires a reprocessing of information from its original form of display, the effect of information display (integrated or pop-up format) becomes irrelevant. Therefore, any difference between the two display formats becomes difficult to be established empirically.

The second observation is that when the measure of outcome involves tasks that require construction of perceptual representation based on the display format of the original information, then the pop-up window condition becomes more superior to the integrated condition. Erhel & Jamet (2006) attributed the outcome to an overcrowding of visual elements in the integrated format that tended to overload the perceptual process during cognition.

In all, the positive result of pop-up windows to improve learning appears to be applicable to APA learning. Consider the ability of an APA to synchronise its behaviour with the surrounding, this gives the possibility to synchronise the pop-up windows as an attention grabber during the APA's instruction. The effect is analogous to the learner activating the pop-up window except that the activation is now done by the APA. Of course, there is no

guarantee that the effect will be effective until it is verified experimentally. The pop-up windows should be integrated with other design functions such as the speech-gesture coordination to instantiate a low interactive APA model. Only then can the effectiveness be fully evaluated against the Research Questions.

### Overall Summary

An APA, by its very own multimedia nature, when coupled with the multimedia of the content found in most online learning, can cause complex interactions between a learner, the content and itself, which in turn can be detrimental to learning. One possible way to resolve this problem is to use low interactive APAs instead. But how to design instruction using low interactive APAs remains unresearched. This study proposes using an Interaction Framework guided by literature review to design the instruction.

When a literature review for the Interaction Framework was carried out, it was found that human cognition, though complex, can be facilitated by providing external help such as a tutor's scaffolding and just-in-time guidance. These tasks are not easily achievable by an APA unless they are instantiated with the help of sophisticated Artificial Intelligence (AI). But using AI is neither practical nor intended for this study.

Further review of relevant literature such as cognitive theories, affordance theory and other research findings found that a learner's view on the meaningfulness of instruction is instrumental to the success of the learning. Meaningfulness is often determined by ease of interacting with the content elements and the types of guidance given to help focus attention. Applying these considerations to APA instruction entails knowing how well a learner perceives the instruction and this in turn will help us know how low APA interactivity

enhances or impedes learning during the instruction. The need to know how the learners perceive the APA instruction prompted the conception of Research Question 1(a).

In searching for more understanding about designing low interactive APA instruction, useful design principles such as split-attention and cognitive overload provide the clues to strategise instruction using simple interactions. This includes delivering information in bite-size units and the use of agent voice in short sentences. However, to instantiate short-sentence speech may have practical issues because real humans seldom converse by just using short sentences. This means that APA instruction employing such speech techniques must be evaluated empirically against its effectiveness. The concern for instructional effectiveness is the basis for formulating Research Question 2(a). As the review went on, more design strategies were derived. These included using pop-up windows to synchronise with background illustrations in such a way as to help focus attention; coordinating an APA's speech with its gestures in a "redundant" manner and using multiple agents to enhance social interactions. The review also found no direct relationship between APA learning and subject matter, but it did find a possible dependency on the ethnicity of the agent used. Thus using an ethnic-independent agent such as a non-humanlike cartoonish character may seem probable. Though the review provided several useful design strategies, they appear piecemeal, and it is not known how effective the instruction will be when all the strategies are synergised together to render the instruction. This reaffirms the need to know the overall effectiveness of the instruction and hence the requirement for Research Question 2(a).

The literature review despite offering the above findings also highlighted an area that is of special importance to APAs, namely, the possible relationship between modality of APA and learners' sensory preferences. The impact of sensory preference on APA learning is a controversial one due mainly to a large body of research that has failed to produce convincing

results to demonstrate the relationship between individual preference and performance. The controversy may be resolved if those studies could provide more details on how individual preference such as sensory preference interacts with exactly what kind of modality elements; for instance, if the modality is delivered by a short-sentence voice or personalised speech? In other words, the finding should not just report using “voice” as the modality but furnish more details on what is interacting with the learners’ preference. Because of this potential confounding effect induced by sensory preference, it becomes necessary to raise the question of how the perceptions of learners and APA effectiveness are affected by this effect. Additional questions must therefore be included to complement the existing research questions. This leads to the formation of Research Questions 1(b) and 2(b) that respectively ask for the effect of sensory preference on learners’ perceptions and on effectiveness of the APA instruction. But in the event that Research Question 2(b) is positive, then there is another need to investigate whether sensory preference also influences types of instruction and what kind of interactional effect it produces. This results in the last Research Question 2(c). As always, the research questions have a crucial role to play because they are used to frame the research methodology which will drive the rest of the chapters in this study.

## **CHAPTER THREE**

### **METHODOLOGY**

#### Introduction

The main aim of this study is to find out whether instruction using low interactive APAs is effective and how learners perceive such instruction. The study also wants to know if the learners' perceptions are influenced by learner background characteristics. The following rationale explains and justifies this aim.

In Chapter One, issues were raised regarding the use of highly interactive APAs for instruction, including the over-reliance on high-end technologies to simulate the APA's "intelligence" and the difficulties faced by small-time designers like school teachers and non-technical instructional designers. To find a possible solution, this study proposes using low interactive APAs instead. This is because many effective instructional tools are designed based on the concept of affordances which stress the connection between the tool's usage and the user's perception of the tool rather than the technical sophistication of the tool.

In Chapter Two - the review of relevant literature, the complexity of the nature of human cognition and the kind of interactions that an APA has to handle if it is to manage instruction like a human teacher – were outlined. Based on the findings of the review, this study proposes a tripartite Interaction Framework (refer to Figure 2.1) that allows the interactions between an APA and its environment to be studied in a more systematic and holistic manner. The framework delineates interactions from three perspectives: Learner-Content Interaction, Learner-APA Interaction, and APA-Content Interaction. Under this framework, this study found that instruction using APAs can be made effective without using high APA interactivity if the instruction focuses on aspects of design that will minimise the cognitive load for

learning and maximise the potential of using modality to present the instruction. The review also found that sensory preference is probably a key learner's characteristic that has an effect on such an APA instruction. Detailed findings are to be discussed under the section named "The Treatment".

The research questions that guided Chapter Two are reproduced here as a reference for discussion:

1. How favourably do learners perceive instruction using low interactive APAs?
  - a. What are the opinions of learners on instruction using low interactive APAs?
  - b. Do their opinions differ with respect to differences in sensory preference? If yes, how do they differ?
2. How effective is instruction using low interactive APAs in terms of helping learners learn?
  - a. How do learners' achievements from instruction using low interactive APAs compare with that from more conventional online instruction?
  - b. Does the achievement vary in accordance with learner's sensory preferences? If yes, how does it vary?
  - c. In view of the answers to 2(a) and 2(b) above, what is the joint impact of types of instruction and sensory preference on achievement?

The purpose of Chapter Three is to explain and justify the research paradigm, approach and method that are appropriate in addressing the research questions. In the case of this study, the process of inquiry involves knowing the "effectiveness" and understanding the "perception" of using low interactive APAs in instruction, both of which can be approached from two probable but differing world views, the positivist and interpretivist paradigms. Each paradigm has its own research tradition to support its own ontology, epistemology and hence the methodology (Corbetta, 2003). Each methodology in turn determines the type of data to

collect - quantitative or qualitative, and the types of collection processes and the data analysis methods (Tuckman, 1999).

In the following sections, the researcher first provides a context for his research by explaining his research stance, his relationship with this study and with the case Institution. He then explains how he formulated the research design. Under the design, the type of approach, sample, subject matter and treatment procedure are explicated. The next part of the chapter concentrates on managing the data. This includes data collection processes using instruments, pilot testing the instruments for verification of validities and reliabilities, ways of coding data and the methods of analysing the data. Last but not least, this chapter also gives a discussion on how this study addresses ethics issues that concern confidentiality and freedom of choice, and also the problems that limit the generalisability of the findings.

### Context of the Study

This section provides a discussion on how the researcher views the setting in which the study is situated. This includes his research paradigm, his views on the case Institution where the study is conducted and his relationship with the study. This gives the backdrop of the research study.

### *The Research Paradigm*

This study adopts a positivist paradigm. The ontology and epistemology of positivism assume respectively that social reality exists outside an individual and the social reality can be objectively understood (Corbetta, 2003). The practical implication of such a philosophical orientation is that social phenomena may be construed as “objects” that exhibit characteristics with lasting patterns and regularities which are knowable through scientific intervention such as experimentations. This also means that social phenomena are predictable and generalisable

if the conditions giving rise to the phenomena are known (Cohen, Manion, & Morrison, 2007). Drawing from such a belief, the researcher of this study sees a coherency between the nature of the inquiry for this study and that of positivism. This is because firstly the researcher believes that the behaviour of the subjects responding to a computer-mediated lesson such as the agent-based lesson used in this study would not change much within a considerable period of time. And should there be any variation to the behaviour, it would be considered as unwanted fluctuations or “noise” as described by Gall, Gall & Borg (2003, p. 18). This is particularly so when the research has to deal with learning styles such as sensory preference which is usually quite resistant to change over a short stint of time (Coffield, Moseley, Hall, & Ecclestone, 2004, p. 23; Myint & Yeap, 2005, p. 18). The posited lasting effect of the observed phenomena allows this study to generalise its results to a larger population of pre-service teachers which is a necessary requirement for the research questions of this study.

Secondly, the researcher also believes that certain truths must exist in life and that these truths must be acceptable to most people objectively such that they can be used as a basis to explain the many other phenomena we encounter every day. Without the presupposition of these truths, the reality of “building new knowledge from past knowledge” will not be possible and the establishment of “cause-and-effect” relationship will be futile. In social science because it deals with humans, causal relationship between phenomena may not always be discernible (e.g. see Corbetta, 2003) but this does not deny the need to pursue such relationship. For example, the investigation of whether poor performance is caused by poor classroom conditions is a possible inquiry that can be pursued by positivism because classroom conditions can be manipulated by experimental means. What experimentation in social science cannot do is that is that it may not be able to determine the causes to the exact degree of the hard sciences. Because of this, some social scientists advocate that social inquiry should focus on knowing the “how” rather than the “what” as in the pursuit of causality. This



gives rise to the interpretivist approach of inquiry. According to Gall, Gall, & Borg (2003, p. 23), an interpretivist approach is “grounded in the assumption that features of the social environment are constructed as interpretations by individuals and that these interpretations tend to be transitory and situational”. In other words, social phenomena understood from the interpretivist perspective are localised and subjective; they are not meant for investigation of causality and for inquiry of a large sample pool such as that used in this study. Grounded in the above thinking, this study finds greater suitability for using positivism for its research inquiry and consequently it will design its methodology with the positivist orientation.

### *The Case Institution*

The institution involved in this study is a sole teacher training institution in Singapore to provide pre-service training and in-service training as well as undergraduate and postgraduate courses in the field of education. It is also the institution where this researcher works.

The institution maintains a close tie with the Singapore Ministry of Education (MOE) and has a mission to pioneer new pedagogies including educational technologies that complement the policies initiated by the MOE. One of the largest initiatives launched by the MOE was the *iN2015* nation-wide project that aimed at spearheading a massive island-wide communication network upgrading and a pervasive use of digital technology in both the industry and education sectors. The call for such a wide-spread use of ICT has an impact for the case Institution as the only teacher training establishment in Singapore. It means the institution needs to launch more online courses in order to leverage the potential of the new infrastructure. Finding effective ways to run the online courses becomes crucial. The use of low interactive APAs provides the possibilities for these courses to be delivered in a less expensive but more innovative fashion. Seeing it in the same light, the case Institution offered its help to this researcher to carry out his study with the hope that the research findings would

provide answers on the effectiveness of using APAs and shed light on how agent technology may be further exploited. The researcher benefited a lot from the institution's kind support and accommodation for request, without which, this study would have been impossible.

### *The Researcher's Positioning in the Study*

The researcher of this study is subject to both external and internal factors that could influence his objectivity in the research process. This is discussed below:

#### 1. External Factors:

The subjects in this study were the same students that this researcher was teaching during the course of the experimentation. As a result, the researcher has a vested interest in the outcome of the study. The same is true for the other tutors who helped in the implementation of the treatment because they too were teaching the same subjects. To remain objective in the whole experimentation process, this researcher took the following measures: to ask his colleagues to conduct the experiment for his own classes and to explain to his colleagues and pre-service teachers that it was necessary to maintain a homogeneous learning condition if the study was to be useful; and the researcher requested that they refrain from discussing the online lesson until the quiz was taken by all. However, because monitoring the implementation process for every class is impossible, non-conformance remains a possibility. The researcher understands that this could constitute a compromise to the research validity but is a condition beyond his ability to control.

#### 2. Internal Factors:

The researcher both designs the research and interprets the data, thus introducing potential bias in terms of undesirable observations especially when one part of the data collected is in text format and require the researcher's own interpretation to transcribe the meanings. To

reduce the extent of biases, the researcher needs to hold the view that the qualitative data are for producing knowledge and not for confirming judgment. In other words, the researcher has to be mindful of not being judgmental and acknowledge areas of possible subjectivity. As Bogdan and Biklen (1998, p. 34) state: “All researchers are affected by observers’ bias” and the proper practice is “...to try to acknowledge and take into account their own biases as a method of dealing with them” (p. 34).

One of the ways this researcher attempted to minimise bias was to have another colleague teaching the same subject matter to code the text data independently. This meant triangulating the coding process. Differences in interpretation were settled by means of discussion and negotiation. It is understood that such processes can only minimise the extent of biases but not eliminate their occurrences entirely, especially when it is known that the researcher’s colleague works in the same environment as the researcher and could have the same mindset towards using APA-based instruction. This is another possible area that limits the extent of validity that this study might achieve.

### Research Design

Designing a research method for a study must be done in such a way that it provides useful answers to its research questions. It is clear from the research questions shown earlier that the fundamental inquiry for this study is to know what effects low interactive APAs will produce for online learning. This is an inquiry of causality which is normally carried out by means of experimentation under the paradigm of positivism (Corbetta, 2003; Creswell, 2005). In experimentation, understanding of reality is achieved by manipulating the conditions called the treatment and studying the effect called the outcome that arises as a result of the treatment. In the case of this study, the treatment is online learning using low interactive APAs and the outcomes are learning performance and perception of the learning. To ensure that the outcome

(effect) is truly the result of the treatment (cause), the approach for the experimentation must ensure that the extraneous factors are reduced to the minimum so that the integrity of the research findings can be preserved.

### *The Approach*

The approach used in this study is quasi-experimentation with a 2 x 4 factorial design to study the effects. It is quasi because true randomisation of a sample is not possible due to the fact that subjects for this study are pre-grouped by the NIE admission office into tutorial groups which are based on the pre-service teachers' subject specialisations. The admission puts pre-service teachers of the same subject specialisation into the same tutorial group. For example, History, Geography and Art are grouped together under a specialisation category called Humanities & Aesthetics (MOE, 2006a). Therefore randomly selecting the pre-service teachers would involve regrouping them into new tutorial groups which would cause an administrative upheaval. But without random sampling, it would mean compromising representativeness due the possibility of having a biased sample which could pose a threat to external validity (Creswell, 2005). To compensate for this constraint, researchers usually use a "pretest-posttest" model with the pretest used for "normalizing" the differences due to subjects' personal characteristics. But this again imposes another problem because the subject matter used in the pretest and posttest in this study is a special topic called multimedia design, and this is a unique domain that requires its application to be situated in a particular context. Without first attending the APA-based design lesson to know what the context is will mean the subjects will have to take the pretest without having a contextual reference. This is a malpractice in designing which can render the result of the pretest invalid and hence meaningless.

An alternative way to get around this problem would be to use a self-reporting questionnaire called *Background Questionnaire (BQ)* instead of a pretest to determine the subjects' proficiency in multimedia design. The questionnaire is designed primarily to categorise subjects into novice and experienced multimedia designers; it is also used to collect demographic information about the subjects. Although this is not a foolproof method to ensure accurate responses because self-reporting is a subjective process which depends very much on the subject's ability to interpret the meaning of the questionnaire items, nonetheless, it provides a baseline criterion that allows the study to exclude subjects who are experienced multimedia designers. This helps to form a sample that comprises only novice learners and reduce the threat to internal validity (Creswell, 2005). Details of the questionnaire are given in Appendix A.

As for the 2 x 4 factorial design, it refers to a two-level treatment for a first independent variable called the "Types of Instruction" and a four-level treatment for a second independent variable called the "Sensory Preference". The need to include Sensory Preference as a second independent variable is a result of the literature review (see Chapter 2) and an attempt to answer Research Questions 1(b), 2(b) and 2(c). In all, there are 8 (i.e.  $2 \times 4 = 8$ ) types of interactions between Types of Instruction and Sensory Preference with each interaction denoted by a cell given in Table 3.1 below. The effects of each interaction are measured by two dependent variables, namely, the "Performance" which measures the level of learning multimedia design and "Perception of Learning" which measures how subjects from the respective groups feel about their learning experience. The two dependent variables are chosen specifically to provide appropriate answers to Research Questions 1(a) and 2(a). Statistical analysis of the data arising from the cells also help to answers Research Questions 1(b), 2(b) and 2(c) where the confounding effect of Sensory Preference is to be found.

Table 3.1 Independent Variables and their Levels in the 2 x 4 Factorial Design

		Types of Instruction	
		Low Interactive APA-based Instruction (LIAI)	Conventional Instruction (CI)
<b>Sensory Preference</b>	Strong Visual (SV)	Cell 1	Cell 5
	Mild Visual (MV)	Cell 2	Cell 6
	Mild Auditory (MA)	Cell 3	Cell 7
	Strong Auditory (SA)	Cell 4	Cell 8

### *The Sample*

The sample consisted of 378 pre-service teachers drawn from a population that had 566 pre-service teachers. The pre-service teachers were at NIE at the time of this study attending a one-year full-time Post Graduate Diploma in Education (PGDE) course. They were trained to teach secondary school level subjects and they were all university graduates in their respective subject areas. Their ages range from 21 to 44 with an average of 26 years. 46% of them are male and 54% are female.

The pre-service teachers attended pedagogical classes to complement the subjects they had to teach in schools including one session of Educational Technology class every week for two hours. The Educational Technology class prepared them to use basic ICT skills such as multimedia as well as selective emerging technologies like blogging to support their teaching

and learning. Therefore, understanding multimedia design principles was an essential component in the course. Multimedia design is the subject matter used by this study to ascertain the effect of learning due to using low interactive APA-based instruction. The entire course lasted 12 sessions but the main study occupied only three of the sessions.

In earlier sections, it has been said that it was not possible to have complete randomisation of the sample, but this study spared no effort to ensure that subjects assigned to the “Low Interactive APA-based Instruction (LIAI)” treatment and the “Conventional Instruction (CI)” treatment are of a matching combination of subject specialisations. This is because the literature review indicated that a person’s previous training has an effect on his/her learning preference and hence sensory preference. Congregation of a particular subject specialisation in the sample would imply a possible existence of a dominant sensory preference. This is undesirable as it can confound research results and compromise both internal and external validity.

### *The Sampling Procedure*

It was carried out by using the *Dimensional Sampling* method (Cohen, Manion & Morrison, 2007). First, all tutorial groups available for sampling are categorised according to types of training based on the Singapore Ministry of Education classification of subject syllabi (MOE, 2006a). They are *Language & Literature (LL)*, *Mathematics & Science (MS)*, and *Humanities & Aesthetics (HA)*. The numbers of subjects corresponding to the three types of training are respectively 52, 197 and 129 - which can be simplified to an approximate ratio of 5:20:13. For the subjects in LIAI and CI to be representative, they must have about the same ratio. So the next step was to assign tutorial groups with subject specialisation to the LIAI and CI until a

ratio close to the desirable one was attained. Table 3.2 shows the distribution of the subjects in terms of subject specialisation and types of instruction.

From Table 3.2, the distribution ratios for LIAI and CI are respectively 4:20:11 and 6:20:14. They are quite comparable and are close to the desirable ratio of 5:20:13. The effort of maintaining a homogeneous sample pool together with the measure of using self-reporting questionnaire to exclude subjects with prior design knowledge means that unsolicited threats that can compromise generalisability and internal validity such as *testing* - an effect due to participants becoming “familiar with the outcome measures and remember responses for later testing (Creswell, 2005, p. 293)” - are minimised as far as possible.

Table 3.2 Subject Distribution in Types of Instruction based on Subject Specialisation

			Subject Specialisation			
			Language & Literature (LL)	Mathematics & Science (MS)	Humanities & Aesthetics (HA)	Total no. of subject
Types of Instruction	Low Interactive APA-based Instruction (LIAI)	No. of subjects	21	97	58	176
		Ratio	4	20	11	
	Conventional Instruction (CI)	No. of subject	31	100	71	202
		Ratio	6	20	14	
		Total no. of subject	52	197	129	



### *The Subject Matter*

Understanding whether using low interactive APAs for online learning is effective and acceptable by the learners needs to be grounded on a specific subject matter. For this study, the subject matter is the learning of multimedia design principles. There are three reasons for this: first, learning how to use multimedia to design lessons is an essential skill for all pre-service teachers. Second, multimedia design is a new subject to the novice participants and hence it is neutral to the participants' background. Although the literature review has pointed out that subject matter does not affect APA learning, while the tasks of learning do, it provides the advantage of setting the task to be of a relatively equal difficulty level to all participants, and thereby reducing the effect of background differences due to past experiences. Third, the time to teach multimedia design on the course in question happens to coincide with the timeline of this study. With such a choice, it is expected that the *Mortality* effect could be cut down (Creswell, 2005) because subjects know the importance of learning the topic well and are unlikely to drop out from the study prematurely. But this additional "motivational" factor could also earn undue favouritism from the subjects resulting in what researchers often called the *Hawthorne effect* (Cohen, Manion, & Morrison, 2007, p.156). To reduce this effect, the subjects' performance in the study was delinked from their course performance so that perception would be judged mainly by the effectiveness of the lesson and not by its importance.

### *The Treatment*

The design of the treatment for the experiment using low interactive APAs is undergirded by findings from two resources: one is from the literature review which provides a framework for designing low interactive APA-based learning and the other is from the work of Clark and

Choi (2005) which offer guidelines on avoiding pitfalls when conducting experiments involving APAs.

The low interactive APA design framework from the literature review in Chapter Two is extracted and reproduced below:

1. Learner-Content Interaction:

- Element interactivity in the content should be kept to the minimum and present the information by maximising the use of voice and visuals.

2. Learner-APA Interaction:

- APAs should use short speech sentences for explanation. Also, render the speech and gestures either in a sequential or concurrent manner to direct learners' attention in such as way to maximise temporal proximity and minimise split-attention effect.
- Rendition of the learning process can make use of multiple APAs to compensate for the possible lack of social presence due to the use low interactive APAs.

3. APA-Content Interaction:

- Information containing illustration should be organised into several pop-up windows (also known as chunking) and the temporal appearance of these windows synchronised with the explanation by the APA. This helps to ease the cognitive load demand on the learners by providing a guided flow of lesson sequence.

For Clack and Choi's (2005) findings, their recommendations for designing APA experiments are summarised as follows:

1. Clark and Choi propose that to obtain meaningful findings, the experiment must include a non-agent group or a control group for comparison.

2. They also suggest that agent-based learning should avoid having entertaining elements that are merely just for the sake of attracting attention. If grabbing attention is necessary, then it should be pedagogically useful and purposeful.
3. Clark and Choi caution the use of self-imposed items in surveys to elicit behavioural responses (e.g. interest) regarding agent learning. They comment that such items usually cannot provide a common interpretation in meaning between the respondents and the researchers. They suggest using alternative ways of obtaining the information.

Based on the above framework and guidelines, designing the experiment would involve providing two types of instruction to the sample, one is to learn from a Low Interactive APA-based online Instruction (LIAI) and the other is to learn from a Conventional online Instruction (CI) using only text and static pictures. The former is the treatment group and the latter is the control group.

The LIAI makes use of two APAs to render instruction - one is a parrot called Peedy and the other is a mythological figure called Genie. The two APAs are to interact in such a way as to engender a social setting. The choice of using cartoonish agents arose as a result of the literature review which suggested a possible effect on perception due to the gender and ethnicity of the agents. Cartoonish agents are neutral in terms of gender and ethnicity and so they help to reduce the effect mentioned above. To provide a context for the learning, Peedy is to play the role of an instructor and Genie is to be its assistant. Content element interactivity is reduced to the minimum by keeping the background empty and showing contents only when called upon by the APAs. The interaction between the two APAs and the learners takes place in two modes: one is from the APAs to the learners, this is carried out via speech, gesture and text; the other is from the learner to the APAs and this is done by means of textboxes and a keyboard. The delivery of content through the APAs is instantiated by using

pop-up windows synchronised with the APA's speech to provide just-in-time explanation. The utterance is made up of separate short sentences so that understanding the speech does not have to depend too much on the quality of the synthetic voice produced by the APAs. To enhance learning, the APAs also ask questions and they encourage learners to think before they click for an answer. Entertaining elements are included only when they are meaningful to the learning.

To give an illustration for the above instantiation, for instance, when a learner logs into the APA instructional system, he/she will first be greeted by Peedy followed by a textbox in which s/he has to enter his/her name (see Figure 3.1). This is to allow the system to recognise the learner and to address him/her in a personal tone by calling his/her name in the subsequent part of the lesson.



Figure 3.1 A Screen Shot showing a Textbox for a Learner to input his/her Name

The learner will then be introduced to Peedy's assistant – Genie, and the procedures on how to proceed with the lesson (see Figure 3.2). After this, the learner will be asked to begin the lesson by clicking the topic “Introduction” from the menu. Learners are asked to follow the order of the topics as given in the menu. This is to ensure learners in the experimental and control groups go through the same instructional sequence, which is an attempt to minimise the possibility of an extraneous interference (see Figure 3.3).

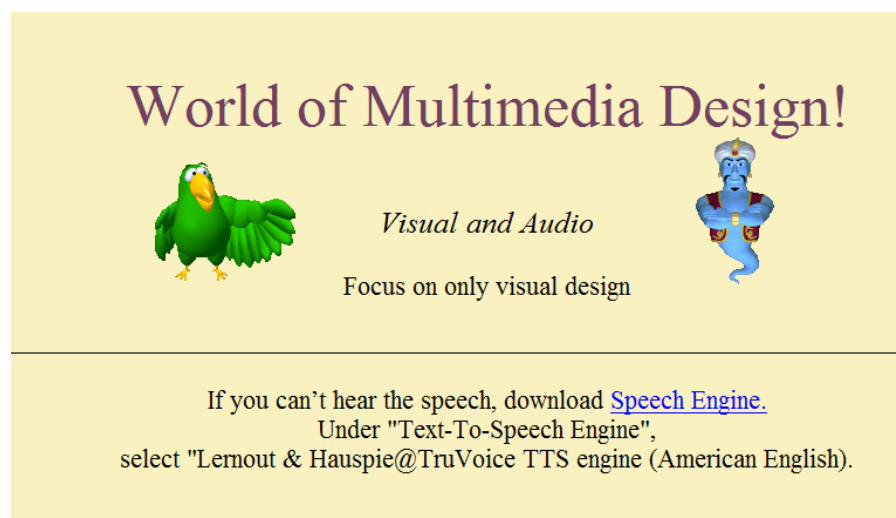


Figure 3.2 A Screen Shot showing Peedy introducing Genie



Figure 3.3 A Screen Shot showing Peedy introducing the Menu

Figure 3.4 shows an episode of learning when a learner is interacting with Peedy and Genie in a topic called “Proximity”. It can be seen that a pop-up window containing small chunks of information (or sometimes graphics) is used to complement Genie’s explanation. This is an application of what the literature has suggested in Chapter Two namely, the process of chunking information and the synchronisation of verbal explanation with relevant visual illustrations. Note also the rather empty background which is designed to contrast the pop-up window so as to provide an undistracted learning environment. This helps to better focus a learner’s attention to desired learning points during instruction. What is not shown in the figure is the APAs’ conversation which is made up of short sentences aided by deictic gesture. For example, instead of saying “this is to provide an introduction which consists of seven types of multimedia design principles”, Genie would say “this is introduction to the seven design principles”. To facilitate attention, Genie’s speech is also accompanied by his deictic gesture as seen in Figure 3.4. Using short-sentence speech synchronised with gestures is a strategy derived from the literature review to facilitate learning with low APA interactivity.

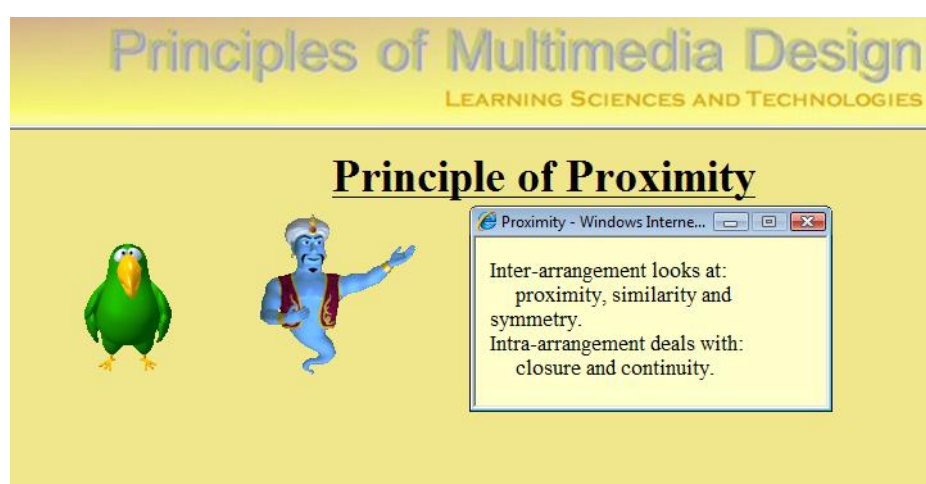


Figure 3.4 A Screen Shot showing Genie teaching with a Pop-up Window

To enhance the learning and engagement, either Peedy or Genie will pose questions at strategic times during the instruction. The learner is then given his/her own time to ponder before furnishing an answer. When in doubt, the learner can check his/her answer by right-clicking Genie's body which will bring out the answer in a form of a pop-up window. Figure 3.5 illustrates this. In the figure, the upper pop-up window shows the graphic for the question and the bottom pop-up window shows the model answer activated by the learner.

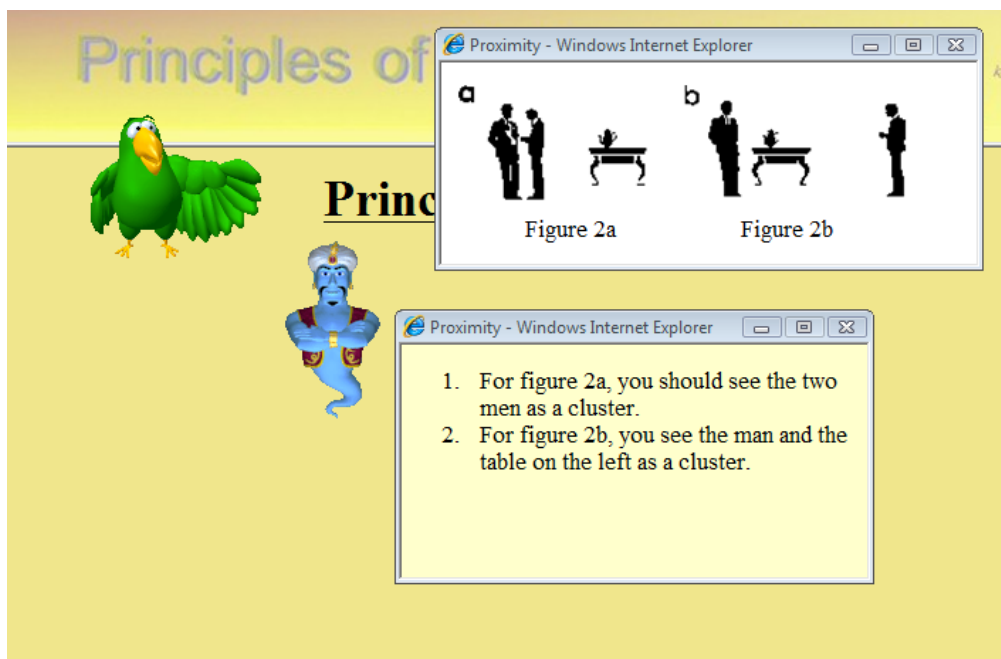


Figure 3.5 A Screen Shot showing how Pop-up Windows aid Questioning and Answering during Instruction

As for the Conventional Instruction (CI), it is delivered by using text and still pictures only. It shares the same content, pictures and Q&A with the LIAI but differs only in the mode of communication. LIAI uses voice as the main mode of communication whereas CI uses text instead. This is to provide control for the experiment so that the prime effect will be due to sensory preference. Figure 3.6 shows how the first page looks like after a learner logs into the system. It has the same menu and general layouts as LIAI except the explanations are all in

textual format. As for the LIAI, learners are to start with the “Introduction” topic and follow the order given in the menu.

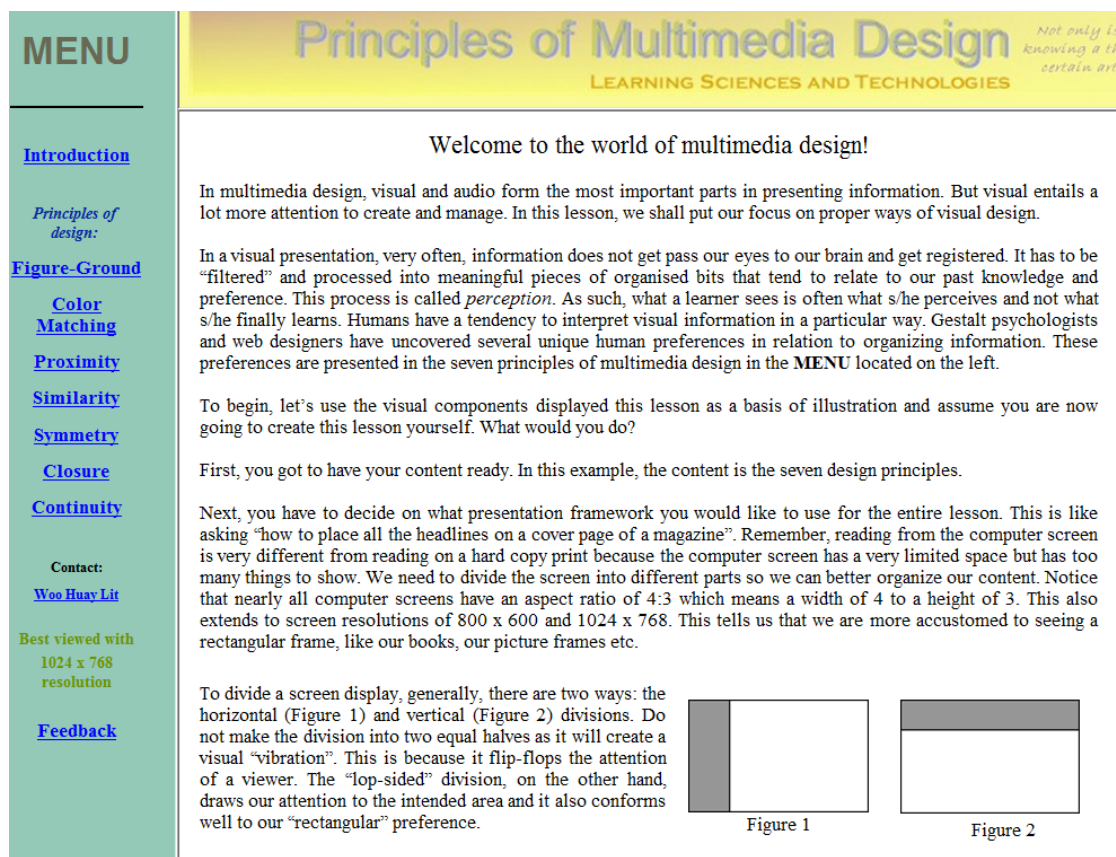


Figure 3.6 A Screen Shot showing the first page of the Conventional Instruction after Logging-in

Figure 3.7 shows the screen shot for the same Q&A given in Figure 3.5. Here, the question is embedded in the page but with a hyperlink (indicated as “here”) included for learners to check their answers. Figure 3.7 also displays the model answer in the form of a pop-up window after being activated by the learner.



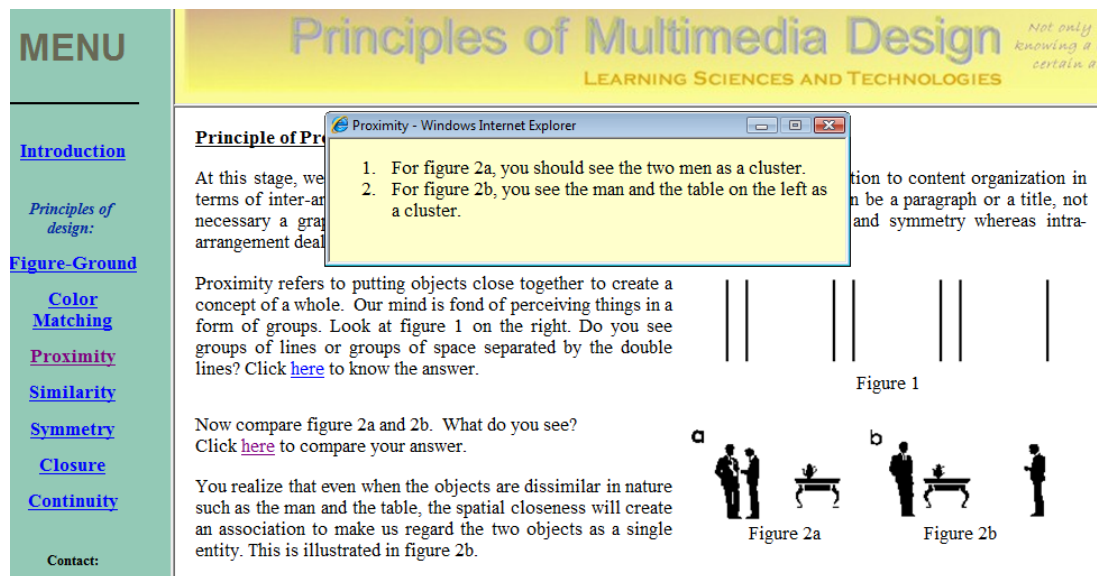


Figure 3.7 A Screen Shot in Conventional Instruction (CI) showing the same Q&A in Figure 3.5 given by the Low Interactive APA-base Instruction (LIAI)

Both LIAI and CI were conducted in the computer labs under the supervision of their tutors. Both types of instruction were given the same duration of time to learn, that is, 45 minutes.

### *The Experiment Procedure and Administration of Instruments*

This section discusses when and how the experiment as well as the instruments was conducted.

#### 1. Before the experiment

Two sets of data were collected during a tutorial class conducted a week before the experiment. This included collecting (1) the subjects' demographic information and their proficiency level of multimedia design in a single instrument called the *Background Questionnaire (BQ)* and (2) their sensory preference via the another instrument called the *Sensory Preference Scale (SPS)*. Both instruments were administered online.

## 2. During the experiment

Each tutorial group attended the online multimedia design lesson according to whether their classes were pre-assigned to a treatment or control group. Before they logged on to their lessons, the tutor in charge of the class gave a short briefing on the purpose of the study and explained why their lesson was to be delivered via a certain type of instruction. All group members were told that participation in the study was absolutely voluntary and that there was no penalty for non-participation. They were also encouraged to clarify any doubts before making a decision. It is important that freedom of choice is respected in a study that involves humans.

The subjects had to complete the lesson by the end of the tutorial and in the presence of their tutor. No extra time or a second login was allowed - to ensure that the same learning condition was adhered to for all classes taking part in the experiment.

For the tutors, they were asked to refrain from giving advice to the subjects during the lesson or expressing their personal views on the experiment. This was to prevent the possible occurrence of *Compensatory Rivalry* between the treatment and control groups (Creswell, 2005, pp. 292-293) due to the tutor's interference and to reduce the *experimenter expectancy effect* as pointed out by McNeill & Chapman (2005, pp. 75-76). The requirement for remaining in a neutral position so as to stay objective in the inquiry process is an essential aspect in positivist research.

## 3. After the experiment

The subjects took a *Perception on Learning Scale (PLS)* followed by a *Performance Quiz (PQ)* in the following tutorial class a week after the experiment. These instruments were

developed to measure respectively the subjects' level of learning and their opinions on the learning process.

Taking the quiz one week after the treatment was a logistic choice rather than a strategic one. This is because most participants were only available during their official class hour and in this case, it was the tutorial that came a week later. But because of this, the study ran a risk of compromising its control over the subjects' learning condition because subjects from both the experiment and control group were likely to compare with one another merely out of sheer curiosity; resulting in what Creswell (2005) calls a *diffusion of treatment* (p. 292). Perhaps the effort to delink quiz performance from course grade as discussed earlier might have helped to discourage such behaviour, but the time gap remained as a possible threat to the reliability of the quiz result.

### Data Collection

The main means of data collection for this study was through the use of survey instruments. This was because a survey helps to collect large scale information which helps to boost the sample representativeness that in turn helps to maintain the generalisability of the findings. Therefore instruments play a vital role in the data collection process. Their qualities must be verified before use. The following discussion concentrates on how the instruments were developed and how their reliabilities and validities were established.

### *Development and Verification of Instruments*

The four instruments highlighted above are consolidated below for ease of reference:

1. Background Questionnaire (BQ)
2. Sensory Preference Scale (SPS)

3. Performance Quiz (PQ)
4. Perception on Learning Scale (PLS)

All the instruments are developed by this researcher except for SPS which is adapted from the *Index for Learning Styles (ILS)*, a questionnaire developed by Soloman and Felder (1994, 2006). SPS and PQ were pilot tested to establish their quality. But for BQ and PLS, because of their unique use in this study, they were not pilot tested but are discussed separately.

### *The Pilot Study*

1. Sensory Preference Scale (SPS)

SPS is an online questionnaire used to identify the visual and auditory preferences of the learners in this study. The need to do this, as explained in the literature review, is that sensory preference can have effects on learners who interact with instructional elements which work in a certain predominant modality. This is particularly so for this study because of the use of low interactivity APAs, which require auditory elements such as dialogue and verbal explanations more than visual elements (like pop-up windows and gestures to sustain engagement for instruction). Using an auditory-rich instruction can create some issues due to learners' preferences, because not all learners are familiar with learning in such a condition, especially adult learners, who are known to be mostly visual learners (as indicated in the literature). Therefore it is crucial for this study to know if preference for a certain modality affects learning, and hence this generated a need to have the SPS instrument find out what the learners' sensory preferences are. But there is a caveat here - the identification of sensory preference is not for predicting learning success as commented by critics of learning styles, but for analytical purposes. It is used to examine how visual and auditory learners interact with the modality elements in the APA instruction. The present researcher understands that methodologically, it would be ideal if

the same could be done for the learners in the Conventional Instruction group so that a comparison between the two groups can be studied, but the researcher is constrained by practical reasons affecting the scope of the research which limited the extent of analysis and the time available to complete the analysis. The researcher acknowledges that this is a limitation of the study and any claims made with respect to sensory preference can only be confined within this limit.

The SPS, because of its unique purpose, has to be adapted from ILS which has a total of 44 objective items (see Appendix B) and of which, only the subscale on Visual/Verbal comprising 11 items is used. This are three reasons for adapting ILS: first, Visual/Verbal offers the closest match for measuring visual and auditory preferences as required by this study; second, each item in ILS contains two options, of which one measures a learner's visual inclination and the other auditory inclination. In other words, it has an equal number of options for visual and auditory preferences and therefore is unbiased towards either sensory preference; third, the scale offers good internal consistency and convergent validity. Its test-retest correlation coefficients is reported to be .870 ( $p < .01$ ) and it has an average Cronbach Alpha value of .62 (Felder & Spurlin, 2005), both figures are within the acceptable criterion (i.e. greater than .50) recommended by Tuckman (1999). Its convergent validity is obtained by studying undergraduates' learning preferences in ten universities (Felder & Spurlin, 2005). Despite the reported strengths of the scale, it cannot be readily adopted for use because the verbal preference it measures is not exactly the same as auditory preference as needed by this study. The former measures "preference for written and spoken words (Felder & Spurlin, 2005, p. 103; Sun, Joy, & Griffiths, 2007, p. 384) whereas the latter measures just spoken words alone (Mayer, 2001, p. 46). Therefore, the original items from the ILS must be modified.

This was done by rewording the options of some of the items so that their descriptions reflect the correct classification of sensory modality. For example, item no. 39 from ILS is originally given as:

For entertainment, I would rather

- a. watch television
- b. read a book

But because “watching television” can involve both the visual and auditory modalities which overlap with the activity “reading a book” which is visual by nature, option (a) therefore is not sufficiently discriminative. So the item was modified to read as:

For entertainment, I would rather

- a. read a joke
- b. listen to a joke

where option (a) “read a joke” is specifically a visual activity whereas option (b) “listen to a joke” is an auditory activity.

In all, 3 items from ILS were retained, 4 items were partially modified and 4 completely replaced. A comparison between the original items and that from the new SPS can be found in Appendix C. The revised version of SPS is shown in Appendix D.

When developing the SPS, one important area is taken into consideration, that is, learners’ familiarisation of the task given in the item. Cognitive theory has pointed out that what makes a person prefer a certain type of task is their familiarity with the task. A

familiar task normally needs less cognitive effort to accomplish and hence is preferred by a learner. This implies that if the questionnaire is to elicit reliable responses from the respondents, then the tasks used in the items must be familiar to the respondents. In this respect, this researcher considers “read” to be the task that is very commonly used in adult learning. But “read” in this questionnaire is used in a wider sense different from the notion of “reading” which is often used in learning styles studies. For example, item 6 asks a person to “read out loud” a telephone number to the respondent is an auditory task. Hence, the use of tasks associated with “read” provides a familiar situation for respondents to discern whether the familiarity of the task is a result of their preferences. Forming the items based on cognitive theory is an attempt to create a more valid questionnaire. But despite this, this researcher concedes that there is still an inherent issue related to using this type of questionnaire - that is, how well the respondent interprets the items. The issue arises because there are situations in which a respondent may prefer both types of modalities. For example, item 4 asks whether a respondent likes (a) teachers who write a lot on the board, or (b) teachers who spend a lot of time explaining. Two possible scenarios can be derived from such an item: first, a respondent may opt for either one option because both options offer equal practical benefits rather than personal preference; second, a respondent with a very strong inclination for a certain modality is likely to choose the option that matches his/her sensory preference. Hence, there is limit to which a survey item can discriminate the learners’ sensory preferences.

To improve the above condition, the scoring system used by the original ILS offers a good way to do this. Its scoring mechanism works on the concept of “net preference”. Scoring begins by assigning one point to each option chosen by a respondent. Since there are 11 options for visual preference and 11 options for auditory preference, an absolutely visual respondent will have a score of 11 points, labelled as “a11” where “a” stands for

visual; similarly an absolutely auditory respondent will also have a score of 11 points, labelled as “b11” where “b” stands for auditory. Because there is no absolute visual or auditory person in practice, any respondent will have two scores, an “a” score and a “b” score with each score lies between 1 and 10. A larger score in the “a” category suggests a stronger inclination for visual preference and likewise, a larger score in the “b” category means a stronger inclination for auditory preference. So the “net sensory preference” for the respondent will be the difference between the respondent’s “a” and “b” scores. The use of “net preference” not only helps to negate the “uncertain” options given by the respondents but also helps to improve the validity of the questionnaire. The “net preference” scoring system has been used in the SPS in this study. Similar details can also be found under “Data Collection”.

The adapted SPS, though it is formed by taking the various considerations described above into account, will still need to be subject to further statistical verifications to ensure its quality. This includes the establishment of convergent validity, internal reliability and test-retest correlation.

The convergent validity of the revised SPS was established by observing how well the instrument behaved when it was used to measure another similar variable (de Vaus, 2002). Such a variable, as used in this pilot study, was the students’ subject specialisation. According to Felder & Spurlin’s (2005) findings, students with an engineering specialisation show noticeable visual preference when asked to report in a survey. This means a relationship between students’ subject specialisation and visual preference is posited. Hence, if the SPS is to be validly measuring sensory preference, then it should be able to detect such relationship.



To verify whether SPS possesses the required validity, 38 pre-service teachers specialising in Technical Education volunteered to take part in the SPS survey. Many of them were engineers before joining the teaching profession. Table 3.3 shows the proportion of participants and their corresponding Sensory Preferences as determined by the revised SPS.

Table 3.3 Proportion of Participants in each Sensory Preference Category

	Sensory Preference				Total
	Strong Visual (SV)	Mild Visual (MV)	Mild Auditory (MA)	Strong Auditory (SA)	
No. of Participants	7	15	9	6	37
Percent of Participants	18.9	40.5	24.3	16.3	100.0

Note that a four-level sensory preference was used to better reflect the variability of choice. From Table 3.3, it can be seen that SPS distinguishes well the visual learners from the auditory learners by the contrast of 59.4% visual learners to 40.6% auditory learners. Within reasonable means, the SPS is considered as having considerable convergent validity.

To determine the internal reliability of the SPS, the instrument was pilot tested by 114 pre-service teachers including the 37 Technical Education teachers who took part in the validity test. The extent of reliability was estimated by calculating its Cronbach Alpha value from the responses collected and this was found to be .558 which is above the minimum acceptable value of .50 (Tuckman, 1999). To further verify the reliability, a

test-retest analysis using the same sample was conducted. The test-retest correlation worked out to be better with a coefficient of .722 ( $p < .05$ ). The test and retest were separated by a time gap of eight weeks to ensure that participants did not have residual memory due to the first test they took. Detailed computation for internal reliability is found in Appendix E.

In all, the validity and reliability of SPS compared well with the figures reported in other studies as stated above. It is therefore regarded as having considerable convergent validity and acceptable reliability to meet the purpose of this study.

## 2. Performance Quiz (PQ)

The PQ was completely developed from scratch to meet the design nature of learning and the context of this study. The first version of PQ consisted of 40 objective items and was designed to be completed online within 50 minutes. To establish both the validity and reliability of the instrument, a sample of 257 pre-service teacher volunteers from a subsequent cohort of pre-service teachers were involved. They learned multimedia design online using the conventional way of instruction (i.e. text and graphics without APAs) and took the quiz a week after.

Development of the items started with a Table of Specification (TOS) (Franzen, 2000, pp. 34-35). This was used to work out a good balance between the expected performance and the level of content to be learnt. This helped to maintain content validity (Tuckman, 1999, p. 213). With this, a 40-item objective quiz was developed (see Table 3.4)

Table 3.4 Table of Specification for the Development of Performance Quiz (PQ)

Content	Item No.			Sub-total	Weighting (%)
	Bloom's Taxonomy				
	Knowledge	Comprehension	Application		
Introduction	1, 3	2, 4	-	4	10.0
Figure-ground	6, 7, 21	5, 8	37	6	15.0
Color matching	9, 10, 12, 14	11, 15	13, 20	8	20.0
Proximity	16, 17	18, 19	25	5	12.5
Similarity	22, 28	24, 29	-	4	10.0
Symmetry	23, 31	26, 30	38	5	12.5
Closure	32, 33	35	27	4	10.0
Continuity	34, 36	39, 40	-	4	10.0
Sub-total	19	15	6	Total = 40 items	
Weighting (%)	47.5	37.5	15.0		Total = 100%

The distribution of items between Knowledge, Comprehension and Application across the seven content areas was maintained at a weighting ratio of 47.5 : 37.5 : 15.0, which was simplified to 10:8:3. The 40-item initial version of PQ is shown in Appendix F.

Like the SPS, the internal reliability of this PQ was established by determining its Cronbach Alpha value from the responses collected. This worked out to be .725 which fell marginally lower than the recommended threshold of .75 by Tuckman's criterion (1999, p. 445). This called for an Item Analysis to be conducted so as to improve the reliability by identifying poor items. Each item's score was correlated to the total score to check for its consistency. Only items with correlations (r) greater than .20 would be accepted otherwise the item was to be discarded (Nunnally & Bernstein, 1994, p. 306). Eventually 22 items

met the criterion and were used to form the new improved version of PQ. A re-run of the Cronbach Alpha test on this new instrument found that Cronbach Alpha value had improved to .775, though not by a big margin, it brought the test to within acceptable levels. Details of the item-analysis can be found in Appendix G.

Because the number of items was reduced, a new TOC based on the new 22 item quiz was reconstructed to check that content validity was maintained. This is shown in Table 3.5.

Table 3.5 A New Table of Specification for the Development of Performance Quiz (PQ)

Content	Item No.			Sub-total	Weighting (%)
	Bloom's Taxonomy				
	Knowledge	Comprehension	Application		
Introduction	1, 3	4	-	3	13.6
Figure-ground	21	-	-	1	4.5
Colour matching	9, 10, 14	11, 15	13, 20	7	31.8
Proximity	16	19	25	3	13.6
Similarity	22, 28	-	-	2	9.2
Symmetry	23	-	-	1	4.5
Closure	33	35	-	2	9.2
Continuity	34	39, 40	-	3	13.6
Sub-total	12	7	3	Total = 22 items	
Weighting (%)	54.5	31.8	13.7		Total = 100%

Note that the ratio between the three taxonomy levels shown in Table 3.5 remains relatively unchanged at 11:6:3 (i.e. 54.5 : 31.8 : 13.7) which is comparable to the original ratio of 10:8:3. Hence the desired performance expectation was not violated.

In all, the new PQ had a reasonable reliability (Cronbach Alpha of .775) and validity.

Because fewer items were used, the expected completion time for the quiz was revised down to 25 minutes. The final version of PQ can be seen in Appendix H.

### *Background Questionnaire (BQ)*

The BQ is to be answered online and is designed to collect demographic information such as age, gender and subject specialisation. It has three Likert-type items to ask about subjects' multimedia design proficiency. The items allow the researcher to isolate the novice from the experienced learners. Only learners who are novice are included in the study so that a common baseline for learning can be established. In other words, the BQ is used as a surrogate pretest in this study. Discussion of using the BQ as a pretest has been done in an earlier section. The BQ can be viewed in Appendix A.

### *Perception of Learning Scale (PLS)*

Designing a scale to obtain the subjects' perceptions of their learning experience is challenging. This is because learning with low interactive APAs is very new especially in the local context and there is little known about using it, let alone the users' perceptions. This means very few resources can be used to help design the items. Therefore the basis for developing the scale has to be based on: (1) implications from literature reviewed in this study and (2) the requirements from the Research Questions. This leads to the following three areas of concern pertaining to perception:

- a. Extent of learning from the instruction,
- b. Presentation of the instruction,
- c. Interest in the instruction.

Extent of learning is an essential requirement derived from Research Question 2; presentation is a manifestation of using low APA interactivity and is an important element to know; and interest level is a distinctive feature of APA-based instruction which is often highlighted in literature. Therefore knowing whether using low interactive APAs can continue to support learners' interest over time is crucial to this study. Addressing the three concerns above provides the scope for understanding the learners' perception.

As there is insufficient literature to support the design of this instrument, it was decided that the scale of the instrument would consist of three Likert-type items with an open-ended question attached to each. Each Likert-type item and its open-ended question cover one area of learning described earlier. Each item has six options and each open-end question has a textbox under it for participants to enter their textual input. The choice of this design is a result of the third recommendation put forth by Clark and Choi (2005) under the section "The Treatment," and the findings from the various studies discussed under "Learners' Sensory Preferences and APAs' Modalities" in Chapter Two. Clark and Choi commented in their paper that using questionnaires with predetermined items on APAs tend to limit the amount of information that can be obtained in terms of learner's perception. They recommended using alternative means that can collect richer data. Furthermore, findings consolidated from studies in Chapter Two (e.g. Massa and Mayer, 2006; Miller's, 2005; Chou and Lin, 1998) imply that simply knowing learners' preferences and learning outcomes does not produce meaningful findings; it is the knowledge of how learners interact with the instructional or task elements during the learning that is useful. By using the above recommendations, this researcher considers the choice of using only one Likert-type item to elicit an overall assessment for each learning aspect and an open-end question for them to articulate the rationale behind their assessments an adequate way to obtain information on the way they interact with the APA

instructional elements. The answers to the open-ended questions also serve as a means to triangulate the results obtained from the Likert-type items. Of course, like all other methods, this method also has its limitations - it depends on how articulate the respondents are and how willing they are to offer their opinions. A copy of the PLS can be found in Appendix I.

In earlier section on “Sensory Preference Scale (SPS), this researcher explained that the scope of investigation of this study was limited by practical reasons and the availability of time. For this, perception of learning for the conventional instruction (control group) was not collected for the purpose of comparing sensory effects with that of APA instruction. This partly is due to the reasons stated earlier and partly is because it was not required by the Research Questions. However, the researcher understands that methodologically, it would be ideal if such information could be made available so that it can provide additional knowledge to better inform this study. As such, claims made with respect to sensory differences between the conventional and APA instruction can only be done by means of inference using relevant literature.

### Data Analysis

The bulk of the data to be analysed were quantitative data except for the open-ended items in PLS which was text data. Data analysis began with coding the raw data into usable numbers so that they could be processed by the appropriate tools.

#### *Data Coding and Theme Recognition*

Quantitative data collected from using SPS, PQ, BQ and PLS were to be coded according to the nature of the data, that is, nominal, ordinal, interval or ratio. Each type of data required a different method of treatment. Below is a discussion of the method of coding according to the instruments used:

## 1. For Sensory Preference Scale (SPS)

This scale collected data in a nominal format. Its scoring method followed that from ILS. Each item allows a choice of ‘a’ or ‘b’ where ‘a’ represents a preference for visual and ‘b’ for auditory. For computation purposes, ‘a’ and ‘b’ are each assigned a value of 1. So more ‘a’s means more visual and more ‘b’s means more auditory. In other words, each participant holds two numbers, one to indicate his/her visual strength and the other the auditory strength. According to Solomon and Felder (1994), the net sensory preference of a person is the difference between his/her visual and auditory strengths; this works out to be a continuum with a scale ranging from 1 to 12. For this study, the scale was further divided into four levels to better reflect the variability of the choices: The levels and their corresponding codes are given below:

<u>Value</u>	<u>Level Name</u>	<u>Level coded as</u>
1-3	Strong Visual (SV)	1
4-6	Mild Visual (MV)	2
7-9	Mild Auditory (MA)	3
10-12	Strong Auditory (SA)	4

After the coding process, each participant’s Sensory Preference was represented by a code, that is, 1, 2, 3 or 4 and the data become ordinal and categorical.

## 2. For Performance Quiz (PQ)

Data collected from PQ was in the form of interval numbers. Each item provided four options, a, b, c or d. The coding was straightforward with each correct item coded with



one point and no point awarded for a wrong attempt. Hence the Performance score for each participant was from 0 to 22. Suggested answers for scoring are given in Appendix J.

### 3. For Background Questionnaire (BQ)

All data generated from BQ were nominal numbers except for Part 2, item3, where the data was in ordinal form. Coding was done with the following coding scheme:

#### a. For demographic information:

Student number, module number, CS1, CS2 and age were recorded as per the default value given in the questionnaire. As for gender, male was coded as “1” and female as “2”.

#### b. For multimedia design proficiency information, the coding followed the scheme below:

<u>Value</u>	<u>Coded as</u>
“Yes”	1
“No”	0
“Negligible Experience”	1
“Novice”	2
“Proficient practitioner”	3
“Expert”	4

Note that this instrument selects only those who are “novice” or have “negligible experience” in multimedia design and have never learnt the same from within or

outside the case institution. Details on how this is carried out are given in Chapter Four under the section “Statistical Characteristics of the Sample”.

#### 4. For Perception of Learning Scale (PLS)

The data collected from the Likert-type component of the items were ordinal numbers that range from 1 to 6. The average score obtained from the total three items represents the overall perception of the participant. The coding scheme is as shown:

<u>Choices made</u>	<u>Coded as</u>
Strongly Disagree	1
Disagree	2
Somewhat Disagree	3
Somewhat Agree	4
Agree	5
Strongly Agree	6

The data collected from the open-ended component of the items were in text format and were coded by means of Open Coding (Strauss & Corbin, 1990). The area of concern each item was assigned to address, constitutes a theme for analysis. For example, “I learn a lot from the lesson” is a theme for the first item. Within this theme, coding is done by first examining the information to form concepts that relate to the theme. Next these concepts were coded with a label that best describes the reported phenomena (Patton, 1990; Strauss & Corbin, 1990). For example, the following excerpt is coded with a concept labelled as “Learning judged by usefulness”.

*I learnt the principles of MML which I did not know previously. Now, I will be*

*more careful when I design MML, bearing these principles in mind.*

Triangulation of the data was carried out with the help of a colleague who coded the data independently. Any differences between the concepts identified were resolved by means of negotiation (Tashakkori & Teddlie, 2003). The types of concept identified from a participant represent his/her scope of perception.

### *Statistical Analysis*

This section discusses the statistical methods employed to process the coded data to produce results that were interpretable and supportive to answering the Research Questions. The main tools used for the analysis was SPSS.

To answer Research Question 1(a) that asks for users' opinions on the use of low interactive APA-based Instruction (LIAI), two analyses were performed, one using descriptive statistics and the other content analysis.

1. **Descriptive Statistics:** These involved counting the number of responses received for each category of choices (6 categories altogether) in SPS, for example, count how many participants chose "Strongly Agree". Then convert the count into percentage. The percentage distribution from "Strongly Agree" to "Strongly Disagree" gives an overview of how favourable LIAI is. The process was done item-by-item.
2. **Content Analysis:** This involved first coding the textual data into meaningful reasons then into phenomena that were judgments on instructional components that could help to offer explanation. Frequencies and percentages of occurrence for both reasons and phenomena were determined. The types of phenomena gave the scope of perceptions whereas their percentage distribution gave the extents of effect each phenomenon have on perceptions.

Addressing Research Question 1(b) that asks if the opinions in Research Question 1(a) do differ in terms of sensory preference involved the same procedures as for Research Question 1(a). First was to analyse the quantitative data. This involved sorting the results found in Research Question 1(a) item-by-item according to the four levels of sensory preference, then formed a Cross-tabulation involving Perception of Learning (in 6 levels) and Sensory Preference (in 4 levels). Depending on whether prerequisites of running a certain statistical test is fulfilled, use Pearson Chi-Square correlation if more than 80% of the cells in the cross-tabulation have frequency of at least 5 (Pallant, 2003, p. 259; Norusis, 2006, p. 163), otherwise, use Kruskal-Wallis Test. The Kruskal-Wallis Test does not depend on the number of counts in a cell formed from a Cross-tabulation but works on comparing the mean ranks of all the groups involved in the analysis (de Vaus, 2002; Norusis, 2006). This means all the observations in Perception of Learning are pooled and ranked from the smallest to the largest and likewise all the observations in Sensory Preference are treated in the same way. After this, the average rank for each of the two groups is calculated and compared. When either Pearson Chi-Square correlation or Kruskal-Wallis Test detects a significant difference, it indicates that opinion (i.e. perception) is affected by sensory preference. The process was repeated for item 2 and 3.

Next was to analyse the qualitative data. This was done by expanding the cross-tabulation in Research Question 1(a) to include differences due to Sensory Preference. Again, the frequencies and percentages for each cell in the cross-tabulation were computed. In the same manner, the scope of perception was determined by the types of reason and the frequency distributions of the phenomena gave the extent of contribution by each phenomenon to the perceptions.

To answer Research Question 2(a) that asks about the extent of achievement obtained by using LIAI and CI the following procedure was used. First, one-way ANOVA was used to compare the means of Performance for LIAI and CI. Normally, when analysis is involved in determining a significant difference in interval scores between two groups of subjects, a t-test is used. But this study chose to use a one-way ANOVA for two reasons. The first reason is that there is no difference in terms of outcome by using either method. A t-test in fact is a special case of ANOVA when the number of groups involved is reduced to two. Under this condition, the F-distribution used in ANOVA became equivalent to the t-distribution and their relationship could be expressed as  $F=t^2$  (Stockburger, 1998). Several authors of social science statistics books treat both methods as equivalent when the conditions in the calculation involve only two independent groups. For example, Pallant (2003) in her “SPSS Survival Manual” explained that “one-way analysis of variance is similar to a t-test, but is used when you have two or more groups and you wish to compare their mean scores on a continuous variable.” (p. 92). Similarly, Gaur and Gaur (2006) also point out in their SPSS guide book that “One-way ANOVA ...is used to test the difference in a single dependent variable among two or more groups formed by a single independent or classification variable.” (p. 71). The other reason for using a one-way ANOVA instead of a t-test is to simplify the type of statistics used. As the study requires a two-way ANOVA in its second part of computation, keeping the first part of analysis to a one-way ANOVA helps to cut down computational redundancy and hence facilitate the data interpretation.

But before any ANOVA could be used, some prerequisite conditions of the data in Performance must first be fulfilled. This involved identification of outliers and verification of normality. If conditions were not fulfilled, a non-parametric alternative such as a Chi-Square would be used. When a significant value is detected, it means there is a statistical difference.

To answer Research Question 2(b) that asks if Performance is related to Sensory Preference a one-way ANOVA was used in a similar way to compare the means of Performance for the four levels of Sensory Preference. When a significant value is detected, it implies an existence of a statistical difference.

To answer Research Question 2(c) that asks what joint impact do Types of Instruction and Sensory Preference have on achievement a two-way ANOVA on the means of Performance between Types of Instruction (consisting of LIAI and CI) and Sensory Preference (consisting of SV, MV, MA and SA) was employed. Like the one-way ANOVA, a two-way ANOVA was used when the analysis required testing the impact of two independent variables on one dependent variable (Pallant, 2003). In this case, the impact was the joint interaction effect from the two independent variables (Types of Instruction and Sensory Preference) on the dependent variable (Performance). If a significant value is detected for an interaction effect, it means Performance difference due to Types of Instruction is affected by Sensory Preference. For the extent of effect contributed by each sensory preference, it was carried out by applying one-way ANOVA on Types of Instruction for each sensory preference. Significant values and magnitude of Eta Squared gave their relative contributions.

### Ethics Issues

There are two concerns relating to ethical issues. First, because learning of the subject matter in the study forms part of the course curriculum, there is a likelihood that some pre-service teachers may feel obliged to take part in the study for fear of being disadvantaged. To allay their fear, the performance of their learning from the study was, they were told, delinked from their course grade and also non-participants of the study were provided with a similar lesson without the APA treatment so that they could learn on the same par with the participants.

Second, because the online learning is delivered by the web-based system provided by the case institution, logging in is required and hence the identity of the participants cannot be entirely anonymous. But for the purpose of this study, only the student identity number was captured but not their names, making their identity less conspicuous. The participants were also assured of the confidentiality of the information collected and they were encouraged to raise their concerns before making a decision. For example, some would like to try the APA-based lesson but did not want their particular to be known, we allowed such a request and we made special arrangement for the pre-service teacher. All candidates for the study were allowed to opt out of the study at any time without any condition attached.

### Generalisability

It is known that experimental research has its limits for generalising its findings to the entire population because experimental research is normally carried out in a very specific setting (Corbetta, 2003; Creswell, 2005). Hence the findings of this study can only be generalised to pre-service graduate teachers using only APA instruction that follows the design framework provided in this study. Generalising outside the stated context would need to be done with caution. Despite this restriction, this study makes all possible attempts within the means of this researcher to allow the study to be replicable by specifying research conditions such as type of participants and the various constraints encountered. Examples of the constraints are the inability to randomise the sample and the impossibility to segregate the components used to render the APA's behaviour. All these tend to reduce the extent of generalisability of this study.

## **CHAPTER FOUR**

### **DATA ANALYSIS AND FINDINGS**

#### Introduction

The purpose of this study is to understand whether instruction using low interactive APAs can be effective in providing learning. A secondary purpose is to discover how participant learners perceive such instruction and whether the perception is affected by their background characteristics, in particular sensory preference. The following research questions are formulated to provide answers to achieve the purpose.

1. How favourably do learners perceive instruction using low interactive APAs?
  - a. What are the opinions of learners on instruction using low interactive APAs?
  - b. Do their opinions differ with respect to differences in sensory preference? If yes, how do they differ?
2. How effective is instruction using low interactive APAs in terms of helping learners learn?
  - a. How do learners' achievements from instruction using low interactive APAs compare with that from more conventional online instruction?
  - b. Does the achievement vary in accordance with learner's sensory preferences? If yes, how does it vary?
  - c. In view of the answers to 2(a) and 2(b) above, what is the joint impact of types of instruction and sensory preference on achievement?

Through review of relevant literature in Chapter Two, a framework for designing the low interactive APA instruction was developed and consequently, two sets of online instruction – one using low interactive APA and the other using conventional mode of delivery – were constructed in Chapter Three. To answer the research questions, a quasi-experiment was



designed to determine the effectiveness and favourability of the low interactive APA instruction together with the development of four instruments. The four instruments are: the Background Questionnaire (BQ), the Sensory Preference Scale (SPS), the Performance Quiz (PQ) and the Perception of Learning Scale (PLS). Please see Table 4.1 for a summary of the purposes of the instruments, the type of data they collect and the variables they measure. Each of the instruments aims at tapping a certain kind of information so that they can collectively engender a more holistic picture of the relationships between Types of Instruction, Sensory Preference, Performance and Perception of Learning. Knowing the interrelationships between these variables and hence their causality effects is pivotal to finding answers to the research questions.

The purpose of Chapter Four is to continue the task from Chapter Three by analysing the collected data for the existence of the said interrelationships and other relevant information by means of statistical methods and inferences. The analysis will be carried out according to the research questions stated above. The results of each research question are then put together to render an overall understanding of the effectiveness and favourability of the low interactive APA instruction as required by the purpose of the study.

Table 4.1 Purpose of Instruments, Type of Data to collect and Variables to be measured

<b>Name of Instrument</b>	<b>Purpose of the Instrument</b>	<b>Type of Data</b>	<b>Variable(s) Associated with the Data</b>	<b>Type of Variable</b>
Background Questionnaire (BQ)	To collect *participants' demographic information including their subject specialisation, age, sex and proficiency level of multimedia design.	Categorical	Not Applicable	Not Applicable
Sensory Preference Scale (SPS)	To categorise participants' sensory preference into four levels: Mild Visual, Strong Visual, Mild Auditory and Strong Auditory.	Categorical	Sensory Preference	Independent Variable
Perception on Learning Scale (PLS)	1. To collect participants' extent of agreement by using Likert-scale items on (a) how much they learn from instruction using low interactive APAs, (2) how well they like the presentation of the instruction and, (3) whether they find the instruction interesting.	1. Ordinal	Perception of Learning	Dependent Variable
	2. To collect the participants' reasons for the responses they gave in (1) above in an open-ended format.	2. Textual	Perception of Learning	Dependent Variable
Performance Quiz (PQ)	To use objective items to determine how well participants achieve from instruction using low interactive APAs as well as from using conventional online instruction.	Interval	Performance	Dependent Variable

\* **Note** that “participant” is used instead of “subject” to avoid confusion with the term “subject specialisation”.

## Results and Findings

All analyses of quantitative data were performed by means of statistical software called SPSS unless otherwise stated. Both descriptive and inferential statistics were used when applicable and all decisions for inferential statistics were based on an alpha level of .05.

### **Research Question 1(a):**

**What are the opinions of learners on instruction using low interactive APAs?**

There were two sets of data – one quantitative and the other qualitative – collected to answer this research question. The quantitative data aimed to provide the extent of perception formed by the learners, whereas the qualitative data gave the rationale behind the perception. The quantitative data were analysed first.

#### *Quantitative Data for Research Question 1(a)*

Quantitative data were collected from three Likert-type items in the Perception of Learning Scale (PLS). Each item addressed one aspect of learning as follows: (1) extent of the learning, (2) presentation of the instruction, and (3) interest in the instruction. Respondents expressed their opinion on their learning experience according to three levels of agreement and three levels of disagreement. The agreement and disagreement levels and their abbreviations are given below:

SD: Strongly Disagree

D: Disagree

SWD: Somewhat Disagree

SWA: Somewhat Agree

A: Agree

SA: Strongly Agree

#### *Results and Findings from Quantitative Data of Research Question 1(a)*

The data collected from the three items were organised and tabulated in Table 4.2.

Table 4.2 Responses to Items in the Perception of Learning Scale

Item No.	Statement of the Item		Responses						
			SD	D	SWD	SWA	A	SA	Total
1.	I learn a lot from the lesson.	Frequency	1	7	15	60	77	16	176
		Percentage	.6%	4.0%	8.5%	34.1%	43.8%	9.1%	100.0%
2.	I like the presentation of the lesson.	Frequency	14	13	21	51	71	6	176
		Percentage	8.0%	7.4%	11.9%	29.0%	40.3%	3.4%	100.0%
3.	The lesson is interesting.	Frequency	4	13	17	57	74	11	176
		Percentage	2.3%	7.4%	9.7%	32.4%	42.0%	6.3%	100.0%

Analysis of the quantitative data was approached in two ways. Each is described below:

First was to take a general view on what overall perception learners had of learning with low interactive APAs. By examining the distribution of the responses across the three items (see Table 4.2), it was observed that the distributions were very similar to one another with a bunching of responses around “A” and “SWA” but peaked at “A”, then tapered off towards “SA” and “SD”. This means that learners had about the same opinion on the three aspects of learning. Also the total number of learners who chose “SWA” or “A” or “SA” outweigh those who chose “SWD” or “D” or “SD” by a big margin. This is justified from the computation in Table 4.3 (extracted from Table 4.2).

Table 4.3 Comparisons between Responses from “SWA” to “SA” and Responses from “SWD” to “SD”

Item	Sum of Percentages for “SWA” or “A” or “SA”	Sum of Percentages for “SWD” or “D” or “SD”	Difference
1	87.0%	23.0%	64.0%
2	72.7%	27.3%	54.4%
3	80.7%	19.3%	61.4%
Average	80.1%	23.2%	59.9%

Referring to the figures in the last column, the difference varied from 54.4% to 64.0%. This means that there were far more positively opinionated learners than negatively opinionated learners for all three aspects of learning. Based on this analysis, it can be said that in general,

the majority of the learners found the low interactive APA instruction effective, they liked the presentation of, and were interested in, the instruction.

Next was to take a specific view on whether there was any particular group of learners that stood out against the rest in terms of extent of agreement. The group that answered “A” in Table 4.2 clearly distinguished itself from the rest of the groups. This was the same for all the three items and hence all the three aspects of learning. The group also outweighed its next contender who answered “SWA” by a large margin of 11.3% for item 2, followed by 9.7% for item 1 and lastly by 9.6% for item 3. If “SWA” was an indication of uncertainty, then “A” and “SA” should convey confidence of choice that implied learners were definite about their opinions. Going by this argument, the extent of learners who were not just positive but also definite in their opinions was indicated by the sum of percentages for “A” and “SA”. Likewise, the extent of learners who were definite about their negative opinions was given by the sum of percentages of “D” and “SD”. The computation for these two groups of learner is shown in Table 4.4.

Table 4.4 Comparisons between Responses for “A” and “SA” and Responses for “D” and “SD”

Item	Sum of Percentages for Responses of “A” and “SA”	Sum of Percentages for Responses of “D” and “SD”
1	52.9%	4.6%
2	43.7%	15.4%
3	48.3%	9.7%
Average	48.3%	9.9%

Figures in the second column in Table 4.4 point out that in each aspect of learning, there were about half the learners (Average = 48.3%) who were definite about their positive opinions on the learning as against those about one-tenth (Average = 9.9%) in smaller proportions (in the last column) who were also definite but were in negative opinions. Despite this general

observation, item 2 needs more attention. It received the least proportion of positive opinions (43.7%) and the largest proportion of negative opinions (15.4%) when compared with the other two aspects of learning. This means that presentation of the APA instruction was the least popular and probably not as easily accepted as the other two aspects of learning. The reasons are derived from the qualitative data collected from the open-ended questions.

So far, results had been computed on a “per item” basis. It would be useful if the data could be analysed on a “collective” basis to see how learners favour or dislike all the three items collectively. This would provide a deeper understanding of the learners’ perceptions.

To do this would require the identification of learners who showed definite positive and definite negative opinions to all three items. From the data, 50 learners were found to have chosen either “A” or “SA” for all the three items. Hence, it can be said that this group of learners had reasonably high overall impression of the low interactive APA instruction because they were satisfied with all the three aspects of learning. The 50 learners were equivalent to 28.4% of the total. In the same manner, the data also revealed that there were 5 learners who chose “D” or “SD” for all the three items. This also showed an equivalent of 2.8% of the total holding a very low opinion on low interactive APA instruction and who were probably also quite dissatisfied with this mode of instruction.

In sum, the quantitative data analysis for Research Question 1(a) revealed that the majority of the learners were seen to hold positive perceptions about what the low interactive APA instruction could offer, that is, the extent of learning, liking for the presentation and extent of interest in the instruction. For each aspect of learning, there were about half of the total that gave definite and positive opinions on the low interactive APA instruction. The extent of opinions given to each aspect of learning also did not differ much. But when seen at a

“collective item” level, 28.4% of them showed definite and positive opinions on all the three aspects of learning and they were considered the highly satisfied learners for the low interactive APA instruction. But the analysis also found that among the three aspects of learning, presentation received the least ranking in terms of degree of agreement. Also, there remained 2.8% of learners who held definite and low opinions in all three aspects of learning; they were therefore considered the highly dissatisfied learners.

#### *Qualitative Data for Research Question 1(a)*

The qualitative data were collected as open-ended answers at the end of each Likert-type items described above. They provided the reasons to support the choices made for the items and hence allowed further understanding on how well learners interacted with the instructional elements. The methodology of analysis followed that of Content Analysis which allowed the textual data to be analysed in a quantitative fashion. The specific approach for coding and analysing the data was adopted from Krippendorff’s *Attribution Approach* (Krippendorff, 1980, pp. 112-114; 2004, pp. 45, 202-205). This approach aims at providing a general profile about a person or event by identifying and counting the key attributes that are known to the person or event. The type of attributes and their occurrences jointly represent the uniqueness of the person or event. By applying this approach to the present study, the textual data was first coded using *Open Coding* which required the examination of the data in order to identify attributes that could form concepts (Strauss & Corbin, 1990). In the context of this study, the attributes were the reasons and the reason was the unit of analysis, also the concepts were the phenomena formed by reasons of the same nature. By counting the number of reasons and also its percentages, the analysis was performed in a quantitative manner.

#### *Coding and Triangulation for Qualitative Data of Research Question 1(a)*

The coding was done item-by-item because each item carried a statement which constituted a specific theme for the analysis. For example, the statement for item 1 was “I learn a lot from the lesson” and hence the theme was “Learn from the lesson”. Identification of the attributes was carried out from general to specific. This entailed first scanning all the text entries to find common elements that could be regarded as reasons, then labeling these reasons with a generic name. For example, the first round of scanning on item 1 produced a general idea that many had cited “content” as a criterion for learning. Hence a generic name called “Content” was used and abbreviated as “C”. Next, entries marked with a “C” were read in detail to further refine the reason. In this case, “usefulness” and “content novelty” were found to appear very frequently. So the generic name was further refined into two new reasons, labelled as “Some or all of the content are new to me” and “All or most of the content is useful”. As the process went on, the existing name for the reasons could be modified or new names added depending on how well the expression in the text fitted into the semantics of the name. Using the same example cited earlier, it was found that many more mentioned “meaningfulness” in addition to “usefulness”. As a result, the name of the second reason was modified to reflect the state of the perception, and the new name became “All or most of the content is useful/*meaningful*”.

The next level of coding was to group reasons that addressed an issue or learning experience with the APA lesson into a concept called a “phenomenon”. A phenomenon has the purpose of raising the level of understanding to an operational level so that it could be used to describe the scope of the perception and served to support the extent of perception that was determined by the quantitative data.

The coding process described above tended to be subjective because it relied upon the researcher’s own interpretation. This is undesirable in a quantitative study like this. Hence the



data had to be triangulated to minimise the subjectivity (Creswell, 2005). This was done by having another colleague who was well-versed with multimedia design to code the same set of data independently. Differences between the two coders were resolved by negotiation. The researcher of this study understands that this is not a foolproof method because negotiating involves compromising which is not entirely objective, but he regards the method as sufficiently useful to reduce biases due to personal preferences. For example, in one of the responses taken from item 1, it states: *“I have read about these concepts from a book before but this serves as a recap for me.”* The researcher regarded this as a negative comment and coded it as “content not refreshing” but the researcher’s colleague interpreted it otherwise and considered it a positive one because it tended to mean “to revise content”. So both the researcher and his colleague deliberated for a more encompassing interpretation. Finally the term “usefulness” was agreed to be the best description and that comment was finally placed under the reason “All or most of the content is useful/meaningful”.

#### *Results and Findings from Qualitative Data of Research Question 1(a)*

The qualitative analysis was carried out item-by-item. For each item, the reasons which the coding process had identified, their corresponding frequency and percentage of occurrence as well as the phenomena determined were consolidated and shown in a tabulated format.

**For Item 1:** Please refer to Table 4.5.

From Table 4.5, ten reasons were identified and they were categorised into three phenomena by virtue of their common attributes. A reason can be positive or negative according to the context it is in. A point to note is that a positive reason does not always correspond to a positive option that a learner made in the quantitative data. For example, one learner opted for “Agree” for the item but gave the reason as *“somehow it [the lesson] is rigid that I can't fast forward to read the summary if it is my second time viewing it”*. The reason means although

the learner had agreed that he/she had learnt from the lesson they would still like to see the interface improve. So the reason was coded as a negative reason even though the quantitative feedback was a positive one.

Table 4.5 Information Identified from Textual Data for Item 1

Item 1: I learn a lot from the lesson						
Reason No.	Reason	No. of Times Cited	Percentage of Occurrence per reason (%)	Phenomenon	Percentage by Phenomenon (%)	Ranking
1.	Some or all of the content are new to me	27	17.9	Positive judgment on Content	45.0	P1
2.	All or most of the content is useful/meaningful	41	27.1			
3.	Lesson is fun/interesting/interactive/engaging/informative	10	6.6	Positive judgment on Instruction	25.8	P2
4.	Lesson is well planned/structured	27	17.9			
5.	Summary at the end of each section is useful	2	1.3			
6.	I like the two agents presenting/I like the animation	3	2.0	Positive judgment on Medium	2.0	P3
7.	I already know most of the content	13	8.6	Negative judgment on Content	8.6	N2
8.	Too much information/lesson too long/too many technical terms to learn	6	4.0	Negative judgment on Instruction	8.0	N3
9.	Not enough examples/illustrations given	6	4.0			
10.	Voice or lesson flow is mechanical/robotic/monotonous/slow	16	10.6	Negative judgment on Medium	10.6	N1
<b>Total</b>		151	100.0		100.0	

To discern the extent of the concerns, the phenomena were ranked according to their percentages of occurrence. Positive ranking was denoted by P1 to P3 and negative ranking was denoted by N1 to N3.

Looking at the results from an overall perspective, the overall positive reasons (i.e. reasons 1 to 6) tallied to 72.8% of the total number of occurrences whereas negative reasons took 27.2% (reasons 7 to 10). The contrast of the two figures affirmed the similar result obtained from the quantitative analysis in which satisfied learners (87.0%) were found far more than dissatisfied (23.0%) learners in terms of the extent of learning resulting from the low interactive APA instruction.

Looking at the results from a phenomenal level, the figures revealed that quality of content was the most frequently cited reason, followed by the quality of instruction and lastly the quality of the medium. Among the three phenomena, quality of content received far more positive comments than negative ones; quality of instruction also had more positive comments than negative ones but to a lesser extent. Quality of medium was the opposite and received more negative comments than positive ones.

Looking at the individual reasons to understand why the above phenomena were observed, it was found that quality of content was mainly judged by its usefulness; quality of instruction was judged first by the appropriateness of the instructional strategies and next by motivational factors such as interestingness and engagingness. For quality of the medium, it was judged by the rendering of the APAs which in this case, was not favourable due to the APA's quality of vocalisation.

**For Item 2:** Please refer to Table 4.6

From Table 4.6, ten reasons were identified and categorised into four phenomena. Ranking of the phenomena is shown in the last column.

Overall positive reasons (reasons 1 to 6) took up 68.3% of the total number of occurrences and negative reasons formed 31.7% (reasons 7 to 10). Similar to the situation for item 1, the result indicated that the majority of the learners found that they liked the presentation delivered by using low interactive APAs. This was in line with the result obtained from the quantitative data which showed liking of the presentation (72.7%) was greater than disliking of the presentation (27.3%).

Table 4.6 Information Identified from Textual Data for Item 2

<b>Item 2: I like the presentation of the lesson</b>						
<b>Reason No.</b>	<b>Reason</b>	<b>No. of Times Cited</b>	<b>Percentage of Occurrence per reason (%)</b>	<b>Phenomenon</b>	<b>Percentage by Phenomenon (%)</b>	<b>Ranking</b>
1.	Presentation is organised/interactive/formative/clear/user-friendly	46	28.1	Positive Judgment on Structure of Presentation	30.5	P1
2.	Provision of a summary at end of each section is useful	4	2.4			
3.	APAs or animation are cute/interesting/funny/useful/likeable	36	22.0	Positive Judgment on Nature of Medium	25.0	P2
4.	APAs addressing individual user's name provides personal touch	5	3.0			
5.	Vocalisation is engaging/acceptable/precise	11	6.7	Positive Judgment on Nature of Modality	6.7	P3
6.	Design of the interface makes content easy to comprehend	10	6.1	Positive Judgment on Design of Interface	6.1	P4
7.	Presentation is boring/not engaging/not suitable for adults/draggy	13	7.9	Negative Judgment on Appeal of Presentation	7.9	N2
8.	Vocalisation is monotonous/slow	24	14.6	Negative Judgment on Nature of Modality	20.7	N1
9.	Do not like narrative instruction	10	6.1			
10.	Interface does not allow pausing at anytime	5	3.1	Negative Judgment on Design of Interface	3.1	N3
<b>Total</b>		164	100.0		100.0	

At the phenomenal level, structure of presentation was the most cited (30.5% positive, 7.9% negative) followed by nature of medium (25.0% positive, no negative comment cited), then nature of modality (6.7% positive, 20.7% negative) and finally the interface of the design (6.1% positive, 3.1% negative). It can be seen from the figures in parenthesis that the structure of presentation and nature of medium were moderately well commented on as compared to interface of the design. However, nature of modality was negatively perceived as reflected by the higher percentage of negative comments. This implies that the modality used by the APAs is of great concern to the learners.

Looking at the individual reason level, it was found that structure of presentation was judged mostly by the arrangement of information delivery; nature of medium was judged by the presentation including animation of the APAs; design of interface was judged by the easiness to access information; and nature of modality was judged by the appeal of the APAs' vocalisation. Further examination of the figures under reasons 5 and 8 showed that APA's monotonous vocalisation attracted 14.6% of comments, but contradictorily, 6.7% of the comments indicated that the APA's vocalisation was engaging. Besides vocalisation, reason 3 also highlighted a 22.0% positive feedback on the APA's animation – the second highest figure next to reason 1. These figures suggest that the APA's deictic gestures and their movements on the screen probably are well-coordinated to render the presentation, but the process is compromised by its lack of interesting voices from the APA. Based on this, it can be said that the APA's animation is one of the reasons accounting for the high 43.7% definite positive comments reported in Item 1 quantitative data analysis, while the poor APA's vocalisation is the main reason for the 15.4% definite negative responses reported in the same analysis

**For Item 3:** Please refer to Table 4.7

From Table 4.7, nine reasons were identified and categorised into four phenomena. The ranking of the phenomena is shown in the last column.

Table 4.7 Information Identified from Textual Data for Item 3

<b>Item 3: The lesson is interesting</b>						
<b>Reason No.</b>	<b>Reason</b>	<b>No. of Times Cited</b>	<b>Percentage of Occurrence per reason (%)</b>	<b>Phenomenon</b>	<b>Percentage by Phenomenon (%)</b>	<b>Ranking</b>
1.	Useful for future application/classroom use/PowerPoint presentation/designing web pages	33	19.5	Positive Judgment on Content	29.0	P1
2.	Let me gain awareness/extra knowledge	16	9.5			
3.	Lesson is interactive/interesting/engaging/easy to understand	36	21.2	Positive Judgment on Instruction	21.2	P2
4.	Animation of the APAs is interesting/enjoyable	20	11.8	Positive Judgment on Medium	11.8	P3
5.	I like multimedia design	4	2.4	Positive Judgment on Personal Choice	2.4	P4
6.	I have already known the content	4	2.4	Negative Judgment on Content	2.4	N3
7.	Lesson is boring/draggy/monotonous/not suitable for adults	35	20.7	Negative Judgment on Instruction	23.7	N1
8.	Too much information to learn	5	3.0			
9.	APA's voice is unclear/excessive/unpleasant	16	9.5	Negative Judgment on Medium	9.5	N2
<b>Total</b>		169	100.0		100.0	

Positive reasons were reasons 1 to 5 which totalled up to 64.4% of total occurrences. The rest were negative reasons (6 to 9) which added up to 35.6% of total occurrences. Again, the result supported the finding from the quantitative data that there were a lot more interested learners of low interactive APA instruction (80.7%) than those who were uninterested (19.3%).

When analysing at the phenomenal level, it appeared that what interested a learner most was first the quality of the content and then the quality of instruction; nature of media came in

next and appeal to personal choice was the last. Quality of content received far more positive comments than negative ones (29.0% positive, 2.4% negative); quality of instruction had about equal positive and negative comments (21.2% positive, 23.7% negative) and the same was true for nature of medium (11.8% positive, 9.5% negative). Appeal of personal choice was only favoured by a very small minority (2.4%). It is worthy of note that learners seem to use primarily the same criteria for evaluating how much they learned as well as how much they were interested in the lesson because quality of content and quality of instruction were repeatedly highlighted in both items 1 and 3. This observation, together with those from items 1 and 2, suggests that when learners are not specifically asked about presentation, their perceptions on what is learnt and whether the learning is interesting or not, are not very dissimilar. This implies that judgments on usefulness of a lesson are related to interest of a lesson – a phenomenon very similar to what is observed in a face-to-face classroom situation. Furthermore, the results also indicated that though the medium (i.e. the APA) used was not ideal in its instantiation, this was not a crucial element regarded by the learners that affected the value of the learning.

When item 3 data was further analysed at the individual reason level, quality of content continued to be judged mainly by its usefulness; quality of instruction was again judged by interest and engagement but unlike item 1, more learners were dissatisfied with the slow pace of the lesson. Quality of medium like item 1 was determined by the quality of the APAs to render instruction, but the response for item 3 was the opposite of item 1 but consistent with item 2- the learners were more satisfied with the APA's animation than its voice. Appeal to personal choice was rather unusual because it was raised by a very small percentage of learners (2.4%) and could only be regarded as “exceptional cases”.

In sum, the qualitative data analysis for Research Question 1(a) revealed the criteria learners used in making judgments on the nature of the learning. The criteria were consolidated below and arranged in a hierarchical manner:

1. For item 1 Criteria for judging “I learn a lot from the lesson”:

1<sup>st</sup>: usefulness of the content

2<sup>nd</sup>: instructional strategies of the delivery

3<sup>rd</sup>: nature of the medium

2. For item 2 Criteria for judging “I like the presentation of the lesson”:

1<sup>st</sup>: structure of the presentation

2<sup>nd</sup>: nature of the medium in the delivery

3<sup>rd</sup>: suitability of modality

4<sup>th</sup>: quality of the interface

3. For item 3 Criteria for judging “The lesson is interesting”:

1<sup>st</sup>: usefulness of the content

2<sup>nd</sup>: instructional strategies of the delivery

3<sup>rd</sup>: nature of the medium

4<sup>th</sup>: appeal of personal choice

*Summary of Overall Findings for Research Question 1(a)*

Combining the findings from both the quantitative and qualitative results, it is clear that in general, learners perceived positively the learning using the low interactive APA instruction in all three aspects of learning. In terms of degree of acceptability, extent of learning was the most accepted, followed by interest in the lesson and lastly the presentation of the lesson.

Among all, 28.4% were positively and definitely satisfied with all the three aspects of



learning but there were also 2.8% of them who were negatively and definitely dissatisfied with all the three aspects of learning.

On the criteria learners used to form their perception, it was found that they placed usefulness of the content in top priority, this was followed by instructional strategies of the delivery, then the medium used in the delivery, next the modality of the instruction and lastly the quality of interface and appeal of personal choice.

The analysis also produced several important findings: (1) some learners liked the role of the APAs in the presentation because the APAs were able to provide the desired interactions through their animations as indicated by reason 6 of item 1, reasons 3 and 4 of item 2 and reason 4 of item 3; (2) some did not find the lesson favourable because the voice of the APAs was not realistically humanlike enough so that it probably became the main cause for the lesson to be uninteresting and slow. This was indicated by reason 10 of item 1, reason 7 of item 2 and reason 7 for item 3; (3) as a result of point (1) and (2), the use of modality became a crucial part in the above findings which could trigger issues of modality preferences as reflected by a small yet noteworthy figure of 6.1% in reason 9 of item 2 – this will be further explored in the next part of data analysis for Research Question 1(b); and (4) though the perception of using low interactive APAs for instruction was somewhat compromised by the APA's voice quality, it was compensated for by useful content and sound instructional methods. This was supported by the various comparisons made between the positive and negative judgments in the analysis.

#### **Research Question 1(b):**

**Do their opinions differ with respect to differences in sensory preference? If yes, how do they differ?**

The analysis of data for Research Question 1(b) adopted the same approach as in research question 1(a), that is, to proceed with quantitative data first then qualitative data.

### *Quantitative Data for Research Question 1(b)*

It was noted in earlier analyses that some learners were dissatisfied with the APA's modality due to its inability to provide real humanlike speech; this gave a clue to suspect that the result was related to learners' sensory preferences. This was explained in the Chapter Two literature review where it was pointed out that unfamiliarity with a task was related to a person's preference for the nature of the task. To test whether the above proposition is correct, a cross-tabulation containing the responses and levels of Sensory Preference was constructed. Cross-tabulation allowed comparison of patterns of distribution for each Sensory Preference level to be carried out systematically. The analysis given in the following paragraphs was carried out item-by-item.

### *Results and Findings from Quantitative Data of Research Question 1(b)*

#### **1. Item 1**

For item 1, the data were given in Table 4.8.

By inspection, the distribution of percentages across the rows for each level of Sensory Preference in Table 4.8 seemed to follow a consistent pattern that varied from "SWD" to "A" in an increasing manner. This indicated that the distribution for all sensory preferences was skewed towards the level of "Agreeing". Percentages at the two extremes of the scale (i.e. towards "SD" and "SA") showed strong visual learners had a very high "SA" percentage (25.0%) indicating a strong support for the extent of learning.

By using statistical analysis, the existence of relationship between the levels of perception and levels of Sensory Preference was to be verified by using the Kruskal-Wallis test. It is an alternative test to the Pearson Chi-square test for data that could not fulfill the Chi-Square prerequisites. The Pearson Chi-square test requires that every cell in the cross-tabulation has at least a frequency of 5 before using the test (Pallant, 2003, pp. 256-260). But the cells in Table 4.8 apparently do not meet the required condition; as a result, the Kruskal-Wallis test was used as a substitute. The Kruskal-Wallis test uses rank order as the means for calculation hence it avoids the restrictions imposed by the Pearson Chi-square method. The nature of Kruskal-Wallis Test has already been explained in Chapter Three under the section “Statistical Analysis”.

Table 4.8 Responses to Item 1 in the Perception of Learning Scale Organised according to Sensory Preference

Item 1: I learn a lot from the lesson								
Sensory Preference		Responses						
		SD	D	SWD	SWA	A	SA	Total
Strong Visual	Frequency	0	1	0	2	9	4	16
	Percentage	0.0	6.3	0.0	12.5	56.2	25.0	100.0%
Mild Visual	Frequency	0	0	5	34	38	4	81
	Percentage	0.0	0.0	6.2	42.0	46.9	4.9	100.0%
Mild Auditory	Frequency	1	5	9	17	22	6	60
	Percentage	1.7	8.3	15.0	28.3	36.7	10.0	100.0%
Strong Auditory	Frequency	0	1	1	7	8	2	19
	Percentage	0.0	5.3	5.3	36.8	42.1	10.5	100.0%

The outcomes of the Kruskal-Wallis test were given in Table 4.9.

Table 4.9 Results of the Kruskal-Wallis Test for Item 1

Sensory Preference	No. of cases in each Sensory Preference Level	Mean Rank	Chi-square Value	Degree of Freedom	Observed Significant Value
Strong Visual	16	117.75	8.154	3	.043
Mild Visual	81	89.00			
Mild Auditory	60	79.58			
Strong Auditory	19	89.92			

Table 4.9 indicates that the observed significance value was smaller than the alpha value of .05 leading to the rejection of the default null hypothesis, which assumed no difference between the two quantities. The corollary of this was that perception was significantly different across the four levels of sensory preferences,  $\chi^2(3) = 8.15$  ( $p < .05$ ). But what has caused the differences? This could be found by using a Mann-Whitney U test to conduct a post hoc analysis (de Vaus, 2002). The Mann-Whitney U test works by comparing the median values between a pair of groups using z-statistics (Pallant, 2003); as there were four sensory groups, it needed six pairs of comparisons, namely Strong Visual compared with Mild Visual, Strong Visual compared with Mild Auditory, Strong Visual compared with Strong Auditory, Mild Visual compared with Mild Auditory, Mild Visual compared with Strong Auditory, and Mild Auditory compared with Strong Auditory. If any of the above pairs produced a significance level of less than .05, the perceptions rendered by that pair would be statistically different and the null hypothesis would be rejected. The results of the Mann-Whitney U test were calculated and shown below:

1. Between Strong Visual (SV) and Mild Visual (MV) Groups  
 $U = 414.00$ ,  $z = -2.49$ ,  $p = .013$ , reject null hypothesis.
2. Between Strong Visual (SV) and Mild Auditory (MA) Groups  
 $U = 294.50$ ,  $z = -2.48$ ,  $p = .013$ , reject null hypothesis.
3. Between Strong Visual (SV) and Strong Auditory (SA) Groups

$U = 103.50$ ,  $z = -1.73$ ,  $p = .084$ , retain null hypothesis.

4. Between Mild Visual (MV) and Mild Auditory (MA) Groups

$U = 2,146.50$ ,  $z = -1.26$ ,  $p = .206$ , retain null hypothesis.

5. Between Mild Visual (MV) and Strong Auditory (SA) Groups

$U = 778.50$ ,  $z = .087$ ,  $p = .931$ , retain null hypothesis.

6. Between Mild Auditory (MA) and Strong Auditory (SA) Groups

$U = 636.50$ ,  $z = .798$ ,  $p = .425$ , retain null hypothesis.

The above results and the decisions to accept or retain the null hypothesis are reorganised and tabulated in Table 4.10.

Table 4.10 Results and Decisions of Mann-Whitney U Test on all Sensory Groups for Item 1

	Observed Significant Value (p) and Action to be taken			
	Strong Visual (SV)	Mild Visual (MV)	Mild Auditory (MA)	Strong Auditory (SA)
Strong Visual (SV)		.013 Reject null hypothesis	.013 Reject null hypothesis	.084 Retain null hypothesis
Mild Visual (MV)			.206 Retain null hypothesis	.931 Retain null hypothesis
Mild Auditory (MA)				.425 Retain null hypothesis
Strong Auditory (SA)				

From Table 4.10, it is noted that only the Strong Visual group was significantly different from Mild Visual and Mild Auditory groups but not with the rest of the sensory groups. This means that Strong visual learners, with the highest mean rank on extent of learning with the APA instruction (see Table 4.8), distinguished themselves well from the mild visual and mild auditory learners but not the strong auditory learners in terms of extent of learning with LIAI.

In other words, the strong visual learners' level of satisfaction with respect to learning with the voice-rich LIAI is the greatest and is distinctively different from the other sensory groups except the strong auditory group. This is a little strange as under normal circumstances, one would expect strong visual learners to show strong favouritism only when they learn with their preferred modality, that is, instruction with more visuals rather than voice. But since the result indicated otherwise, it could mean that strong visual learners and strong auditory learners share something in common in terms of evaluating the extent of learning for LIAI; but this is not known from the present data.

In essence, the above results seem to imply that strong visual learners were probably attracted by something else in the APA lesson more than just the modality of the presentation. More was needed to find out what the actual cause was.

In the following analysis for items 2 and 3, the same method as for item 1 was applied.

## **2. Item 2**

The responses for item 2 for each level of Sensory Preference were arranged in a cross-tabulation presented in Table 4.11.

By inspecting Table 4.11, the distribution of percentages for all levels of Sensory Preference appeared to share the same increasing pattern from "SWA" to "A". For percentages at extreme ends, no special pattern was observed and they generally remained small in value. In other words, the perception behaviour of different sensory preference levels appeared to be quite homogeneous in terms of liking the presentation of the lesson.

Table 4.11 Responses to Item 2 in the Perception of Learning Scale Organised according to Sensory Preference

Item 2: I like the presentation of the lesson								
Sensory Preference		Responses						
		SD	D	SWD	SWA	A	SA	Total
Strong Visual	Frequency	1	0	2	3	9	1	16
	Percentage	6.3	0.0	12.5	18.7	56.2	6.3	100.0%
Mild Visual	Frequency	6	5	13	24	30	3	81
	Percentage	7.4	6.2	16.1	29.6	37.0	3.7	100.0%
Mild Auditory	Frequency	6	5	4	18	25	2	60
	Percentage	10.0	8.3	6.7	30.0	41.7	3.3	100.0%
Strong Auditory	Frequency	1	3	2	6	7	0	19
	Percentage	5.3	15.8	10.5	31.6	36.8	0.0	100.0%

The above findings were further verified by statistical means using Kruskal-Wallis test. The results of the test were given in Table 4.12.

The outcome in Table 4.12 shows that the observed significance value was greater than the alpha value of .05 and hence it did not suggest a significant difference in the level of perception across the 4 levels of sensory preferences,  $\chi^2 (3) = 2.71$  ( $p > .05$ ). This was also supported by the small differences between the Mean Rank values for all levels of Sensory Preference. This statistical finding was consistent with the earlier finding by data inspection which confirmed the perception that liking the presentation was not affected by sensory preference.

Table 4.12 Results of the Kruskal-Wallis Test for Item 2

Sensory Preference	No. of cases in each Sensory Preference Level	Mean Rank	Chi-square Value	Degree of Freedom	Observed Significant Value
Strong Visual	16	105.88	2.708	3	.439
Mild Visual	81	86.30			
Mild Auditory	60	89.27			
Strong Auditory	19	80.82			

### 3. Item 3

For item 3, the responses for each level of Sensory Preference were arranged into a cross-tabulation and were given in Table 4.13.

Table 4.13 Responses to Item 3 in the Perception of Learning Scale Organised according to Sensory Preference

Item 3: The lesson is interesting								
Sensory Preference		Responses						
		SD	D	SWD	SWA	A	SA	Total
Strong Visual	Frequency	0	1	1	4	8	2	16
	Percentage	0.0	6.3	6.3	25.0	50.0	12.5	100.0%
Mild Visual	Frequency	2	4	7	30	33	5	81
	Percentage	2.5	4.9	8.6	37.1	40.7	6.2	100.0%
Mild Auditory	Frequency	2	6	7	17	24	4	60
	Percentage	3.3	10.0	11.7	28.3	40.0	6.7	100.0%
Strong Auditory	Frequency	0	2	2	6	9	0	19
	Percentage	0.0	10.5	10.5	31.6	47.4	0.0	100.0%

By inspection, all sensory preference levels appeared to follow the same pattern of percentage increase from “SWD” to “A” while extreme values remained relatively lower. Percentage for “SA” by strong visual learners (12.5%) stood out against the other learners showing more learners from this group were very interested in the lesson. This was very similar to the outcome for item 1 where “learning a lot from the lesson” was strongly supported by many of the strong visual learners. This preliminary observation seems to suggest that strong visual



learners probably used a common criterion to evaluate both extent of learning and interest in learning for LIAI.

To confirm the above observation, Kruskal-Wallis Test was applied on item 3 and the results were shown in Table 4.14.

Table 4.14 Results of the Kruskal-Wallis Test for Item 3

Sensory Preference	No. of cases in each Sensory Preference Level	Mean Rank	Chi-square Value	Degree of Freedom	Observed Significant Value
Strong Visual	16	103.69	2.073	3	.557
Mild Visual	81	89.09			
Mild Auditory	60	84.87			
Strong Auditory	19	84.66			

Results in Table 4.14 showed that the observed significant value was greater than the alpha value of .05 with the statistical result  $\chi^2(3) = 2.07$  ( $p > .05$ ). Accordingly, no perception difference due to Sensory Preference could be claimed despite the strong showing of favouritism by the strong visual learners reflected in Table 4.13. This suggested that though strong visual learners appeared to have a contrasting perception as compared to the other groups, the difference was not significantly enough to make an impact. This was also supported by the small differences in Mean Rank values between the sensory groups. The difference in Kruskal-Wallis' results for item 1 and 3 provides evidence to deny the previously stated observation based on inspection of Table 4.13 – that strong visual learners used common criteria to evaluate extent of learning and interest in learning. Therefore sensory differences are only evidenced for extent of learning.

In summary, the quantitative findings for Research Question 1(b) found that perception was related to Sensory Preference only occurred more distinctively for strong visual learners when they were asked to evaluate how much they had learnt. Presentation of the lesson and interest in the lesson were found to be unrelated to Sensory Preference. The dependency of perception on Sensory Preference for extent of learning was due mainly to the extra support given by the strong visual learners albeit the support was less marked compared to strong auditory learners. Hence, there is a need to know why strong visual learners are particularly supportive when asked about how much is learnt.

#### *Qualitative Data for Research Question 1(b)*

The qualitative analysis for Research Question 1(b) was to examine the reasons offered by the learners to see if their perceptions were related to Sensory Preference. This was done by recategorising the data previously given in Tables 4.8, 4.11 and 4.13 to include the effect of Sensory Preference. The following analysis was carried out item-by-item.

#### *Results and Findings from Qualitative Data of Research Question 1(b)*

##### **1. Item 1**

By examining Table 4.15, the Strong Visual and Strong Auditory learners' perceptions on what constitutes learning the lesson were quite different from that of Mild Visual and Mild Auditory learners. This draws a parallel from the quantitative findings reported earlier that strong visual learners are more distinctively different in terms of perception from the other sensory groups, except strong auditory learners.

Table 4.15 Textual Information arranged by Sensory Preference for Item 1

<b>Item 1: I learn a lot from the lesson</b>						
<b>Reason No.</b>	<b>Reason</b>	<b>Phenomenon</b>	<b>Sensory Preference</b>			
			<b>Strong Visual</b>	<b>Mild Visual</b>	<b>Mild Auditory</b>	<b>Strong Auditory</b>
			<b>No. of Times Cited the Reason (Percentage of Occurrence)</b>			
1.	Some or all of the content are new to me	Positive Judgment on Content	4 (30.8%)	11 (15.9%)	11 (21.2%)	1 (5.9%)
2.	All or most of the content is useful/meaningful		2 (15.4%)	19 (27.5%)	14 (26.9%)	6 (35.3%)
3.	Lesson is fun/interesting/interactive/engaging/informative	Positive Judgment on Pedagogy	3 (23.0%)	3 (4.4%)	2 (3.9%)	2 (11.7%)
4.	Lesson is well planned/structured		2 (15.4%)	15 (21.7%)	9 (17.3%)	1 (5.9%)
5.	Summary at the end of each section is useful		0	2 (3.0%)	0	0
6.	I like the two agents presenting/I like the animation	Positive Judgment on Medium	0	2 (2.9%)	0	1 (5.9%)
7.	I already know most of the content	Negative Judgment on Content	0	5 (7.2%)	5 (9.6%)	3 (17.7%)
8.	Too much information/lesson too long/too many technical terms to learn	Negative Judgment on Pedagogy	2 (15.4%)	3 (4.4%)	0	1 (5.9%)
9.	Not enough examples/illustrations given		0	5 (7.2%)	1 (1.9%)	0
10.	Voice or lesson flow is mechanical/robotic/monotonous/slow	Negative Judgment on Medium	0	4 (5.8%)	10 (19.2%)	2 (11.7%)
		<b>Total</b>	<b>13 (100.0%)</b>	<b>69 (100.0%)</b>	<b>52 (100.0%)</b>	<b>17 (100.0%)</b>

The very high percentage (30.8%) of comments on novelty of content (reason 1) for strong visual learners and a similar high percentage (35.3%) of comments on usefulness of content (reason 2) for strong auditory learners indicate that both strong sensory learners viewed quality of content as a major criterion for evaluating extent of learning. The common evaluative view gives a clue to explain why the Mann-Whitney U test for item 1 could not produce a significant difference in perception between the two groups of strong sensory learners. Table 4.15 also shows that strong visual learners made no comments about the medium used in the instruction which implied that strong visual learners were not very

concerned about whether APAs were used as a medium in the instruction. This gives another clue to explain why strong visual learners cast a strong support for the extent of learning despite being exposed to learning with an auditorily-demanding lesson. This was why they tended to congregate their perceptions around the high positive end of the scale and hence the significant difference they actuated in the statistical test. The observation also provides an answer to the question raised earlier under the summary for quantitative findings for Research Question 1(b) on the previous page.

Mild visual and mild auditory learners were positive with content and pedagogy but mild visual learners gave more positive comments than their auditory counterparts. However, the same did not apply to medium used in the instruction. APA's vocalisation was more negatively commented by mild auditory learners as compared to their visual counterparts due probably to voice being their preferred modality of learning. On the whole, mild visual learners were more critical in judgment than mild auditory learners in terms of extent of learning.

## **2. Item 2**

In Table 4.16, there appeared to be some consistency across all levels of Sensory Preference on the extent they liked the lesson.

All levels appeared to like the presentation and the animation but were dissatisfied with the vocalisation of the lesson. Strong visual learners behaved erratically over the perception on vocalisation. Some were fond of the vocalisation (27.3% for reason 5) while others showed their dissatisfaction at a level of 18.2% (reason 8). A possible explanation for this was that because vocalisation was an integral part of the presentation, using APA's speech to deliver instruction would make the vocalisation the main focus for evaluation. So for some who were

strongly guided by this notion of thinking, they probably graded the presentation unfavourably while others who were unfazed by the modality probably chose to judge the presentation by its pedagogy instead. Because of the lack of a strong behavioural pattern across the four sensory groups, the finding supports the “no sensory differences on perception” for presentation of the instruction as obtained from the quantitative means.

Table 4.16 Textual Information arranged by Sensory Preference for Item 2

<b>Item 2: I like the presentation of the lesson</b>						
<b>Reason No.</b>	<b>Reason</b>	<b>Phenomenon</b>	<b>Sensory Preference</b>			
			<b>Strong Visual</b>	<b>Mild Visual</b>	<b>Mild Auditory</b>	<b>Strong Auditory</b>
			<b>No. of Times Cited the Reason (Percentage of Occurrence)</b>			
1.	Presentation is organised/interactive/formative/clear/user-friendly	Positive Judgment on Structure of Presentation	2 (18.2%)	20 (29.4%)	20 (29.8%)	4 (22.2%)
2.	Provision of a summary at end of each section is useful		1 (9.0%)	0	3 (4.5%)	0
3.	APAs or animation are cute/interesting/funny/useful/likeable	Positive Judgment on Nature of Medium used	1 (9.1%)	14 (20.6%)	18 (26.8%)	3 (16.7%)
4.	APAs addressing individual user's name provides personal touch		0	1 (1.5%)	4 (6.0%)	0
5.	Vocalisation is engaging/acceptable/precise	Positive Judgment on Nature of Modality used	3 (27.3%)	3 (4.4%)	2 (3.0%)	3 (16.7%)
6.	Design of the interface makes content easy to comprehend	Positive Judgment on Design of Interface	1 (9.1%)	5 (7.3%)	1 (1.5%)	3 (16.7%)
7.	Presentation is boring/not engaging/not suitable for adults/draggy	Negative Judgment on Appeal of Presentation	0	6 (8.8%)	6 (9.0%)	1 (5.5%)
8.	Vocalisation is monotonous/slow	Negative Judgment on Nature of Modality used	2 (18.2%)	8 (11.8%)	11 (16.4%)	3 (16.7%)
9.	Do not like narrative instruction		0	7 (10.3%)	2 (3.0%)	1 (5.5%)
10.	Interface does not allow pausing at anytime	Negative Judgment on Design of Interface	1 (9.1%)	4 (5.9%)	0	0
		<b>Total</b>	<b>11 (100.0%)</b>	<b>68 (100.0%)</b>	<b>67 (100.0%)</b>	<b>18 (100.0%)</b>

### **3. Item 3**

In Table 4.17, the range of reasons for interest in the lesson when examined across the Sensory Preference groups did not exhibit any marked differences. All learners continued to use content and pedagogy as top criteria to evaluate learning but vocalization remained as an unappealing component. Mild visual learners consistently produced more comments either positively or negatively than mild auditory learners. This repeated pattern provides evidence to corroborate the impression given in item 1 that mild visual learners were critical thinkers because they were able to give more comments.

For strong sensory preference learners, strong auditory learners seemed to have exceptionally high percentages in two areas, one being the positive comment on lesson usefulness (40.0% under reason 1) and the other relating to the negative comment on slowness of the lesson (33.3% under reason 7). This presented two interesting findings. (1) Strong auditory learners particularly commented on voice quality of the presenter (which was the APA in this case) despite being auditorily-inclined. (2) Strong auditory learners being auditorially-inclined relied on auditory modality more than their visual counterparts. So they placed great emphasis on how voice was used in conjunction with the pedagogy. The first finding helps to explain why many were dissatisfied with the pace of the lesson (reason 7) because of the slowness of the APA's voice. The second finding pointed out that though voice quality of the APAs was a concern, it detracted little from learning overall and probably remained helpful in the instruction which explained why many still considered the lesson useful.

Table 4.17 Textual Information arranged by Sensory Preference for Item 3

<b>Item 3: The lesson is interesting</b>						
<b>Reason No.</b>	<b>Reason</b>	<b>Phenomenon</b>	<b>Sensory Preference</b>			
			<b>Strong Visual</b>	<b>Mild Visual</b>	<b>Mild Auditory</b>	<b>Strong Auditory</b>
			<b>No. of Times Cited the Reason (Percentage of Occurrence)</b>			
1.	Useful for future application/classroom use/PowerPoint presentation/designing web pages	Positive Judgment on Content	3 (20.0%)	15 (17.4%)	9 (17.0%)	6 (40.0%)
2.	Let me gain awareness/extra knowledge		3 (20.0%)	9 (10.5%)	3 (5.7%)	1 (6.7%)
3.	Lesson is interactive/interesting/engaging/easy to understand	Positive Judgment on Pedagogy	3 (20.0%)	18 (20.9%)	13 (24.5%)	2 (13.3%)
4.	Animation of the APAs is interesting/enjoyable	Positive Judgment on Media	0	11 (12.8%)	8 (15.1%)	1 (6.7%)
5.	I like multimedia design	Positive Judgment on Personal Choice	1 (6.7%)	2 (2.3%)	1 (1.9%)	0
6.	I have already known the content	Negative Judgment on Content	1 (6.7%)	3 (3.5%)	0	0
7.	Lesson is boring/draggy/monotonous/not suitable for adults	Negative Judgment on Pedagogy	2 (13.2%)	17 (19.8%)	11 (20.7%)	5 (33.3%)
8.	Too much information to learn		1 (6.7%)	2 (2.3%)	2 (3.8%)	0
9.	APA's voice is unclear/excessive/unpleasant	Negative Judgment on Media	1 (6.7%)	9 (10.5%)	6 (11.3%)	0
		<b>Total</b>	<b>15 (100.0%)</b>	<b>86 (100.0%)</b>	<b>53 (100.0%)</b>	<b>15 (100.0%)</b>

### *Summary of Overall Findings for Research Question 1(b)*

Overall, statistical analysis could not find any relationship between overall perception and Sensory Preference for “liking the presentation” and “interest in the lesson” except for “learning from the lesson” where it was particularly favoured by a large proportion of strong visual learners. Strong visual learners, however, did not differ significantly from strong

auditory learners in terms of extent of learning. Results from the qualitative analysis provided additional information to the quantitative findings and these are listed below:

1. All sensory groups regarded usefulness of content and quality of pedagogy as their top criteria when evaluating the extent of learning and these two areas scored the highest positive comments.
2. It is observed that the very favourable overall perception on extent of learning from the strong visual learners was due to their low priority of using media as a criterion to evaluate learning. This explains why their perceptions were not affected by the use of APAs and their less-than-ideal voice quality.
3. Also why strong visual learners were not very different from strong auditory learners in terms of extent of learning because both groups of learners used quality of content as a common evaluative criterion.
4. All sensory groups liked the presentation and animation of the lesson but also expressed dissatisfaction about the vocalisation of the APAs.
5. Not all strong visual learners were unhappy about the APA's vocalisation. Some even found the vocalisation engaging. This dichotomous phenomenon probably was due to the fact that when presentation was made the subject of evaluation, medium became a crucial element in the evaluation process and hence the quality of the APAs' vocalisation became liable for scrutiny. Those who were bound by this thinking probably graded the vocalisation unfavourably while those unfazed by the modality continued to use content and pedagogy to grade the presentation.
6. Like in point (1) above, all sensory groups used the same criteria of content and pedagogy to evaluate interest in the lesson and were positive in these two areas. Despite this, they all had concern about the APA's voice and slow pace of the lesson.



7. The slow pace of the lesson was most commented on by the strong auditory learners despite themselves being auditorily-inclined. Why did strong auditorily-inclined learners not favour a voice-rich lesson? A possible explanation would be that strong auditory learners relied more on auditory modality to process information and hence placed great emphasis on the quality of the auditory sound, or how modality was used in conjunction with the pedagogy. They probably found the APA's delivery of the lesson not commensurate with their expectations, but still found its explanation and animation useful in the learning process. So the delivery was graded lowly but the content was graded highly.

**Research Question 2(a):**

**How do learners' achievements from instruction using low interactive APAs compare with that from more conventional online instruction?**

Achievement of learners was measured by the score obtained by using the Performance Quiz. The score was of interval data and the analysis was based on quantitative methods using one-way *Analysis of Variance* (ANOVA). One-way ANOVA was employed to compare the means of two independent groups belonging to the same independent variable (Pallant, 2003. pp. 92-93). For this research question, the dependent variable was Performance and the independent variable was Types of Instruction that had two groups, one was called Low Interactive APA Instruction (LIAI) and the other was Conventional Instruction (CI). The means to be compared were the means of LIAI and CI.

Because ANOVA analysis is based on variances and means which are sensitive to outliers and normality of a distribution (de Vaus, 2002), the first step to the process of ANOVA was to check for existence of outliers from the dependent variable and if applicable, remove them.

The next step was to examine the distribution for conformance of normality. Severe deviation from normality would require an alternative method of analysis.

### *Outliers*

An outlier is defined as any score that is greater or smaller than 1.5 times the interquartile range of the distribution. An interquartile is the range between the first and third quartiles within a distribution (Lind, Marchal & Mason, 2002, pp. 125-127). The detection of such an outlier was carried out by using SPSS *Boxplot*. Boxplot visually displays the interquartile as a box (hence is called Boxplot) and marked the two 1.5 times interquartile positions with a “whisker” (de Vaus, 2002, p. 210). Any score that has a value falling outside the two “whisker’s” positions (both positive and negative) is recognised as an outlier and is labelled with a “o” symbol. For SPSS, the case number of the outlier is shown alongside with the “o” symbol. Figure 4.1 shows the Boxplot for the dependent variable “Performance”.

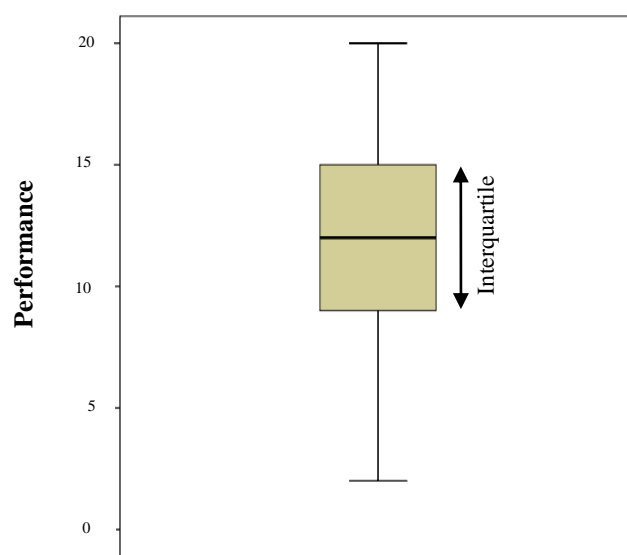


Figure 4.1 Boxplot for Dependent Variable “Performance” Produced by using SPSS

It can be seen from Figure 4.1 that there was no labelling of “o” symbol and hence no outlier was detected. To further confirm such a finding, a *5% trimmed mean* was computed. In SPSS, the “5% trimmed mean” is a new mean value calculated after removing the top and bottom 5% of the cases in a data set. The removal of extreme cases helps to remove the effects due to outliers. Below compared the original mean and the “5% trimmed mean”:

Original mean  $M = 11.99$  ( $SD=3.62$ )

5% trimmed mean  $M = 12.01$  ( $SD=3.60$ )

The difference between the original mean and the “5% trimmed mean” was a small 0.02 which was equivalent to 0.17% of the original mean. Therefore extreme cases including any undetected outliers had no significant effect on the distribution of the data for Performance. This implied that the quiz scores for Performance were suitable for use with ANOVA.

### *Normality*

The next pre-ANOVA test was to check for normality of the distribution for Performance. Normality refers to how well a set of data conforms to a standardised distribution that is measured by its skewness and peakness (also known as kurtosis) (Pallant, 2003, pp. 53-54). A distribution that is over-skewed or over-peaked will affect the choice of tools and hence the method of analysis.

The normality was first inspected visually by comparing the observed distribution in the form of a histogram with a theoretical standard normal distribution. For ease of comparison, the standard normal distribution was superimposed on the histogram. Figure 4.2 showed the two distributions.

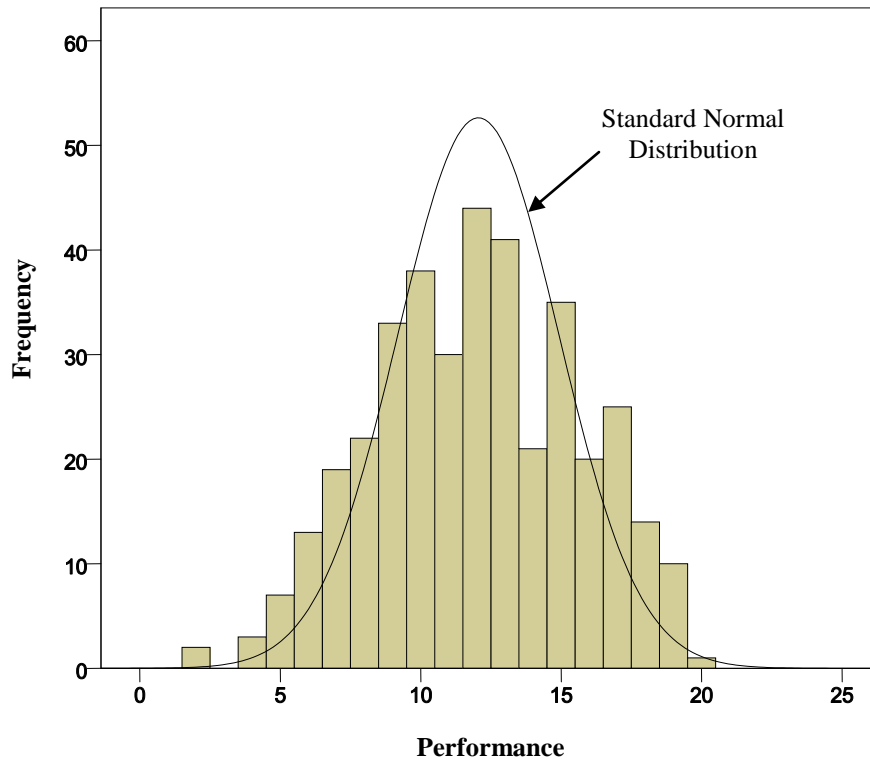


Figure 4.2 Histogram for Performance and its corresponding Standard Normal Distribution

Figure 4.2 showed that the histogram of Performance conforming fairly well in terms of skewness but falling short slightly in terms of kurtosis. The observation was confirmed by using Kolmogorov-Smirnov (KS) test. The KS test result,  $D(378) = .075$ ,  $p < .001$ , indicated that the p-value was smaller than the alpha value of .05 and hence the normality of Performance was not supported. But the result did not immediately rule out the use of ANOVA because rejection normally depended on the severity of the non-normality (Pallant, 2003, p. 59). To gauge the level of non-normality, the skewness and kurtosis were separately determined using the descriptive function in SPSS. They were found to be as follows:

Skewness = - .060 (SE = .125)

Kurtosis = - .573 (SE = .250)

The skewness and kurtosis of a standard normal distribution were known to have a value of zero. Based on de Vaus's (2002, p. 76) criterion, only values greater than 1.0 would be considered as non-normal. Based on the result obtained, the skewness was well within the acceptable range but the kurtosis showed the distribution was a little flat, but the risk of accepting this was rather low because effect of non-normality on variance was small when size of a sample was greater than 200 (Pallant, 2003, p. 53-54). Since the sample size of this study was 378, the researcher's decision was to accept the mild non-normality and treated the effect as non-interfering to the use of ANOVA.

*Results and Findings from One-way ANOVA for Research Question 2(a)*

One-way ANOVA was carried out using SPSS. The means to be compared were the means of Performance from the two groups of Types of Instruction, which were, the Low Interactive APA Instruction (LIAI) and Conventional Instruction (CI). Their relationship was described in Table 4.18.

Table 4.18 Means to Compare in One-way ANOVA for Types of Instruction

<b>Types of Instruction</b>	
LIAI	CI
Mean performance score is to be determined and compared	Mean performance score is to be determined and compared

For accurate result, the variances for the two groups under comparison must be fairly similar to assume that they were from the same population. This condition was verified by using Levene's test. From the Levene's test results, which was found to be  $F(1, 376) = 1.09$ ,  $p = .297$ , the difference was non-significant because its p-value was greater than .05, indicating that the variances of the two groups were not significantly different. Therefore, the

requirement for homogeneity of variances for ANOVA was supported and the ANOVA could be used without risk. The results from the test of ANOVA were shown in Table 4.19.

Table 4.19 Results of One-way ANOVA Test on Performance between LIAI and CI

	Sum of Squares	Degree of Freedom	Mean Square	F-Value	Significant Value	Eta Squared
Between Groups	160.497	1	160.497	12.595	.000	.032
Within Groups	4791.461	376	12.743			
Total	4951.958	377				

The results from Table 4.19 indicated a significant difference in Performance for LIAI and CI,  $F(1, 376) = 12.60, p < .001$ . But it did not show how much the difference was and which instruction was better. This had to be determined by separately calculating the mean Performances for the two types of instruction. The results were shown below:

Mean Performance for LIAI = 12.7 (SD = 3.74)

Mean Performance for CI = 11.4 (SD = 3.41)

Clearly, LIAI outperformed CI by a significant difference of 1.3. This was about 5.9% of the maximum possible score. In other words, Performance was indeed dependent on Type of Instruction. Effect size of the difference was found to be .03 as indicted by the Eta Squared from Table 4.19, which was classified as moderately small according to Cohen's criteria (Cohen, 1988). Hence although learners from Low Interactive APAs instruction achieved better than those from Conventional Instruction, the effect due to the difference in instruction was moderately small.

*Summary of Overall Findings for Research Question 2(a)*

Achievement obtained from learning with Low Interactive APA Instruction was found to be statistically better than learning from Conventional Instruction by about 5.9%. Hence using Low Interactive APAs Instruction has an effect on enhancing learning but the effect is moderately small.

**Research Question 2(b):**

**Does the achievement vary in accordance with learner's sensory preference? If yes, how does it vary?**

To answer Research Question 2(b), one-way ANOVA was used to find the existence of differences in Performance for Sensory Preference. This was done by comparing the mean performance scores for the four sensory preferences. The mean performance score was the score for the two types of instruction combined together. The relationship was described in Table 4.20.

Table 4.20 Means to Compare in One-way ANOVA for Sensory Preference

<b>Sensory Preference</b>	Strong Visual	Mean performance score is to be determined and compared
	Mild Visual	Mean performance score is to be determined and compared
	Mild Auditory	Mean performance score is to be determined and compared
	Strong Auditory	Mean performance score is to be determined and compared

As in research question 2(a), the homoscedasticity of the four sensory groups was first checked for consistency before application of the ANOVA. The checking was done by using the same Levene's test.

From the Levene's test result, which was  $F(3, 374) = .736$ ,  $p = .531$ , the difference was non-significant because its p-value was greater than .05, indicating that the variances of the four sensory groups were not significantly different. Therefore, homoscedasticity existed among the four sensory groups which suggested that ANOVA could be used without statistical risk.

The results for applying ANOVA on Performance for Sensory Preference were shown in Table 4.21.

Table 4.21 Results of One-way ANOVA for Performance on Sensory Preference

	Sum of Squares	Degree of Freedom	Mean Square	F-Value	Significant Value
Between Groups	5.325	3	1.775	.134	.940
Within Groups	4946.633	374	13.226		
Total	4951.958	377			

From Table 4.20, the results showed that no significant difference existed between the four Sensory Preference groups,  $F(3, 374) = .134$ ,  $p = .940$ . This implied that the means for Performance for the four sensory preference groups were very close to each other. Table 4.22 revealed the condition.

Table 4.22 Mean Scores in Performance (with Standard Deviation) for Different Sensory Levels

	Performance	
Sensory Preference	Mean (M)	Standard Deviation (SD)
Strong Visual	11.69	3.82
Mild Visual	11.95	3.41
Mild Auditory	12.10	3.73
Strong Auditory	12.06	4.08



It can be seen from Table 4.22 that the means were indeed very close to one another with the biggest margin worked out to be only .41. Together with the non-significant result obtained earlier, it can be said that achievement did not depend on sensory preferences when the learning is irrespective of types of instruction. The finding is also in line with what this researcher has explained in Chapter Two Literature Review that learning styles should not be used as a sole predictor for learning outcome due to the complex nature of learning which often involves multiple forms of interactions; it should however be used as an additional factor to see how it may moderate the interactions during the learning process. The single use of sensory preference on performance without the mediation of instruction indicated here is a phenomenon that is frequently criticised in the literature, including that of Coffield et. al. (2004) and other critics of learning styles.

#### *Summary of Overall Findings for Research Question 2(b)*

Achievement of learners from both Low Interactive APA Instruction and Conventional Instruction combined together were found to be unrelated to Sensory Preference. Hence Sensory Preference alone could not predetermine achievement.

#### **Research Question 2(c):**

**In view of the answers to 2(a) and 2(b), what is the joint impact of types of instruction and sensory preference on achievement?**

Research Question 2(c) was answered by using two-way ANOVA to analyse the data.

Conceptually, the joint impact of Types of Instruction and Sensory Preference on Performance could be represented by integrating Table 4.18 and Table 4.20 into a single table representing the joint interaction between the variables. This was shown in Table 4.23.

Table 4.23 Means to Compare in Two-way ANOVA for Types of Instruction and Sensory Preference

		Types of Instruction	
		LIAI	CI
<b>Sensory Preference</b>	Strong Visual	Mean performance score is to be determined and compared	Mean performance score is to be determined and compared
	Mild Visual	Mean performance score is to be determined and compared	Mean performance score is to be determined and compared
	Mild Auditory	Mean performance score is to be determined and compared	Mean performance score is to be determined and compared
	Strong Auditory	Mean performance score is to be determined and compared	Mean performance score is to be determined and compared

Table 4.23 depicted the possible ways of interaction between the two independent variables. For example, strong visual learners can interact with the elements of voice-rich APA instruction (LIAI) or the elements in text-rich conventional instruction (CI) to produce learning. In other words, sensory preference is not used as a sole predictor but a confounding factor to see how it mediates the two types of instruction.

In SPSS, the interaction between Sensory Preference and Types of Instruction was computed by using a two-way ANOVA based on a regression model. As per all ANOVA procedures, the homoscedasticity of the distribution in each cell had to be first checked. This was done by the Levene's Test which gave  $F(7, 370) = .928$ ,  $p = .485$ . The significant value was greater than .05 so the homoscedasticity condition was not violated and the two-way ANOVA was applied.

Table 4.24 showed the results of the two-way ANOVA.

Table 4.24 Results of Two-way ANOVA for Performance on Types of Instruction and Sensory Preference

Source	Sum of Squares	Degree of Freedom	Mean Square	F-Value	Significant Value	Partial Eta Squared
Corrected Model	563.414	7	80.488	6.786	.000	.114
Intercept	32586.157	1	32586.157	2747.353	.000	.881
Types of Instruction	56.762	1	56.762	4.786	.029	.013
Sensory Preference	12.182	3	4.061	.342	.795	.003
(Types of Instruction) * (Sensory Preference)	396.174	3	132.058	11.134	.000	.083
Error	4388.543	370	11.861			
Total	59288.000	378				
Corrected Total	4951.958	377				

In Table 4.24, the computation for “dependence of Performance on Types of Instruction” and “dependence of Performance on Sensory Preference” were repeated as a standard procedure in SPSS whenever a two-way ANOVA was run. The contributions by the two “dependences” were called the *main effects*. They produced the same outcome as those obtained in Research Questions 1(a) and 1(b). The results were shown here as  $F(1, 370) = 4.79$ ,  $p < .05$  for Types of Instruction and  $F(3, 370) = .342$ ,  $p = .342$  for Sensory Preference, both could be found in Table 4.24. Joint impact from the two independent variables was measured by the interaction effect denoted by (Types of Instruction) \* (Sensory Preference) in the same table. The results revealed that there was a significant interaction effect [ $F(3, 370) = 11.1$ ,  $p < .001$ ] with an effect size of .08 (measured by the partial Eta Squared) and was classified as moderately large by Cohen’s criteria (Cohen, 1988). This means that there was a significant joint impact by the two variables on achievement (measured by Performance) and the effects Types of Instruction had on achievement were moderated by Sensory Preference.

To further understand how effect on achievement due to Types of Instruction was affected by Sensory Preference, one-way ANOVA on Performance by Types of Instruction was applied separately to each sensory group (Pallant, 2003, pp. 207-208). The results for each Sensory Preference were collectively tabulated in Table 4.25.

Table 4.25 Results of One-way ANOVA for Performance on Types of Instruction for each Sensory Preference Group

Sensory Preference	Source	Sum of Squares	Degree of Freedom	Mean Square	F-Value	Significant Value	Eta Squared
Strong Visual	Between Groups	123.339	1	123.339	10.800	.002	.24
	Within Groups	388.300	34	11.421			
	Total	511.639	35				
Mild Visual	Between Groups	208.980	1	208.980	19.983	.000	.11
	Within Groups	1725.535	165	10.458			
	Total	1934.515	166				
Mild Auditory	Between Groups	10.538	1	10.538	.757	.386	N.A.
	Within Groups	1908.052	137	13.927			
	Total	1918.590	138				
Strong Auditory	Between Groups	215.233	1	215.233	19.958	.000	.37
	Within Groups	366.656	34	10.784			
	Total	581.889	35				

The results from Table 4.25 show that all sensory groups with the exception of mild auditory learners exert certain effects on Performance due to Types of Instruction. The extent of effect they exert was measured by Eta Squared (also effect size) and was found to be in decreasing order, that is, - .37 for strong auditory learners, .24 for strong visual learners and .11 for mild visual learners. To aid explanation, the above effects were transformed into a graphic

representation depicting the differences in mean performance scores between LIAI and CI for each sensory group. This is shown in Figure 4.3.

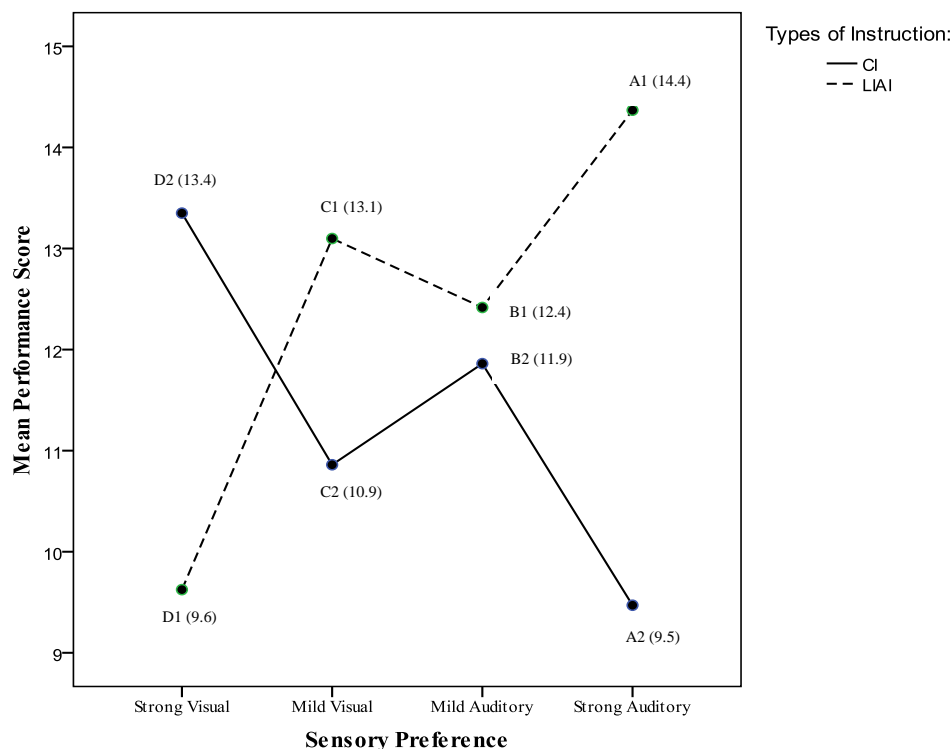


Figure 4.3 Mean Performance Scores between LIAI and CI for each Sensory Group

From Figure 4.3 it can be seen that the two curves formed from the two types of instruction intercept one another, giving rise to a “crossover interaction”. The occurrence of a “crossover interaction” is very important as it fulfils the requirement proposed by Pashler, McDaniel, Rohrer, & Bjork (2008) (discussed in Chapter 2) to show scientific evidence on the existence of a “modality-instruction” effect. The existence of such interaction also helps to “authenticate” the claims and observations made in earlier discussions in conjunction with the Research Questions. Further information obtained from the curves reveals that strong auditory learners benefited the most from learning with LIAI with a mean score of 14.4 out of a maximum of 22 (see point A1). This is consistent with their general perception which indicated that they learned from the APA instruction despite their dislike with the APA’s

vocalisation. In contrast, strong auditory learners suffered the most when learning with CI and chalked up a mean score of only 9.5 (see point A2). Since LIAI is voice-rich and CI is text-rich in delivery format, the results support the proposition that a learner learns better when s/he can interact with instructional elements that engender modalities consistent with his/her sensory preference. Such a view is also supported by the results of the strong visual learners. When the strong visually-inclined group learned with voice-rich LIAI, they scored relatively low with a mean of 9.6 (see point D1) but when another similar strong visually-inclined group learned with the text-rich CI, they did well with a mean score of 13.4 (see point D2). This again illustrates the importance of allowing learners to interact with instructional elements in their preferred modalities.

But for mild visual and mild auditory learners, the phenomenon was rather different. The matching of modality with sensory preference did not seem to apply well to these two groups of learners. Mild auditory learners did not benefit from learning conditions using their preferred modality (see points B1 and B2) while mild visual learners reversed the modality effect and performed better in the opposite modality (see points C1 and C2). This is a very strange phenomenon. From the available results obtained so far, it may infer that if mild visual learners are truly more critical than their auditory counterparts as posited before, this implies that they were more attentive during the learning process, hence they gave more thought to the lesson and produced more comments. It could be that additional attention they paid to the lesson gave them an edge over their mild auditory counterparts. But such a view can only be applied to the APA learning condition as this study did not collect perceptual information pertaining to learning in non-APA conditions. Hence, whether attention is a decisive factor in learning for both types of instruction is not fully understood. As it is, the argument based on attention can only remain as a hypothesis.

### *Summary of Overall Findings for Research Question 2(c)*

Achievement of learners using LIAI segregated into Sensory Preference groups was found to be significantly different from learners using CI also segregated into Sensory Preference groups. In other words, differences in achievement due to Types of Instruction were affected by the Sensory Preference of the learners. This means that there is a joint impact on achievement by Types of Instruction and Sensory Preference.

The joint impact was found to have the following effects: The largest achievement difference due to Types of Instruction was produced by the strong auditory learners with LIAI outperforming CI. The second largest was produced by the strong visual learners with CI outperforming LIAI. The third largest was produced by the mild visual learners with LIAI outperforming CI. The last was from the mild auditory learners who did not produce any achievement difference between LIAI and CI.

### Chapter Summary for the Two Main Research Questions

Sub-research Questions 1(a) and 1(b) were designed to answer the main Research Question 1 and likewise sub-research Questions 2(a), 2(b) and 2(c) were designed to answer the main Research Question 2. The following are the consolidations of findings from the various sub-research questions. They were arranged to address the two main research questions accordingly.

#### *For Main Research Question 1*

In a nutshell, the Low Interactive APA Instruction (LIAI) was well received by the learners due mainly to the satisfaction with the usefulness of the content and the quality of the pedagogy. About half of them expressed definite consent to the positiveness of the lesson while the other one-tenth gave their definite dissent. Others were indefinite about their

opinions. Learners' main dissatisfied area was the quality of the APA's voice which tended to limit the pace of delivery. However, this was somehow offset by some who praised the APA's animation instead. Modalities, quality of interface and personal choice were raised but were incidental and did not constitute a concern.

Perception was not affected by Sensory Preference when learners were asked if they liked the presentation and were interested in the lesson. Perception was affected by Sensory Preference, however, when they were asked how much they learned. The perception of strong visual learners was the most positive in this respect and was distinctly different from the other sensory groups except for strong auditory learners. An explanation for this is that both strong visual and auditory learners used a common criterion pertaining to quality of content for evaluation. Despite the findings cited, learners' feedback revealed that all Sensory Preference groups evaluated the lesson mainly by usefulness of the content and instructional strategies used which explained why LIAI could still appeal to majority of them despite its shortcoming in vocalisation. The poor APA's quality of voice appeared to be a constant remark that cut across all Sensory Preference groups whereas slowness of lesson was most commented on by the strong auditory learners.

#### *For Main Research Question 2*

As for achievement, learning with LIAI produced a moderately small improvement over learning with CI. When learning was compared across the different Sensory Preference groups disregarding Types of Instruction, it was found that Sensory Preference did not cause achievement to vary. In other words, achievement was not related to variation of Sensory Preference alone. But when achievement was examined with respect to a joint impact by both Sensory Preference and Types of Instruction, it was found that how well a learner achieved in LIAI or CI was dependent upon the Sensory Preference of the learner. The outcomes also



demonstrated the “crossover interaction” effect as required by Pashler et. al. (2008) to be a form of evidence to show the existence of a sensory effect. The relationships between Sensory Preference and Types of Instruction were such that strong auditory learners benefited the most from LIAI but the least from CI; strong visual learners was the next in rank but benefited in the opposite way - more from CI but less from LIAI. Mild visual learners restored the order and benefited well from LIAI and poorly from CI. For mild auditory learners, they did neither better nor worse from either instruction. The joint impact by both Sensory Preference and Types of Instruction was considered to be moderately large.

In sum, Low Interactive APA Instruction was able to produce learning effectively for the learners in general, and was found to be marginally better than the conventional online instruction. Low Interactive APA Instruction is particularly effective for strong visual and strong auditory learners and moderately effective for mild visual learners. It was not effective for mild auditory learners.

## CHAPTER FIVE

### DISCUSSION

#### Introduction

The purpose of this chapter is to review the findings from Chapter Four and provide a discussion on how these findings relate to previous literature. The discussion also seeks to provide explanations for some of the observed phenomena and to understand their impact on online learning in general. The discussion is divided into three sections. A short description for each of the sections is given below:

- A Brief Summary of the Study

This section gives a short recapitulation of how this study came into being and what it intended to find out.

- Synthesis of the Findings

A continuation from the previous section, this section repeats the empirical findings from Chapter Four but in a synthesised manner so that findings can be viewed from a conceptual perspective.

- How the Findings inform the Study?

Here, meanings of the findings are interpreted both theoretically and conceptually in the context of the study. This is done by making references to the interaction framework given in Chapter Two. Whenever applicable, new or additional literature may be included to provide support to the discussion.

#### A Brief Summary of the Study

Animated pedagogical agents (APAs) are often thought to be associated with high interactivity so that they can behave like real humans in order to engender a realistic learning

environment. But this study argues that high interactivity often entails high technological requirements and expensive design costs which are not always affordable by ordinary instructional designers and institutions operating on tight budgets. This may limit the design of APA-based learning to relatively few professionals.

The use of APAs is particularly important in online settings because they can help to compensate for the lack of human presence, which is also a critical area often criticised by online learners. In this respect, while never replacing humans, they may help to reduce human resource costs, especially in teaching-intensive courses. To overcome the need to design highly interactive APAs and at the same time use APAs supportively in online environments will require the APAs to be re-designed so that they can render simple but yet effective instruction. In other words, the redesigning should consider using low interactive APAs guided by authentic pedagogy to deliver instruction. This is the main reason for instituting this study.

The literature review provided possible ways to design low interactive APA instruction from a pedagogical perspective rather than from a technological consideration. As a result, a tripartite interaction framework which consisted of three types of interactions was developed and described in Chapter Three. The framework focused on producing simple but yet effective interactions using sound pedagogy. Guidelines for design of the framework are reproduced below from Chapter Three:

1. Learner-Content Interaction

- Element interactivity in the content should be kept to the minimum and present the information by maximising the use of voice and visuals.

2. Learner-APA Interaction

- APAs should use short speech sentences for explanation. Also, render the speech and gestures either in a sequential or concurrent manner to direct learners' attention in such as way to maximise temporal proximity and minimise split-attention effect.
- Rendition of the learning process can make use of multiple APAs to compensate for the possible lack of social presence due to the use low interactive APAs.

### 3. APA-Content Interaction

- Information containing illustration should be organised into several pop-up windows and the temporal appearance of these windows synchronised with the explanation by the APA. This helps to ease the cognitive load demand on the learners by providing a guided flow of lesson sequence.

Using the above guidelines, a low interactive APA online lesson called LIAI was developed. It was designed for a sample of 378 pre-service teachers to learn multimedia design. Because this study adopted a quasi-experimental approach to ascertain the quality of LIAI, a similar lesson called CI with the same content but delivered in a conventional format was also constructed. The CI was used as a control and for comparing learning outcomes with LIAI in terms of performance only; perceptions were not compared due to practical constraints as explained in Chapter Three.

The effectiveness and favourability of LIAI were measured by three questionnaires and one quiz. The data the instruments collected were for answering the following main and sub-questions.

1. How favourably do learners perceive instruction using low interactive APAs?
  - a. What are the opinions of learners on instruction using low interactive APAs?

- b. Do their opinions differ with respect to differences in sensory preference? If yes, how do they differ?
- 2. How effective is instruction using low interactive APAs in terms of helping learners learn?
  - a. How do learners' achievements from instruction using low interactive APAs compare with that from more conventional online instruction?
  - b. Does the achievement vary in accordance with learner's sensory preferences? If yes, how does it vary?
  - c. In view of the answers to 2(a) and 2(b) above, what is the joint impact of types of instruction and sensory preference on achievement?

The instruments were administered, the data were collected, coded, analysed and findings were produced in Chapter Four. In the following section, the findings will be synthesised and presented according to the research questions.

### Synthesis of the Findings

The empirical findings for each research question, including the sub-questions, are collectively presented below. They are compiled and reorganised so that they are less technically-inclined but more conceptually oriented. This is to facilitate the discussion in the third section.

*Question 1: How favourably do learners perceive instruction using low interactive APAs?*

- a. What are the opinions of learners on instruction using low interactive APAs?*
- b. Do their opinions differ with respect to differences in sensory preference? If yes, how do they differ?*

### *General Perceptions*

The general findings for Research Question 1 were that instruction using low interactive APAs was in general well received by the learners. This is evidenced by both quantitative and qualitative findings. For quantitative findings, favourability was analysed at three levels, the overall level, individual learning level, and shared learning level. At the overall level, average figures that apply to all the three aspects of learning were identified. Using this criterion, each aspect of learning was found to be favoured by about half of the learners who showed definite and positive opinions (see Table 4.4); but not favoured by the other approximately one-tenth of the learners who were also definite but had negative opinions. The remaining fellow learners were considered as non-opinionated learners because they showed uncertainty in their responses.

At the individual learning level which compares favourability between the three aspects of learning, it was found that extent of learning received the highest level of satisfaction, followed by interest in the lesson and lastly the presentation of the lesson.

At the shared learning level, extreme learners who had a strong feeling for, or against, all three aspects of learning were identified. “Strong” as in “strong feeling” refers to those who answered with options “Agree”, “Strongly Agree”, “Disagree” or “Strongly Disagree”. Based on this, 28.4% of learners were found to be strong supporters for the APA-based lesson while 2.8% were strong dissatisfied learners of the same lesson.

The results from the qualitative analysis provided additional information to complement the quantitative findings; in fact, the qualitative analysis produced similar outcomes to those of the quantitative through the use of open-ended questions to triangulate the single Likert-type items used in the Perception of Learning Scale (PLS) as highlighted in Chapter Three. About two-thirds of the reasons posted for the three aspects of learning were complementary while

the remaining one-third was non-complimentary. What satisfied the learners most with respect to the three aspects of learning was first the extent of learning, second the interest in the lesson and lastly the presentation of the lesson. This is in good agreement with the quantitative findings.

Results from the qualitative analysis found that learners used self-imposed criteria to evaluate the three aspects of learning with APAs. They used (1) usefulness of content, (2) instructional strategies of instruction and, (3) nature of medium, to evaluate extent of learning and interest in the lesson. But when evaluating presentation of the lesson, they used (4) structure of presentation and (5) nature of modality instead. These five criteria are key to determining learners' perceptions. Other criteria raised in the survey were quality of interface and personal choice. But because these criteria were raised only occasionally and by only a handful of learners; they were therefore considered incidental phenomena and were not regarded as contributing factors.

Among the five criteria learners used, usefulness of content was the main reason for favouring the “extent of the learning” and “interest in the lesson” followed by effective instructional strategies. As for “liking the presentation”, it was well-structured presentation followed by interesting APA animation (i.e. the medium) that were the main causes for the favourability. Despite the positiveness, unfavourability was also observed. Poor vocalisation (i.e. modality) was the main reason for not “liking the presentation” which possibly had also caused a small minority to dislike the APA (i.e. the medium) as well as the pace of delivery (i.e. instruction) as observed in “extent of learning” and “interest in lesson”. To make the above findings more comprehensible, the observed phenomena were consolidated into a matrix table (see Table 5.1). Table 5.1 uses “+” to denote favourability and “-” to denote unfavourability. More “+” or “-” means greater extent of favourability or unfavourability respectively.

From Table 5.1, the nature of modality became an issue only when learners were asked to comment about presentation. This shows that the modality of the APA is not a major concern for learners when asked to evaluate extent of learning and interest of learning.

Table 5.1 Learner's Favourability and Unfavourability on Aspects of Learning

Aspects of Learning	Learner's Favourability and Unfavourability on Learning				
	Usefulness of Content	Instructional Strategies	Nature of Medium	Structure of Presentation	Nature of Modality
Extent of Learning	++++	+++ –	–		
Like the Presentation			++ –	+++	--
Interest in the Lesson	+++	++ –	+ –		

**Note:** “+” denotes favourability; “-” denotes unfavourability.

No. of “+” or “-” denotes the strength of favourability or unfavourability respectively.

### *Perceptions and Sensory Preference*

Quantitatively, learners' perceptions on low interactive APA instruction was found to be unaffected by their sensory preferences on all aspects of learning except for extent of learning in which strong visual learners outscored mild visual and mild auditory learners in terms of favourability, but not strong auditory learners. Strong visual learners, unlike the other sensory learners, made no negative remarks at all about the medium of the lesson and commented very favourably on the lesson's content and pedagogy.

Strong visual learners were also found to have no statistical influences on the other two aspects of learning namely – Liking of the Presentation and Interest in the lesson. This is likely due to evaluating presentation and interest requiring a closer scrutiny of the APA's animation and vocalization, which did not allow strong visual learners to focus on just content



any more. Animation and vocalisation invited both positive and negative perceptions which made the overall effect due to strong visual learners similar to the rest of sensory groups and hence the insignificant influence reported by the statistical test.

Strong auditory learners on the other hand, unlike the strong visual learners, cared very much about the slowness of the lesson. They expressed this sentiment markedly when they gave feedback on interest in the lesson. Despite this, many praised the usefulness of the content and a sizable number also commented favourably on the APA's animation. It can be seen that strong visual and strong auditory learners were different in their views on modality but their views converged when they were asked to evaluate how much they learned from the APA instruction. They both regarded good quality of content as a very important criterion.

The perceptions of mild auditory learners were similar to their strong auditory counterparts who showed dissatisfaction with the APA's vocalisation and slow pace of the lesson when judged across the three aspects of learning. They also praised the APA's animation for the interesting role they played in the instruction.

Mild visual learners proved to be the most critical as seen by their widespread of comments, both positively and negatively, on all three aspects of learning. They shared similar sentiments to the other sensory groups, that is, satisfied with the content and instructional strategies, like the APA's animation, but dislike the APA's vocalisation and pace of the lesson delivery.

In all, the answers to Research Question 1 can be condensed into the following paragraphs:

1. Learners of the low interactive APA instruction expressed five areas of concern as their yardsticks to evaluate the APA-based lesson. They found the content of the

lesson very useful, the instructional strategies including the structure of presentation effective; but they had mixed reactions to the use of APAs as the medium of delivery and were dissatisfied with the type of voice used as the modality for instruction.

2. Strong visual learners had strong positive feelings on the extent of learning and low concern for use of the medium. They - like the strong auditory learners - used quality of content as an important criterion to evaluate extent of learning. The other sensory groups conformed to the same set of perceptions found in point (1) above which was: dissent in terms of using the type of voice as the modality for delivery but acknowledgement for the type of APA's animation as an effective medium for instruction. Among all sensory groups, mild visual learners proved to be more critical than the others by offering more comments beyond the five areas identified above.

*Question 2: How effective is instruction using low interactive APAs in terms of helping learners learn?*

- a. How do learners' achievements from instruction using low interactive APAs compare with that from more conventional online instruction?*
- b. Does the achievement vary in accordance with learners' sensory preferences? If yes, how does it vary?*
- c. In view of the answers to 2(a) and 2(b) above, what is the joint impact of types of instruction and sensory preference on achievement?*

#### *Learners' Achievement with respect to Types of Instruction and Sensory Preference*

When learners' achievement, as measured by Performance, was not differentiated by Sensory Preference but was compared only by Types of Instruction, learners using low interactive APA instruction were found to outperform learners using conventional online instruction by a

moderately small margin of 5.9%. On the other hand, when learners' achievement was compared solely by different levels of Sensory Preferences without giving regard to Types of Instruction, Sensory Preference was found to have no effect on achievement. But when analysis was performed on how Sensory Preference interacted with Types of Instruction to produce achievement, a moderately large effect was detected. The analysis found that achievement among strong visual, mild visual and strong auditory learners was different when they were compared between learning with the low interactive APA instruction (LIAI) and learning with the conventional online instruction (CI). For mild auditory learners, their achievement was unaffected by the two types of instruction.

Strong auditory learners learned best with the voice-rich APA instruction but worst with the text-rich conventional online instruction. This was followed by strong visual learners who learned the next best with conventional online instruction but suffered the next worst with APA-based instruction. Hence, strong sensory learners are affected by modality of instruction. The mild visual learners, however, did not conform to the modality effect and they performed well in the opposite modality. Therefore, it looks like the modality effect applies only to the strong sensory learners. The results alone from the analysis could not provide a conclusive answer to the 'strange' behaviour of the mild visual learners. Therefore there is a need to understand the mild visual learners from a more theoretical perspective. This will be discussed in the third section.

In all, the answers to Research Question 2 can be condensed into the following:

In general, when all sensory learners were combined, low interactive APA instruction was moderately more effective than conventional online instruction in providing learning. But this advantage would vary when learners' sensory preferences were taken into consideration. Both groups of strong sensory learners benefited from learning when the modality of the instruction

was consistent with their preference. Mild sensory learners' performances were quite different with mild visual learners learning well in their opposite modality and mild auditory learners not benefiting from either modality.

### How the Findings inform the Study?

The combined findings from the two main research questions provided both the pros and cons of using low interactive APAs for instruction in online learning. To understand how these pros and cons came about and what have contributed to their being, it is necessary to revisit the Interaction Framework that provided the design guidelines for creating the low interactive APA instruction. Figure 5.1 shows the framework and its instructional elements in a pictorial view. The guidelines for designing are inserted either next to the components (shown in boxes) or between the components. Those inserted between the components are the instructional elements for instantiating the interactions meant for the pair of components.

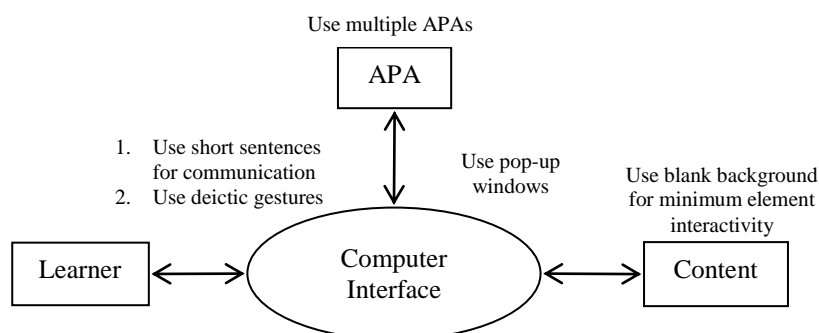


Figure 5.1 Design of Low Interactive APA Instruction based on Interaction Framework

Based on the framework in Figure 5.1, the following discussion will proceed according to the three major components, these are: Content and its Interactions, APAs and their Interactions and, Learners and their Interactions.

### *Content and its Interactions*

Content is the most important component in a lesson because it is what really changes the mental state of a learner. About half of the learners from the APA-based instruction perceived that they learned the lesson well and many of them gave the reason that it was due to the usefulness of content and effectiveness of instructional strategies. In fact this observed relationship between perceptive usefulness of instruction and perceptive learning outcome is consistent with theoretical predictions and can be explained by the concept of affordance which has been discussed in the literature review. Affordance theorists such as Norman (1998) and other researchers such as van Vugt, Hoorn, Konijn and Dimitriadou (2006) point out that what really makes a tool effective is the perceived usefulness of the tool which has the capacity to trigger interactions between the tool and the user in a learning process. In the case of the APA instruction, the tool is the composite integration of the content and instructional elements which consists of the APAs, their animations and dialogue, the background and pop-up windows. Therefore, by extending the concept of affordance to the APA instruction, it can be seen that the ability to create a perception of usefulness among the learners is a prerequisite to sustain a continuing usage of the instruction. In this respect, the APA lesson can be considered to have achieved this. But to know if the instruction is effective overall, there is a need to look at the interactions it provides.

Interaction is a complex process but it gives rich information to unfold what really lies behind an intricate learning process; this is why studies which omit the consideration of interaction normally fail to account successfully the learning outcomes for some educational phenomena.

This is the case of learning style research that uses personal styles alone to predict learning outcome.

The interactions with the content and other instructional elements provided in the APA instruction are facilitated by using two approaches proposed by the Interaction Framework in Chapter Two; they are: (1) to maintain an empty background on the screen so as to keep the element interactivity low and (2) to use pop-up windows to display small chunks of information and synchronise their appearances with the APA's voice explanation (see Figure 5.1). This integration of visual and auditory components has been described under the heading called "Treatment" in Chapter Three. The empty background is to remove unnecessary distraction to allow learners to stay focused and be directed to the happenings determined only by the lesson. The pop-up windows are small windows carrying short information such as a statement, an answer or a diagram meant to instantiate the happenings stated earlier together with the onset of voice explanation delivered by the APA. This design aims at providing guided instruction with directed attention. But how effective is this method?

To answer the question, one first needs to look at the content of the subject matter. The content for learning used in the APA instruction is multimedia design which is a new topic to the learners. When the content is new, the learners usually lack the heuristics to pay attention selectively to only salient information and many a time, s/he will have to resort to trial-and-error to accomplish the process (Sweller, 2005). This often will result in what is called the "misinterpretation" of the content. When this happens, the learning is seen as meaningless and hence the content. It is therefore expected that learners would give comments such as "the content was not useful" but the feedback obtained showed the contrary. There must be something else, in particular, the elements in the instruction that helped to defuse the difficulty encountered.

The use of timely popping-up windows complemented by the APA's voice explanation appeared to be able to avoid the "misinterpretation" by giving a learner an organised way of directing his/her attention to relevant information – a strategy often called scaffolding (Schunk, 2000, pp. 244-245). The display of information window-by-window and the accompaniment of explanation sentence-by-sentence spare the learner from having to comb through information just to know where to pay attention to and, as a result, allows the learner to use their mental resources more effectively. Of course, this is not possible without the empty background deliberately created to ward off distraction. The scaffolding process described above has to a large extent achieved a similar effect to that provided in Betrancourt and Bissret's (1998), and Erhel and Jamet's (2006) studies on using pop-up windows to support learning. In their findings, they argued that using pop-windows to display illustrations timely and strategically in addition to text explanation can enhance learners' attention on what to focus. But Erhel and Jamet caution that the benefit is only evidenced when learners are tested on tasks that require the same format of information display to that given to learners during their learning. This is because the display format used by the pop-up windows helps learners to construct a similar representation in their mind.

The setting of Erhel and Jamet's study and this study has two things in common. First, both studies use pop-up windows to scaffold attention; next, both use tests that require similar information display as the pop-up windows (see Performance Quiz of this study, item nos. 5, 7, 9, 13, 16 and 17). What makes these two studies different is that this study used an APA's voice and deictic gestures to replace the text explanation in Erhel and Jamet's study. But since this study received quite an encouraging level of acceptability in terms of extent of learning and effectiveness of instructional strategies, it makes sense to infer that the coordination of APA's voice and deictic gestures with the pop-up windows are also seen as producing a

sound instructional strategy that is generally acceptable by the majority learners albeit some unhappiness about the APA's vocalisation. APA's animation and vocalisation will be discussed in detail under "APAs and their Interactions".

The above discussion considered the content and its delivery by the APA's voice, gestures and pop-up windows an integrated entity; this is because learners were not asked specific details in the questionnaire about individual elements such as the pop-up windows or the nature of the screen background. Because of this, the unit of analysis for the interaction process has to be limited to composite elements; and in this case, the composite element is the synergy of the APA's voices, deictic gestures and pop-up windows. From this viewpoint, generalisation of findings from this study is restricted to those situations which have the same settings. This is an inherent limitation of this study.

The effectiveness of the APA instruction can similarly be evaluated from another perspective using the learners' performance. When performance of the learners who learned with the low interactive APA instruction was compared with the learners who learned with the conventional instruction, the former was reported to perform better than the latter, albeit only marginally so. The reasons for causing the better performance could indeed be manifold but this study believes that the guidance rendered by the APAs is likely to be one of the contributing factors. This belief cannot be supported by feedback data from the conventional instruction for reasons that have been explained in Chapter Three, however, it can be inferred from theoretical underpinnings.

It is important, first, to look at the extent of scaffolding given in the two types of instruction. The APA-based design uses the APA voice and pop-up windows to establish a learning condition that is mediated by external help. But in the case of the conventional design,



learning is entirely by the learners' own effort, no mediation is offered. The difference in cognitive effort is instrumental in determining how much a learner can learn. This can be explained by cognitive theory which argues that a person's executive ability to manage the different memory stores such as the sensory memory, the working memory and the long-term memory in a learning process is complex and demanding (Eggen & Kauchak, 2001; Goldstein, 2008). This is especially so when the learning involves new content and is the case for both the APA and conventional instruction. The APA-based design has more advantages than the conventional design because it has the extra guidance to help the executing process in a more structured manner. This gives an edge to the APA-based design and hence its better performance.

Next, is to compare the use of pop-up windows in the two designs. Most of the pop-up windows used in the APA-based design are meant for illustrative purposes which involve the showing of pictures that are accompanied by voice explanation. In contrast, the pop-up windows in the conventional design are used only for displaying answers which are not illustrative in nature. Using Erhel and Jamet's (2006) findings which support using pop-up windows for illustrative purpose, the use of pop-up windows in the APA-based design should have contributed to better learning and hence better performance.

In sum, the study found the use of pop-up windows activated by APA voice a useful means of facilitating information processing without having to involve complicated APA interactivity. It gave rise to favourable perceptions on the usefulness of content and instructional strategies. This has answered Research Question 1(a) and partly Research Question 1(b). It is also believed that the mediation provided by the APAs and the use of pop-up windows for illustration in the low interactivity method would have contributed partially to the better

achievement when it is compared with the achievement obtained by the conventional method. This addresses Research Question 2(a).

### *APAs and their Interactions*

The role of APAs in this learning episode is unique. This is because firstly, the lesson employed two APAs to engage in dialogues and at the same time deliver instruction. Secondly, one of the APAs was designed to emulate the common instructional style of a real human teacher and the other was to behave as an assistant. The use of an assistant is not commonly practised in the local classroom situation and it is very new in online instruction. To emulate a real teacher without having to employ sophisticated technology and high interactivity, the design followed the guidelines of “using short sentences for communication” and “using deictic gestures” (refer to Figure 5.1) to produce four instructional strategies which supposedly should heighten the instructional effectiveness and complement the use of low interactivity.

The first strategy was to use two APAs to play the role of a tutor and an assistant so that they could interact with each other in the form of dialoguing and exchanging of viewpoints. The purpose of this is to produce a more engaging environment because learning with a virtual character that has limited speech ability and body action can be quite challenging to one’s patience. Understandably, the problem would have been avoided if highly interactive APAs with sophisticated intelligence and cybernetic capability were used but this is not the intention of the study. The concept of generating a social setting to engage learning is partly a result of the eShow Room project (Krenn, Pirker, Grice, Baumann, Piwek, & Deemter’s et al., 2002) described in Chapter Two Literature Review and partly to capitalise on the vicarious learning theory (Eggen & Kauchak, 2001, p. 238-239; Slavin, 1997, pp. 171-172). The eShow Room project has shown that having customers watch a scenario played by APAs in a car sale

dialogue between a virtual car salesman and a virtual potential customer can invoke greater understanding of the car. The vicarious learning theory on the other hand points out that by observing what others do can increase a learner's self-efficacy (Driscoll, 2005), modify behaviour change (Feldman, 1993; Ormrod, 1995) and enhance performance (Bresman, 2006). In other words, vicarious learning can help to shape perception and increase understanding.

The second strategy was to have the APAs ask the learners questions at some strategic point in the instruction. Questioning is the most fundamental but also an effective form of interaction in a real classroom (Ormrod, 1995, p. 210; Slavin, 1997, p. 222). It allows learners to check for understanding at a time decided by the teacher (Arends, 2004). To check for an answer, the learner clicks on the APA assistant's body where a pop-up window with the answer will be shown. In this way, the learner has a choice to decide how long he/she needs to think about the question and when he/she wants the answer.

The third strategy was to render instruction by using short-sentenced speeches. This technique is employed to reduce the negative effect brought about by the APA's synthetic voice because a short sentence is usually easier to comprehend as it has fewer semantics to understand (Gao & Woo, 2008). The technique also ensures that important meanings are repeated in the speech to reinforce the learner's memory. The method is derived from the concept of Speech-Gesture Coordination proposed by Buisine and Martin (2007) and described in the Interaction Framework.

The fourth strategy was to use deictic gestures to deliberately point at or move to an item of reference to enhance the explanation. Deictic gesturing is a powerful and alternative way of communication (Gao & Woo, 2008) other than the normal oral speech. Because the low

interactive APA has limited gesturing features, the gesturing is carried out in synchrony with the APA's speech to emulate the natural way a classroom teacher delivers instruction.

The effectiveness of the four strategies will be discussed with reference to the comments provided by learners. Generally, learners were concerned about the slow pace of the lesson and expressed dissatisfaction with the APA's quality of voice. Despite this, a sizable number of them found the APA's animation interesting and even engaging. Based on this, the discussion will address the APA's voice first and then the APA's animation.

The voice of the APAs in this study was delivered by using a class of synthetic voice called the "Lernout & Hauspie TruVoice" which is obtainable from Microsoft Agent main website (<http://www.microsoft.com/PRODUCTS/msagent/main.aspx>). The characteristic of the voice is that it is personalised to the character of the Microsoft agents so that each agent speaks with one unique voice. In this study, the tutor is enacted by a character called Peedy and the assistant enacted by another character called Genie. They both speak with their own individual accent. So voice quality is more or less predetermined although the speech engine allows a little tweaking on the pitch and intonation to actuate the pronunciation of some unusual words. The consideration of using the Microsoft voice synthesizer is that it is simple to design and easy to implement (Lewis, 2003).

The impact of using the Microsoft voice synthesizer is not very well investigated. Very few studies have ever made use of Microsoft agents in an educational setting. This study will use the eShow Room study by Piwek (2003) for discussion.

The eShow Room project has been mentioned previously, was a project that used two pedagogical agents to enact a conversation between a car salesman and a potential buyer. The

speech was rendered by using Microsoft voice technology. The study reported that about 41% of the users who had listened to the sales talk in the project complained about the poor quality of the voice delivered by the agents. Though Piwek's study did not offer any explanation of the observation, the dissatisfaction for the voice was in a way similar to that obtained in this study but to a smaller extent. The findings of this study recorded a 10%-25% negative response ratio related to the quality of voice in all three areas of learning. One big difference between Piwek's study and this study is that Piwek's study was based on a small sample of only 28 participants but this study has a sample size of 378. Hence there was a possibility that Piwek's result could be biased towards a particular modality preference which gave rise to the larger figure. There could be another factor that could have contributed to the negative comments, which is unique to this study, namely, the use of the short sentences for the speech. Using short sentences to speak may be conducive instructionally but is awkward in real life situations. Therefore the strategy may have benefited the learners by being able to convey meanings more clearly, but this was at the expense of natural speech patterns.

Closely related to the APA's voice is the action of questioning because questioning requires the production of voice. But interestingly, the feedback survey did not find any specific comment on questioning except more generic ones like "the presentation is interactive" and "the lesson is engaging". This gives rise to an assumption: the questioning must have been seen by the learners as an integral part of the presentation and because structure of presentation was graded favourably as the second most positively commented area of learning, the questioning must have functioned well for its purpose and did not invoke any ill-feeling. This is further justified by the assumption that the question statement must be concise in order to be clear, which again favours the use of short sentences. This is probably why voice problems did not occur in the rendering of Q&A.

The next part of the discussion will focus on the animation of the APAs. Verification of the effectiveness of APA animation is less straightforward because animation is a complex endeavour that involves gesturing, animating facial expression and body movements; and most importantly, the kind of messages that the animation is intended to convey.

For the purpose of this study, the APA animation is intentionally reduced to only deictic gestures embedded in explanation and body movements exhibited during the interaction between the two APAs. The design follows the recommendation from the Interaction Framework to reduce element interactivity (Sweller, 2002). As to whether such a low interactive animation is effective in rendering instruction, the results from the feedback and quiz are used again for discussion. This study found that about 2% to 22% of learners reported positive comments on animation for all three areas of learning. So acceptability-wise, the low interactivity animation was able to entice up to about one-fifth of learners. But what about the effectiveness of using a tutor and an assistant to complement interactivity? As this was not specifically asked in the questionnaire, like the case of Q&A, a good way to answer it may be to compare the design with literature that has a specific focus on Microsoft agents.

Wissick's (2002) study led him to recommend the use of a Microsoft agent as a tutor to provide verbal prompts in a learning process - when a user does not access the correct key or respond appropriately. Lewis (2003) stressed the importance of using easy-to-develop Microsoft agents for instructional designers to design instruction. He suggested a few ways to design instruction with Microsoft agents. The first was to provide animations to guide a learner's attention so that the instruction could be more engaging. Second, the animation should assume the role of a tutor who should constantly give immediate feedback in the form of interaction. Third, was to employ multiple agents to work together to simulate a more interesting social setting. However, Wissick cautioned the possibility of implicating the

interface design due to such implementation. Thomas (2005) warned against repeating a failure committed by Microsoft in his study. He used the example of a Microsoft paper clip agent called “Clippy” which figured in Microsoft office products in the 1997s. The Clippy was heavily criticised then because it was used in the wrong context for offering help that was not instructionally needed. It has since been taken out from the Microsoft products officially. Therefore designers must know the right role the agent needs to play for the right task. Based on the above proposal from the various authors, it seems that using two Microsoft agents to enact a tutor and an assistant with animation to focus on directing attention is a right instructional choice. Although no direct results could be used to support the claim, pockets of information from the feedback such as “I like the two agents presenting” shown in reason 6 of item 1, “animation is useful” shown in reason 3 of item 2 and reason 4 of item 3 are good indications that the overall synergy provided by the roles and animation of the two APAs is generally acceptable despite the limited interactivity they provide.

### *Learners and their Interactions*

The nature of the learner, like the APAs and content, has a pivotal effect on the success of learning. In this section, discussion will focus on learners’ characteristics which include types of perceptions they offered, their modality and sensory preferences; and how these interact with instructional elements during the learning process. Before the discussion, it is necessary to look at some of the important findings derived from the survey and performance quiz regarding modality of instruction and sensory preference. These are:

1. Learners vary in their perceptions on the three aspects of learning in conjunction with APA instruction. Although each aspect of learning drew about 50% of definitely positive learners and about 10% of definitely negative learners, there were extreme learners who either like or dislike all three aspects of the learning. They made up 28.4% and 2.8% respectively of the learner population.

2. Learners used their own criteria to evaluate the three aspects of learning. They used usefulness of content, instructional strategies and nature of medium to evaluate extent of learning and interest in the lesson; but when evaluating presentation of the lesson, they used structure of presentation and nature of modality instead.
3. Strong auditory learners commented the most on the slow pace of the lesson despite them being auditorily-inclined and they benefited the most when learning with the instruction that used their preferred sensory modality.
4. Mild auditory learners did not benefit from learning with instruction using their preferred modality, or otherwise.
5. Strong visual learners also benefited from learning using their preferred sensory modality.
6. Mild visual learners were very different from the others as they benefited only when learning with the opposite modality of preference. They also appeared to be more critical than the others by offering more comments beyond the five main areas of concern raised in the feedback for perception.

Below are explanations offered for each of these observations.

#### 1. *All Learners*

Despite their variability in perceptions, learners could produce consistent criteria when evaluating the APA instruction - which is a testimony to the existence of some common characteristics among them. The evidence of these characteristics is dependent on the type of learning that was in question. For example, when asked about the presentation of the lesson, modality became a common concern but when asked about the extent of learning, usefulness of the content became the priority. This means that a learner's characteristic is latent but becomes prominent only when the learner interacts with some elements in a task that makes



use of that characteristic. In other words, it is the task and its associated interactions that activate a particular characteristic of the learner. Therefore, whether a learner's characteristic such as sensory preference is a necessary consideration or not in a learning situation will depend on the task and the interactions between the task elements. This speaks for the various calls made by researchers (e.g. Chou & Lin, 1998; Miller, 2005) in the literature review to look at task details rather than just the learning styles of learners. In the case of APA instruction, the instruction task requires learners to interact with specific elements including pop-up windows, APA's gestures, animations and voice. Among all, the APA's voice turned out to be a concern for most of the learners. This, as explained earlier, is an outcome of not being able to utilise one's sensory characteristic fully to interact with the voice element to achieve the learning task. This also affirms the need to include sensory preference in the investigation as proposed in Chapter Two, the Literature Review, and indicated by Research Questions 1(b), 2(b) and 2(c). The impacts of sensory preference on perceptions and learning are further discussed below:

## *2. Strong Auditory Learners*

Perceptions obtained from the survey indicated that strong auditory learners were most perturbed by the slowness of the lesson but yet learned the most from this mode of instruction may be explained by the fact that being auditorily-inclined, they were very used to the normal way of human conversation and were less tolerant to the sentence-by-sentence type of articulation which was deliberately used in the low interactive APA lesson. This can be explained by the familiarity which one accords to a task that s/he is used to and hence develops the preference for that task (Low and Sweller, 2005). For this, the discomfort resulting from interacting with the unfamiliar APA voice did not deter them from listening to the voice explanation because they knew the importance of the lesson which had motivated them to follow through the lesson. It is also likely that by

learning with their preferred sensory modality they benefited by maximising their sensory capacity – an effect acknowledged by many cognitive psychologies (e.g. Baddeley & Hitch, 1974; Goldstein, 2008; Mayer, 2001; Moreno & Mayer, 2007) and other researchers (e.g. Gyselinck, Jamet, & Dubois, 2008; Higgison, 2000; Tanner & Allen, 2004) as described in the literature review. This is so because humans have a tendency to store information in the format it is sensed; that is, voice information is stored as echoic objects and visual information as iconic objects (Goldstein, 2008). By presenting the information in the same modality as what a learner prefers will certainly help in the storing process during the cognition which explains why strong auditory learners learn better with voice-rich instruction.

The behaviour of the strong auditory learners also exhibited coherency with Driscoll's ideas of sensory memory. Driscoll (2005) argues that auditory information stays in a person's sensory memory for up to four seconds compared to visual information which stays for only about a quarter of a second. This time differential allows the strong auditory learners more time to process the information, giving them a stronger retention of the information that helped them to retain their sensory representation more accurately. It is this that gives them an edge over the other sensory counterparts which explains why they performed the best in the quiz (refer to A<sub>1</sub> in Figure 4.3). The above results derived from the perception and the quiz reveal an interesting observation, namely - that perception may not always concur with performance; the learners may have a poor perception on a certain type of learning but can still perform well in that learning.

When strong auditory learners were situated in the text-rich conventional instruction, their strong auditory preference probably forbade them from processing the textual information properly although there was no perception data collected with respect to this. But based on

the same argument used for the APA instruction, the instructional scaffolding rendered in the conventional instruction probably was less deliberate and intensive. This makes the strong auditory learners face a very challenging learning task when learning in this mode of instruction which gives a plausible explanation as to why they performed the worst under the said condition (refer to A<sub>2</sub> in Figure 4.3).

### 3. *Mild Auditory Learners*

Although mild auditory learners did not benefit from either auditory or visual modalities, they can be quite attuned to both types of modality but still rely more on voice rather than text to understand information. When mild auditory learners were exposed to the instruction delivered by the APAs, they found the voice quality of the APAs not meeting their desired expectations; they quickly turned to the alternative textual modality to continue to look for information. However, because all textual information was confined within a small pop-up window, the amount of information was limited and was also segmented. This is because pop-up information is supposed to be processed in conjunction with the voice explanation. Under such a circumstance, mild auditory learners were not better off in the textual modality. They therefore needed to overcome high cognitive load and high element interactivity in order to learn well. The result was that they performed more poorly than their strong auditory counterparts (compare B<sub>1</sub> with A<sub>1</sub> in Figure 4.3).

When the learning was switched to the text-rich conventional instruction, mild auditory learners were compelled to learn in a less preferred sensory modality but were assumed to still be able to cope fairly well in the opposite modality. This again, is a plausible assumption due to the lack of data on perception to support the claim. The greater flexibility for modality probably helps to explain why they did better than their strong auditory counterparts in text-rich conventional instruction (compare B<sub>2</sub> with A<sub>2</sub> in Figure

4.3). The ease of switching from one modality to another to process information probably gave rise to the insignificant difference in quiz results between learning from the two types of instruction (compare B<sub>1</sub> with B<sub>2</sub> in Figure 4.3).

#### 4. *Strong Visual Learners*

Besides performing well in achievement test, strong visual learners were found to be the most positive on content usefulness and hence may be construed as the most motivated group of learners. But perhaps their preferred modality did not allow them to follow the voice of the APA closely and hence they could not perform well in the voice-rich APA-based instruction. It is also assumed that the visual element – the pop-up window - could not benefit them either, because the textual information on the window was too limited to have any positive effect on their preferred visual modality. In fact, this was the same situation faced by the mild auditory learners. However, when the strong visual learners were exposed to the text-rich conventional instruction, it is assumed that they could put all their visual acuities to good use because all information in this instructional mode was displayed in textual format. But unlike the APA-based instruction, the conventional instruction appeared to lack instructional scaffolding so the entire learning had to depend on the learners themselves. This inadvertently increased the learning difficulty level which could have resulted in a poorer performance when compared with their strong auditory counterparts (compare D<sub>2</sub> with A<sub>1</sub> in Figure 4.3). Of course, this assertion remains plausible until it is further proven by empirical data.

#### 5. *Mild Visual Learners*

Mild visual learners, like the mild auditory learners, are attuned to both types of modality but are more inclined to visual information. But the mild visual learners in this study appeared to be more serious in their learning as justified by their more all-rounded

comments as shown in their perception feedback. In other words, they were more attentive to details and critical about outcomes. When mild visual learners were situated to learn with the voice-rich APA-based instruction, they were like their mild auditory counterparts, prone to switch to the other modality when they were faced with the APA's vocalisation. As for other groups, they also found the information on the pop-up windows insufficient to allow them to capitalise on their preferred sensory modality. By right, under such a circumstance, they should have suffered learning difficulty, but this study posits that their extra attentiveness and seriousness could have helped them to remain engaged with the instruction, albeit with a sense of displeasure at listening to the APA's voice and undergoing the slow paced lesson. It is as a result of this extra motivation that they turned out to do well in the opposite modality (see  $C_1$  in Figure 4.3). The argument of having extra attention for mild visual learners was also raised and discussed in Chapter Four under "Summary of Overall Findings for Research Question 2(a)".

What happened when mild visual learners were situated in the text-rich learning condition offered by the conventional instruction? It is assumed that mild visual learners should have processed the information proficiently because all information was displayed in their preferred format. But this was not the case as reflected in the results (refer to  $C_2$  in Figure 4.3). This study postulates that the lack of instructional scaffolding could have outdone their ability to process visual information which gave rise to the weaker performance. However, as there was no information available in this study to tell how the learners reacted to the conventional instruction, the above proposition could not be verified empirically. That leaves the question on why mild visually-inclined learners could not perform well in a visually-rich learning environment unresolved.

In sum, this study found that a low interactive APA though disadvantaged by its limited ability to simulate intelligent association with the learners and to produce natural voice, is well compensated by specific instructional strategies such as attention guidance and vicarious learning. This allows it to engender a more conducive learning environment than its conventional counterpart. This explanation addresses Research Question 2(a).

The attempt to use low interactive APAs had resulted in using specific instructional elements to interact with the learners. This includes using pop-up windows as the main means to display content and APA's voice and gestures to complement the explanation. Voice was deliberately delivered in short and simple sentences to negate the synthetic quality of the articulation. Using instructional modality in this way may not be familiar to many learners, which can trigger an issue of sensory preference because preference for a familiar mode of working is a part of human characteristics. For this, this study also looked into the possible effect of sensory preference on learning with APAs.

Because this study did not collect data on learners' perception on the conventional instruction (control group) for reasons already stated in Chapter Three, explanations for sensory effects between APA and conventional instruction were done mainly by inference using relevant literature. Using this method, it was inferred that strong sensory learners benefited from instruction that used their preferred sensory modality for delivery whereas mild sensory learners - due to their ability to switch to their less preferred sensory modality easily - did not behave like their strong sensory counterparts. Mild auditory learners being less reliant on auditory information to learn maintained the ability to cope with learning using the opposite modality but to a limited extent. On the other hand, mild visual learners were supposed to be like their mild auditory counterparts showed only average performance but they did better in their opposite modality and worse in their own

preferred modality. The better result in the opposite modality is posited as being prompted by the learners' extra motivation because they were found to be more attentive and keen to achieve outcomes. But as to why they produced worse results in their own preferred modality is intriguing and is not answered by this study due to the lack of sufficient information.

The study also found two unsolicited observations: (1) Perception is not always congruent with action. For example, a learner who perceives unfavourably the APA's voice can still do well in the learning. (2) Being critical in opinion may not necessarily imply negative attitude as it can mean a greater concern for learning and a greater desire to learn. The above two observations are evident in the scope and numbers of comments made by the mild visual learners when learning in opposite modality but still performed well in the achievement test. Collectively, the above explanations address the concerns raised in Research Questions 1(b), 2(b) and 2(c).

## CHAPTER SIX

### CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

#### Introduction

The purpose of this study is to investigate whether APAs with low interactivity can be effective in aiding learning and at the same time be perceptively acceptable to learners. Using low interactive APAs entails the integration of pop-up windows to display content, an APA's voice and deictic gestures to provide explanations. Such strategy also requires the voice to be the main instructional modality and be delivered in short-sentences which may be unfamiliar to many learners. Because unfamiliarity works against personal preference, this study is concerned with whether sensory preference will interact with modality used in instruction to affect learning. Accordingly, this study designed two online learning lessons for the investigation - one using low interactive APAs for learning a topic called Multimedia Design Principles and the other using a conventional text-based method for learning the same topic. The investigation was conducted via an experimental approach and on a sample of pre-service teachers that came from a case Institute in Singapore. The performances of the learners from the two types of learning were compared and only the learners' perceptions on learning with the APAs were collected. The crux of the study was to answer the following research questions:

1. How favourably do learners perceive instruction using low interactive APAs?
  - a. What are the opinions of learners on instruction using low interactive APAs?
  - b. Do their opinions differ with respect to differences in sensory preference? If yes, how do they differ?
2. How effective is instruction using low interactive APAs in terms of helping learners learn?



- a. How do learners' achievements from instruction using low interactive APAs compare with that from more conventional online instruction?
- b. Does the achievement vary in accordance with learner's sensory preferences? If yes, how does it vary?
- c. In view of the answers to 2(a) and 2(b) above, what is the joint impact of types of instruction and sensory preference on achievement?

The main findings of the study were discussed in Chapter 5. This chapter provides an overview of the Conclusions, Implications and Recommendations to the study. The Conclusions summarise the main findings of the study and highlight the difficulties and limitations of the research process; this section also includes an assessment by the researcher on what the study has achieved with respect to the intended purposes. The knowledge gained from the conclusions should inform stakeholders of the significance of the findings and what possible impacts the findings may produce - which are included in the section on Implications. Finally, the section on Recommendations will discuss ways for improving on the present study through future endeavours.

### Conclusions

This section first consolidates the purpose, context and limitation of the study so as to highlight the boundary of the study and also its setting. It next synthesises the findings with supporting explanations. It also gives an account of the researcher's own assessment on the findings.

#### *From Conception to Research and the Difficulties Encountered*

The initiation of this study stemmed from the need to look for an alternative instructional approach to complement the conventional mode of online learning. Online learning is often

thought to be inadequate and limited due to the absence of human interaction. The advent of APAs appears to offer good potential to address this problem because of their ability to anthropomorphise (provide human surrogates) and hence provide a more amenable learning environment. Besides this humanising aspect, however, research has not yet confirmed whether the use of APAs might also enhance learning performance (Thomas, 2005). This raises the issue of instructional effectiveness.

The use of APAs also faces another problem because the anthropomorphisation of an APA is a costly and complex process. It requires high-end technology to render close-to-human interactivity in order to make the APA look intelligent and hence lifelike. This imposes a limit to who can design APA instruction. School teachers and small-time instructional designers, without the special skills and resources to meet the requirements, are often unable to design suitable APA-based instruction. Without the involvement of these two groups of people, APA-based lessons cannot be customised as and when needed to meet the individual needs of the schools or institutions, or a particular nature of a classroom. This causes another issue, that is, the worthiness of investing in a learning system that is expensive and technically demanding but not easily customisable.

The two issues above formed the basis of this study. The literature review undertaken revealed a possible way to address the issues. For example, it was found that APA instruction may be designed without high-end technology by reducing the interactivity of the APAs and by designing the instruction using appropriate pedagogy that focuses on effective learning rather than simply on appeal. But using low interactivity in APAs is uncommon and their impact on online learning is rarely researched (Clarebout & Elen, 2007). Apparently, there is little known about whether such a method of learning is effective and whether it is acceptable to the learners. As such, conducting a formal study is warranted to provide the answers. Two

main research questions with sub-questions were formulated (shown in previous section) to guide the development of the study. Taking into consideration the context of the inquiry and the resources available to the researcher, this study adopted a Quasi-experimental approach with a 2 x 4 factorial design (Creswell, 2005); and the sample it used was a group of 378 pre-service teachers from a case Institute in Singapore who were attending lessons on multimedia design principles as part of their course requirements.

As a self-initiated study, the researcher encountered some difficulties during the course of the research, some of which may have impacted on the findings. This is illustrated as follows: The first difficulty was the inability to fully randomise the allocation of participants to the control and experiment groups. The participants in the sample were made up of pre-service teachers who had been pre-grouped by the case Institute's administration office according to the participants' teaching subjects. Randomising the sample became unfeasible because of its administrative upheaval. Therefore 'randomisation' was done in part, through units of subject group rather than in units of individual student. However, the use of subject groups was not without problems, since they increase the likelihood of differing initial conditions for the control and experiment groups and hence invite probable threats to the internal validity of the study (Gall, Gall & Borg, 2003). To get around this, this study took two measures: One was to ensure that the combination of subject groups in the control and experiment groups were similar, this is an attempt to establish more equalized initial conditions for both of the groups. For example, the proportions of students from *Language & Literature (LL)*, *Mathematics & Science (MS)* and *Humanities & Aesthetics (HA)* for the experiment and control groups were kept very similar, that is, in the ratios of 4:20:11 and 6:20:14 respectively (see the section on "The Sample" under Chapter Three).

The other measure was to use a self-reported survey to exclude participants who were experienced multimedia designers from taking part in the experiment. Experienced multimedia designers have a tendency to upset validity of the treatment and affect the results collected from the posttest. With only novice multimedia participants in the control and experiment groups, the chance of ascertaining the true effect of the ‘treatment’ is enhanced.

However, even with the two measures put in place, biases due to sampling error can remain. For example, there was a relatively high proportion of Mathematics & Science participants present in both the control and experiment groups that could not be controlled experimentally due to the self-selection process during the recruitment exercise. This could have given rise to undesirable influences due to the group’s dominance. Also, using a self-reported survey to assess multimedia design ability is a technique that relies heavily on a respondent’s perception rather than on his/her true ability. It therefore induces subjectivity.

The second difficulty was the inability to collect perception data from learners in the control group who were using conventional instructional methods to learn. As explained in Chapter Three, the scope of investigation of this study is limited by practicalities such as the availability of time and resources to collect and interpret these data; but most importantly, the perception information for the control group was not a requirement in addressing the research questions. However, for the purpose of extending knowledge beyond the scope of this study, it is understood that obtaining parallel perceptual information from the learners in the control group would allow useful comparisons to be made which in turn help to interpret the interactive relationships among the instructional elements used in the two types of instruction. But because this was not carried out in this study, some of the phenomena discussed in Chapter Five can only be explained by means of inference using the relevant literature.

It can be seen from the above that there were practical problems that could not be entirely eradicated, although the researcher endeavoured to limit their effects as much as possible. These inherent problems thus form the constraints to this study and they could have affected its validity.

The third difficulty was the inability to segregate the elements used in the rendering of the APA's behaviour. The behaviour of an APA is supposed to emulate that of a lifelike character which can only be achieved by integrating the complex and inextricable intertwine of gestures, voice and body movement. This is especially so for this study because the APA's behaviour is supposed to be enacted through low interactivity. It is therefore not conducive to control a single element like voice, and then to try to find out how another element, such as gesture, affects learning. This is because it would undermine the true effect that can be produced by low interactivity. Using an integrative approach for the rendering has a tradeoff as pointed out in Chapter Five – it makes the granularity for analysis too large and hence can cause difficulty in explaining causal relationships. Realising this problem, this study used an Interaction Framework to provide a structure for integrating the rendering components and to serve as a guide for designers to animate the APA interaction (see “The Treatment” under Chapter Three). But this method helps only if the research agenda of a study falls within the description of the framework. This means that research generalisability is confined to those similar situations which use the same framework for animation and interactivity.

In all, the possibility of a dominant group in the sample, the lack of knowledge in knowing how learners perceive their learning in the control group and the inability to isolate the effect caused by each instructional element during the rendering of APAs' behaviour - are the three major constraints that pertain to this study. Understandably, they pose a limit to the research validity and generalisability.

### *Outcomes of the Study and Possible Explanations*

This study adopted an experimental approach to produce empirical findings that allowed the following research questions to be answered and explained.

#### Research Question 1:

How favourably do learners perceive instruction using low interactive APAs?

- a. What are the opinions of learners on instruction using low interactive APAs?
- b. Do their opinions differ with respect to differences in sensory preference? If yes, how do they differ?

The low interactive mode of APA instruction was able to garner definite and positive support from about 50% of the learners, but failed to do so for about 10%, with the remaining 40% showing uncertainty in their opinions (see Table 4.4). Based on this, the acceptability level of the lesson can be considered as somewhat encouraging after discounting the dissatisfied responses from the survey.

The above perceptions were measured by three aspects of learning, namely, extent of learning, interest in the lesson and presentation of the lesson. Among the three aspects of learning, learners were most satisfied with extent of learning, followed by interest in the lesson and lastly presentation of the lesson. In all, 28.4% of learners showed satisfaction for all three aspects of learning whereas only 2.8% were dissatisfied with all the three aspects of learning.

This study found that learners used five key criteria to form their opinions. They relied on: (1) usefulness of content, (2) instructional strategies of instruction, (3) nature of medium, (4) structure of presentation and (5) nature of modality to evaluate the instruction. Learners'

perceptions revealed that the reasons why they learned the lesson and were interested in it were because of the usefulness of content and sound instructional strategies. Also they liked the presentation because the presentation had a good structure and an interesting APA (i.e. medium) animation. On the other hand, they also expressed dissatisfaction with the type of voice used as the modality for instruction and the slow pace of lesson delivery.

On whether learners' sensory preferences affect their perceptions of the APA mode of learning, it was found that perceptions given on two out of the three aspects of learning were unaffected by sensory preference. The two were: interest in the lesson and presentation of the lesson. As for the extent of learning, strong visual learners' perceptions were found to be significantly different from the mild visual and mild auditory learners but not the strong auditory learners. The reason for this is that both strong visual and strong auditory learners used a common criterion - quality of content - to evaluate extent of learning. Strong visual learners also exhibited a very unique behaviour in that they gave strong positive comments based solely on content usefulness and effective instructional strategies and gave no negative comments at all. This is unlike other sensory groups who produced both positive and negative remarks.

Although perceptions were statistically determined to be affected predominantly by strong visual learners, perceptions from other preference groups also exhibited certain unique characteristics that can be equally useful in revealing the cause-and-effect relationships behind some of the observed phenomena. Strong auditory learners were very particular about the slowness of the lesson but praised the usefulness of the content; mild auditory learners were also particular about the slow pace of the lesson and the APA's vocalisation, but found the APA's animation interesting. For mild visual learners, they were the most critical for all

three aspects of learning; they liked the content, instructional strategies and APA's animation, but disliked the APA's vocalisation and the slow pace of lesson delivery.

The favourable perceptions on the extent of learning and interest in the lesson can be attributed to three design strategies that were deliberately included in the APA instruction to maintain interactivity. The strategies were derived from the Interaction Framework. The first strategy was the use of a blank display background to keep the interactivity of content elements low and to reduce distraction. The second strategy was to use pop-up windows to display content information in small chunks so as to ease the problem of limited memory. The third strategy was to use APA's voice and deictic gestures to synchronise with the pop-up windows to offer explanations. It was inferred that because pop-up windows and the contents they displayed were visual elements, they tended to appeal more to the strong visual learners and hence contribute to their very favourable perception.

The reason why presentation of the lesson was not as favourably received as extent of learning and interest in the lesson could be due to the way the APA's animation and speech were rendered. The use of double APAs to engender a social setting which required voice to be used exaggeratedly, together with the use of short-sentence speech to render explanation, was a possible cause for the vocalisation to be unnatural and hence the dissatisfaction expressed by some learners. But interestingly, the learners did not let their unhappiness spill over to the APA's animation. Indeed, up to one-fifth of the learners were enticed by the APA's animation because they found it interesting.

The use of short-sentence speech in the APA instruction is paradoxical. It was supposed to facilitate the understanding of semantics in the speech, but ended up making the utterance sound unnatural. The short sentences also had a tendency to prolong the explanation which in



turn slowed down the pace of delivery which is why it was another area of dissatisfaction felt by the learners.

#### Research Question 2:

How effective is instruction using low interactive APAs in terms of helping learners learn?

- a. How do learners' achievements from instruction using low interactive APAs compare with that from more conventional online instruction?
- b. Does the achievement vary in accordance with learners' sensory preferences? If yes, how does it vary?
- c. In view of the answers to 2(a) and 2(b) above, what is the joint impact of types of instruction and sensory preference on achievement?

The achievement obtained by learning with low interactive APA instruction was found to be moderately better than that obtained by learning with conventional online instructional methods. The study also found that Sensory Preference alone could not explain the effect on achievement. The result is well in line with findings from previous research (e.g. Chou & Lin, 1998; Miller, 2005; Stansbury, 2010). But when Sensory Preference was allowed to interact with Type of Instruction, it was found to impact achievement in a certain manner. Strong auditory learners benefited the most when learning with low interactive APA instruction, followed by mild visual learners, then mild auditory learners and lastly strong visual learners. The outcome is quite different for that of conventional online learning methods. Conventional methods benefit strong visual learners the most, followed by mild auditory learners, then mild visual learners and lastly strong auditory learners. The extensive use of voice in APA instruction and the predominant use of text in conventional method are the likely cause for the better performance of the strong auditory and strong visual learners, respectively. The outcome is well within the prediction of learning style theory (see for example, Tanner &

Allen, 2004). But as to why mild visual and mild auditory learners did not appear in the order expected by matching their sensory preferences with the instructional modalities was unusual and puzzling.

This study argues that mild auditory learners being mild in sensory preference maintain the ability to cope with learning in the opposite modality but only to a limited extent. This provides a plausible reason to explain why they did less well than their strong auditory counterparts but could still perform reasonably well in their opposite modality. But the same could not be applied to the mild visual learners because they appeared to be less able to cope in their preferred modality but more able to cope in the opposite modality. This study considers this strange phenomenon exhibited by the mild visual learners as being attributed to the learners' extra motivation because they were found to be more attentive and keen to achieve outcomes. But as to why they produced worse results in their own preferred modality is intriguing and is beyond the scope of this study.

In short, the empirical findings indicate that the low interactive APA instruction is better than the conventional online method albeit only moderately and is especially useful for strong auditory learners.

#### *The Researcher's Assessment of the Study*

Two findings in particular, were unexpected. First, was the fact that the low interactive APA instruction was able to attract positive perceptions from about half of the learners given its limited animation and the quality of synthetic voice. Before the study, the researcher was quite concerned about whether the limited use of animation would divert learners into paying too much attention to the APA's speech. If this was so, the quality of instruction could be jeopardised. After the study, the worry was justified, but the quality of instruction was not

entirely compromised because the lesson was still able to maintain its favourability by having useful content and good instructional strategies. This affirms the claim that sound pedagogy is more critical than high technology (i.e. the medium) as contended by Clark (2002) who wrote “...it’s not the medium that causes learning. Rather it is the design of the lesson itself and the best use of instructional methods that make the difference”. This claim is also echoed by John & Sutherland (2005) who state “...there is nothing inherent in technology that automatically guarantees learning”. But sound pedagogy must also include consideration of the choice of task used in the instruction. The results obtained in this study were based on tasks that were designed specifically for the topic of multimedia design principles and the participants were all novice learners. Although the literature review indicated that APA learning was not related to subject matter, it did point out the confounding effect of interacting with instructional elements that is determined by the tasks. Therefore, when adopting a similar APA instruction to this study - for other subject areas, it would be prudent to ensure that first the subject content is new and unfamiliar to most learners so that the scaffolding method of using pop-up windows and APA’s explanations will work properly; next the task of learning must contain information that can be illustratively displayed; last, the assessment for the learning must be based on the same information display format so that learning and assessment are not in dissimilar context.

Second, was the ability to obtain the “crossover interaction” of the two curves formed by LIAI and CI when plotted against the different levels of sensory preference (see Figure 4.3 of Chapter 4). LIAI refers to instruction using low interactive APAs and CI is instruction using a conventional method. The “crossover interaction” is a necessary condition to demonstrate the existence of a modality effect as argued by Pashler, McDaniel, Rohrer and Bjork (2008). Pashler et al. commented that to prove the existence of a true modality effect experimentally, one must show evidence that a subject works well in one modality but poorly in another

modality using the same measure. The “crossover interaction” evidence produced by this study conforms to Pashler’s et al. requirements. It therefore helps to affirm the existence of the modality effect to a certain extent because the modality effect is known to be the most pronounced only for learners with strong sensory preferences. It does not apply well to mild sensory learners.

Besides the above findings, this study contains one failed effort – namely, the deliberate tweaking of the intonation of the APA’s voice. The researcher knew that the default voice that came with the Microsoft agents was below par when compared with the quality of a human voice, so he took an extra step to re-script the voice by varying the pitch of intonation and the pause between words. But this effort did not seem to address the problem adequately as observed from the negative responses over the quality of the APA’s vocalisation. Nonetheless, the effort - though void - proved to be a good learning point because it helps one to realize the significance of the voice quality – it is an element in instruction that a learner will not compromise easily.

### Implications

The implications of the study must benefit the stakeholders and those who are interested in harnessing the potentials of APAs for teaching and learning. The implications can be discussed at two levels: namely the Curriculum Level and Pedagogical Level. The two levels have been highlighted in Chapter One as significance of the study.

#### *At Curriculum Level*

##### 1. For the case Institute:

The case Institute is the biggest stakeholder of this study and hence the findings will have the greatest impact to it. The broad acceptance of learning provided by the low interactive APAs

together with its ability to maintain sound performance output give grounds for the case Institute to consider implementing APA-enabled instruction to complement the lack of “human presence” often found in online learning. But because the finding was based on only multimedia design as the subject matter, the use of low interactive APAs would appear most suitable when the curriculum adopts topics that are of a similar nature. In a same vein, as the finding was derived from a sample obtained from only one of the many programmes that the institute was offering, the application of low interactive APAs on instruction may not work well in other programmes other than the Post-Graduate Diploma in Education programme (PGDE).

2. For the online learning providers:

With the very encouraging acceptance level found in the study, the use of simple agents such as the Microsoft agents appears to offer a possible way of using low-technology agents to support online learning. In addition, such low interactive APAs also incur less design requirements and production costs and are easier to be customised; thus making it very suitable for small-scale online learning providers.

*At Pedagogical Level*

1. For instructional and school teacher designers:

- a. The finding that learners adopt usefulness of content and sound instructional strategies as their two main criteria for evaluating the APA instruction has a strong implication for designers. It pointed out that only instructional elements that are perceived to be facilitating the learning process are considered as favourable to the learners. It also demonstrated a useful phenomenon, that is, learners appear to be more tolerant to design defects if the overall learning condition is perceived to be useful and an aid to learning. This is reflected in the survey findings in that learners reported poor APA vocalisation but graded the lesson as useful and interesting. Therefore it

makes sense to spend more effort to design instruction that has a sound pedagogic foundation rather than just ‘bells and whistles’. It also explains why low interactivity without high human intelligence can still be acceptable to the majority of the learners.

- b. The synergy of using of pop-up windows to help deliver content, APA’s explanation to complement the pop-up windows and multiple agents to provide a social condition to maintain interactivity was shown to provide a means to enhance learning. In other words, the guidelines provided in the Interaction Framework can be said to have helped design appropriate interactions without using much technicality. But designers need to exercise discretion as to how these guidelines are to be interpreted to best fit the instructional demands.
- c. The extensive use of the agent’s voice due to using low interactivity could impose a challenge to learners who are not strongly auditorially inclined. Therefore designers need to make a discernable choice if sensory preference is a dominant feature among the learners.
- d. Although low interactive APA instruction only produced an advantage gain of 5.9% in terms of performance over its conventional counterpart, it was able to sustain good interest in learning as indicated by the favourable responses derived from item 3 of the Perception for Learning Scale (PLS), which attracted about 50% of definitely interested learners as against about 10% of definitely disinterested learners. The other 40% were undecided learners. Worthy of note is the term “definite” used in this study refers to responses obtained from answering either “Agree” or “Strong Agree” for the former, or “Disagree” or “Strongly Disagree” for the latter. Despite the said observation, the extent of interest in learning cannot be judged in the same way for the conventional instruction mode due to lack of sufficient information as explained before. Using the considerations described above, instructional designers who are more concerned with the affective aspect of learning may want to adopt the low

interactive APA design for instruction, given the fact that low interactive APA designs are not difficult to carry out and also not expensive to implement. But the caveat here is that learners' interest in APA instruction may not necessarily be greater than that in the conventional counterpart, hence designers are cautioned against making decisions based solely on interest alone.

- e. For general designers, the knowledge that both strong auditory and strong visual learners learn best in their preferred modalities and both groups of learners also regard quality of content as an important factor in judging the quality of a lesson has strong implications for designing text-based and voice-based instruction. This means that when designing instruction for learners with a strong inclination for either auditory or visual modalities, the instruction must contain not only interactive elements that will facilitate their modalities but also useful and relevant content. However, such design strategy may not be effective for mild sensory learners given that they are less susceptible to sensory preference and hence are more amenable to either modality.

2. For researchers:

- a. Because voice, gestures and pop-up windows are integratively combined to render interaction based on the guidelines given by the Interaction Framework, the scope of interaction is large and complex which could induce a concern for research granularity. This means that interaction has to be considered as a composite variable which can restrict researchers who want to study specific behaviour components independently or in an isolated fashion.
- b. This study used only three aspects of learning namely "extent of learning", "interest in the lesson" and "liking for the presentation" to measure the level of acceptability for learning with low interactive APAs. But these three aspects of learning are not the best constructs as far as understanding learners' perception is concerned. They are chosen

because they allow a wide range of ideas to be collected which is useful when the study has very little knowledge on how learners will react to learning with an artificially-enabled APA character. Hence for researchers who want to replicate the measurement of perception for a more in-depth study, the constructs may need to be refined or modified so that they can cover more depth rather than just breadth as was used in this study.

### Recommendations

The indication that using the strategies derived from the Interaction framework could provide useful learning and entice interest in the APA lesson speaks of the potential to use low technology tools instead of their high technology counterparts for designing useful learning activities. Accordingly, designers of online learning environments might want to consider capitalising on the concept of affordance by optimising only simple affordances of a tool and apply them to activities that are designed by using sound pedagogies. The process will not be smooth-sailing initially and the stakes are high but the return is worthwhile because technology cost will be lower and customisation will be easier. In a long run, the economical output should be better.

This study is not without shortcomings, it has two instructional design areas that could be further improved upon by future research: these are the APA's quality of vocalisation and the pace of delivery. The less-than-expected synthetic voice produced by the Microsoft agents may be replaced by more advanced natural voice engines that can be incorporated in the Microsoft scripting environment. Scripting is the process of enabling the speech and movements of an agent. Although the incorporation of such a natural voice may not produce a direct impact on the learning as evidenced by the study's findings, it could improve the pace of instruction by allowing more sophisticated sentences to be constructed without



compromising clarity. This helps to address the unfavourable but useful feedback that learners raised in the survey.

This study also encountered three research areas that could not be addressed. First is the strange behaviour exhibited by the mild visual learners who were shown to have a better performance when they learned through instruction using their opposite modality, that is, in the auditory modality. This is an observation that could not be explained by the Learning Style theory alone as noted in the literature review. Perhaps more in-depth research into how visual learners interact with text/visual elements could help to find an answer. To do this, a second level of inquiry would be needed which is beyond the scope of this study. It is hoped that future research could continue from here to unveil the mystery behind the strange phenomenon.

A further issue is the inability to provide a randomised sample, mentioned at the start of this chapter. Because the sample could not be randomised, the sample assignment had to be done by units of subject group rather than individual participants; as a result, it renders a possibility that the effect due to subject group may become overly influential which can confound the outcome of the investigation. Though steps have been taken to ensure that the subject group combinations are similar for both the control and experiment groups, the occurrence remains probable. So it would be good if any future studies could employ a randomised sample to replicate this study so the results could be cross-validated. The new findings may cast light on whether or not the unusual behaviour highlighted in this study is influenced by group dominance.

The last area is that since this study did not collect perception data for the control group, it suffers the limitation of not knowing how learners interacted differently with instructional

elements contained in the APA and conventional instruction. Knowledge of such would have been useful to extend to the use APA technology beyond the scope of this study. It would be fruitful if future studies were to have a methodological design that empirically compares the learners' interactions in the two different types of instruction.

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## Background Questionnaire

*This questionnaire forms part of the data collection process for our study. The information collected will help us access your multimedia design knowledge proficiency. Data will be used anonymously and confidentiality will be maintained. Please note that filling out the questionnaire is not obligatory so please feel free to opt out if you do not find it comfortable with the items. Many thanks.*

<b>Part 1 : About You</b>	
Student No: <input type="text"/>	
<b>Your Study</b>	
1. Module	<input type="radio"/> QED522 <input type="radio"/> QED503 <input type="radio"/> DED102 <input type="radio"/> DED132
2. Tutorial Group	<input type="text" value="Please select from list"/>
3. CS1	<input type="text" value="Please select from list"/>
4. CS2	<input type="text" value="Please select from list"/>
5. CS3	<input type="text" value="Not Applicable"/>
<b>Yourself</b>	
6. Age	<input type="text" value="Please select from list"/>
7. Sex	<input type="radio"/> Male <input type="radio"/> Female
<b>Part 2 : About Multimedia Design</b>	
1	I have taken similar multimedia design lesson prior to NIE <input type="radio"/> No <input type="radio"/> Yes
2	I have learnt multimedia design in other Curriculum Study (CS) areas <input type="radio"/> No <input type="radio"/> Yes
3	I grade my prior experience on multimedia design before taking this module as <input type="radio"/> Negligible experience <input type="radio"/> Novice <input type="radio"/> Proficient practitioner <input type="radio"/> Expert
<div>Done</div> <div>Opt out</div>	

Thank you

**Original Index of Learning Style Questionnaire**

(Extracted from <http://www.engr.ncsu.edu/learningstyles/ilsweb.html>)

**NC STATE UNIVERSITY**

## **Index of Learning Styles Questionnaire**

**Barbara A. Soloman  
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### **Directions**

Please provide us with your full name. Your name will be printed on the information that is returned to you.

**Full Name**

For each of the 44 questions below select either "a" or "b" to indicate your answer. Please choose only one answer for each question. If both "a" and "b" seem to apply to you, choose the one that applies more frequently. When you are finished selecting answers to each question please select the submit button at the end of the form.

1. I understand something better after I
  - ☐ (a) try it out.
  - ☐ (b) think it through.
2. I would rather be considered
  - ☐ (a) realistic.
  - ☐ (b) innovative.
3. When I think about what I did yesterday, I am most likely to get
  - ☐ (a) a picture.
  - ☐ (b) words.
4. I tend to
  - ☐ (a) understand details of a subject but may be fuzzy about its overall structure.
  - ☐ (b) understand the overall structure but may be fuzzy about details.
5. When I am learning something new, it helps me to
  - ☐ (a) talk about it.
  - ☐ (b) think about it.

## APPENDIX B

6. If I were a teacher, I would rather teach a course
  - ☐ (a) that deals with facts and real life situations.
  - ☐ (b) that deals with ideas and theories.
7. I prefer to get new information in
  - ☐ (a) pictures, diagrams, graphs, or maps.
  - ☐ (b) written directions or verbal information.
8. Once I understand
  - ☐ (a) all the parts, I understand the whole thing.
  - ☐ (b) the whole thing, I see how the parts fit.
9. In a study group working on difficult material, I am more likely to
  - ☐ (a) jump in and contribute ideas.
  - ☐ (b) sit back and listen.
10. I find it easier
  - ☐ (a) to learn facts.
  - ☐ (b) to learn concepts.
11. In a book with lots of pictures and charts, I am likely to
  - ☐ (a) look over the pictures and charts carefully.
  - ☐ (b) focus on the written text.
12. When I solve math problems
  - ☐ (a) I usually work my way to the solutions one step at a time.
  - ☐ (b) I often just see the solutions but then have to struggle to figure out the steps to get to them.
13. In classes I have taken
  - ☐ (a) I have usually gotten to know many of the students.
  - ☐ (b) I have rarely gotten to know many of the students.
14. In reading nonfiction, I prefer
  - ☐ (a) something that teaches me new facts or tells me how to do something.
  - ☐ (b) something that gives me new ideas to think about.
15. I like teachers
  - ☐ (a) who put a lot of diagrams on the board.
  - ☐ (b) who spend a lot of time explaining.
16. When I'm analyzing a story or a novel
  - ☐ (a) I think of the incidents and try to put them together to figure out the themes.
  - ☐ (b) I just know what the themes are when I finish reading and then I have to go back and find the incidents that demonstrate them.
17. When I start a homework problem, I am more likely to
  - ☐ (a) start working on the solution immediately.
  - ☐ (b) try to fully understand the problem first.

## APPENDIX B

18. I prefer the idea of  
☐ (a) certainty.  
☐ (b) theory.
19. I remember best  
☐ (a) what I see.  
☐ (b) what I hear.
20. It is more important to me that an instructor  
☐ (a) lay out the material in clear sequential steps.  
☐ (b) give me an overall picture and relate the material to other subjects.
21. I prefer to study  
☐ (a) in a study group.  
☐ (b) alone.
22. I am more likely to be considered  
☐ (a) careful about the details of my work.  
☐ (b) creative about how to do my work.
23. When I get directions to a new place, I prefer  
☐ (a) a map.  
☐ (b) written instructions.
24. I learn  
☐ (a) at a fairly regular pace. If I study hard, I'll "get it."  
☐ (b) in fits and starts. I'll be totally confused and then suddenly it all "clicks."
25. I would rather first  
☐ (a) try things out.  
☐ (b) think about how I'm going to do it.
26. When I am reading for enjoyment, I like writers to  
☐ (a) clearly say what they mean.  
☐ (b) say things in creative, interesting ways.
27. When I see a diagram or sketch in class, I am most likely to remember  
☐ (a) the picture.  
☐ (b) what the instructor said about it.
28. When considering a body of information, I am more likely to  
☐ (a) focus on details and miss the big picture.  
☐ (b) try to understand the big picture before getting into the details.
29. I more easily remember  
☐ (a) something I have done.  
☐ (b) something I have thought a lot about.

## APPENDIX B

30. When I have to perform a task, I prefer to
- ☐ (a) master one way of doing it.
  - ☐ (b) come up with new ways of doing it.
31. When someone is showing me data, I prefer
- ☐ (a) charts or graphs.
  - ☐ (b) text summarizing the results.
32. When writing a paper, I am more likely to
- ☐ (a) work on (think about or write) the beginning of the paper and progress forward.
  - ☐ (b) work on (think about or write) different parts of the paper and then order them.
33. When I have to work on a group project, I first want to
- ☐ (a) have "group brainstorming" where everyone contributes ideas.
  - ☐ (b) brainstorm individually and then come together as a group to compare ideas.
34. I consider it higher praise to call someone
- ☐ (a) sensible.
  - ☐ (b) imaginative.
35. When I meet people at a party, I am more likely to remember
- ☐ (a) what they looked like.
  - ☐ (b) what they said about themselves.
36. When I am learning a new subject, I prefer to
- ☐ (a) stay focused on that subject, learning as much about it as I can.
  - ☐ (b) try to make connections between that subject and related subjects.
37. I am more likely to be considered
- ☐ (a) outgoing.
  - ☐ (b) reserved.
38. I prefer courses that emphasize
- ☐ (a) concrete material (facts, data).
  - ☐ (b) abstract material (concepts, theories).
39. For entertainment, I would rather
- ☐ (a) watch television.
  - ☐ (b) read a book.
40. Some teachers start their lectures with an outline of what they will cover. Such outlines are
- ☐ (a) somewhat helpful to me.
  - ☐ (b) very helpful to me.

## APPENDIX B

41. The idea of doing homework in groups, with one grade for the entire group,
- ☐ (a) appeals to me.
  - ☐ (b) does not appeal to me.
42. When I am doing long calculations,
- ☐ (a) I tend to repeat all my steps and check my work carefully.
  - ☐ (b) I find checking my work tiresome and have to force myself to do it.
43. I tend to picture places I have been
- ☐ (a) easily and fairly accurately.
  - ☐ (b) with difficulty and without much detail.
44. When solving problems in a group, I would be more likely to
- ☐ (a) think of the steps in the solution process.
  - ☐ (b) think of possible consequences or applications of the solution in a wide range of areas.

When you have completed filling out the above form please click on the Submit button below. Your results will be returned to you. If you are not satisfied with your answers above please click on Reset to clear the form.

Submit

Reset

---

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## APPENDIX C

### **Comparison between Items from Visual/Verbal Scale in Index of Learning Styles Questionnaire and Sensory Preference Scale**

Visual/Verbal Scale in Index of Learning Styles (ILS) Questionnaire		Sensory Preference Scale (SPS)		
Item No.	Content of Item	Item No.	Content of Item	Remark
3	When I think about what I did yesterday, I am most likely to get (a) A picture. (b) Words.	1	When I meet people at a party, I am more likely to remember (a) What they looked like. (b) What they said about themselves.	Retain ILS no. 35
7	I prefer to get new information in (a) Pictures, diagrams, graphs, or maps. (b) Written directions or verbal information.	2	I prefer to learn new things (a) By reading from a textbook. (b) By listening to a lecture.	Modified partially from ILS no. 7
11.	In a book with lots of pictures and charts, I am likely to (a) Look over the pictures and charts carefully. (b) Focus on the written text.	3	In an English movie with English subtitle, I am likely to (a) Focus only on the subtitle. (b) Concentrate only on the conversation.	Replaced completely
15.	I like teachers (a) Who put a lot of diagrams on the board. (b) Who spend a lot of time explaining.	4	I like teachers (a) Who put a lot of diagrams on the board. (b) Who spend a lot of time explaining.	Retained ILS no. 15
19.	I remember best (a) What I see. (b) What I hear.	5	I remember best (a) What I see. (b) What I hear.	Retained ILS no. 19.
23.	When I get directions to a new place, I prefer (a) A map. (b) Written instructions.	6	When someone gives me a phone number, I prefer the number to be (a) Written down. (b) Read out loud.	Replaced completely
27.	When I see a diagram or sketch in class, I am most likely to remember (a) The picture. (b) What the instructor said about it.	7	I like to revise my work by (a) Reading the words in my mind. (b) Reading the words loud.	Replaced completely
31.	When someone is showing me data, I prefer (a) Charts or graphs. (b) Text summarizing the results.	8	When I want to know the news today, I will (a) Read the newspaper. (b) Turn on the news station on the radio.	Modified partially from ILS no. 31
35.	When I meet people at a party, I am more likely to remember (a) What they looked like. (b) What they said about themselves.	9	When I visit a museum, I prefer to find information (a) From the display board. (b) From the tour guide's explanation.	Modified partially from ILS no. 23
39.	For entertainment, I would rather (a) Watch television. (b) Read a book.	10	For entertainment, I would rather (a) Read a joke. (b) Listen to a joke.	Modified partially from ILS no. 39
43.	I tend to picture places I have been (a) Easily and fairly accurately. (b) With difficulty and without much detail.	11	I find it easier to convince someone if I (a) Write to him. (b) Talk to him.	Replaced completely

## Sensory Preference Scale

**Instruction** The items below are for finding out your sensory preference which will be used in our study. We will ensure the confidentiality of the information collected. Please feel free to opt out by using the button below if you do not wish to take part in this survey. Otherwise you may begin by entering your answers to each item shown below. Certainly, you will not be disadvantaged for not taking part in this survey.  
Please choose only one answer for each item. If both "a" and "b" seem to apply to you, choose the one that applies more frequently. Thank you.

Student No:

1.	When I meet people at a party, I am more likely to remember <input type="radio"/> (a) what they look like. <input type="radio"/> (b) what they said about themselves.
2.	I prefer to learn new things <input type="radio"/> (a) by reading from a textbook. <input type="radio"/> (b) by listening to a lecture.
3.	In an English movie with English subtitle, I am likely to <input type="radio"/> (a) focus only on the subtitle. <input type="radio"/> (b) concentrate only on the conversation.
4.	I like teachers <input type="radio"/> (a) who writes a lot on the board. <input type="radio"/> (b) who spend a lot of time explaining.
5.	I remember best <input checked="" type="radio"/> (a) what I read. <input type="radio"/> (b) what I hear.
6.	When someone gives me a phone number, I prefer the number to be <input checked="" type="radio"/> (a) written down. <input type="radio"/> (b) read out loud.
7.	I like to revise my work by <input type="radio"/> (a) reading the words in my mind. <input type="radio"/> (b) reading the words aloud.
8.	When I want to know the news today, I will <input type="radio"/> (a) read the newspaper. <input type="radio"/> (b) turn on the news station on the radio.



## APPENDIX D

9.	When I visit a museum, I prefer to find information <input type="radio"/> (a) from the display board. <input type="radio"/> (b) from the tour guide's explanation.
10.	For entertainment, I would rather <input type="radio"/> (a) read a joke. <input type="radio"/> (b) listen to a joke.
11.	I find it easier to convince someone if I <input type="radio"/> (a) write to him. <input type="radio"/> (b) talk to him.
	<div><div>Submit your response</div><div>Opt out</div></div>

Thank you.

## APPENDIX E

### **Establishing Reliability for Sensory Preference Scale (SPS) by using Cronbach Alpha Coefficient and Test-Retest Correlation from SPSS**

#### **Computing Cronbach Alpha Value:**

114 participants took part in this test. To calculate Cronbach alpha, first an inter-item correlation matrix is to be drawn up. From here, any item which has unexpected correlation (i.e.  $r < .20$ ) would be examined to decide if the item should be discarded.

Table E.1 Inter-Item Correlation Matrix

	Item1	Item2	Item3	Item4	Item5	Item6	item7	Item8	Item9	Item10	Item11
Item1	1.000	.080	.091	.016	.200	.285	.261	.193	.112	.177	.069
Item2	<b>.080</b>	1.000	.067	.146	.198	.094	.078	.122	.078	.156	.196
Item3	<b>.091</b>	<b>.067</b>	1.000	.089	.031	.091	.057	.083	.092	.022	.002
Item4	<b>.016</b>	<b>.146</b>	<b>.089</b>	1.000	.097	.026	.075	.001	.064	-.026	.027
Item5	<b>.200</b>	<b>.198</b>	<b>.031</b>	<b>.097</b>	1.000	.259	.114	.218	.034	.114	.116
Item6	<b>.285</b>	<b>.094</b>	<b>.091</b>	<b>.026</b>	<b>.259</b>	1.000	.273	.209	.125	.088	.177
item7	<b>.261</b>	<b>.078</b>	<b>.057</b>	<b>.075</b>	<b>.114</b>	<b>.273</b>	1.000	.074	.066	.068	-.021
Item8	<b>.193</b>	<b>.122</b>	<b>.083</b>	<b>.001</b>	<b>.218</b>	<b>.209</b>	<b>.074</b>	1.000	.084	.162	.029
Item9	<b>.112</b>	<b>.078</b>	<b>.092</b>	<b>.064</b>	<b>.034</b>	<b>.125</b>	<b>.066</b>	<b>.084</b>	1.000	.004	-.028
Item10	<b>.177</b>	<b>.156</b>	<b>.022</b>	<b>-.026</b>	<b>.114</b>	<b>.088</b>	<b>.068</b>	<b>.162</b>	<b>.004</b>	1.000	.179
Item11	<b>.069</b>	<b>.196</b>	<b>.002</b>	<b>.027</b>	<b>.116</b>	<b>.177</b>	<b>-.021</b>	<b>.029</b>	<b>-.028</b>	<b>.179</b>	1.000

Next, SPSS is used to calculate the improvement (if any) in Cronbach Alpha Coefficient if the particular item is removed. This is reflected in the last column of the Item-Total Statistics table. The result helps to determine if removal of a particular item is necessary.

From the table, none of the item is removed as the resultant effect is insignificant.

Table E.2 Item-Total Statistics

	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
item1	.345	.166	.505
Item2	.275	.110	.524
Item3	.138	.030	.561
Item4	.121	.042	.559
Item5	.314	.139	.513
Item6	.388	.206	.500
item7	.237	.125	.534
Item8	.272	.110	.527
Item9	.141	.040	.560
Item10	.216	.090	.539
Item11	.163	.098	.552

The Cronbach Alpha value without any item removed is found to be .558

## APPENDIX E

### Computing Test-Retest Reliability:

The same 114 participants took part in the retest.

Table E.3 Descriptive Statistics for the First and Retest on Sensory Preference

Sensory Presence	Mean Score	Standard Deviation	No. of Participants
1st test	6.22	1.723	114
Retest	5.99	2.029	114

Table E.4 Correlation Matrix showing Correlations between Means of First and Retest

		First Test	Retest
First Test	Pearson Correlation (2-tailed test)	1.00	.722(**)
Retest	Pearson Correlation (2-tailed test)	.722(**)	1.00

\*\* Denotes correlation is significant at the 0.01 level (2-tailed).

From Table E.2 test-retest correlation is found to be .722 ( $p < .05$ ) with two tailed test.

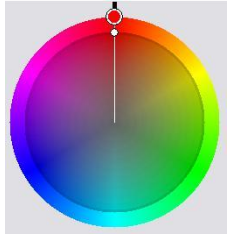
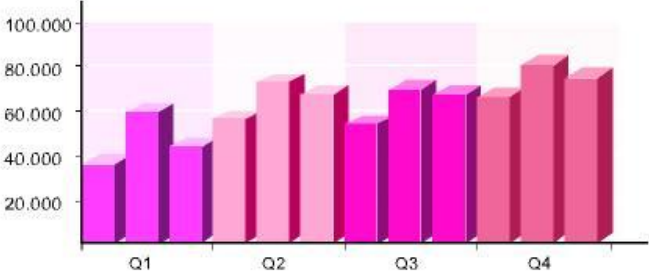
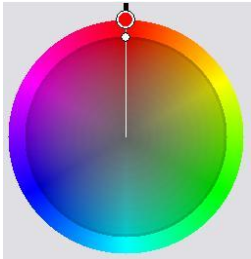
**First Version of Performance Quiz****Performance Quiz**

<b>Student No:</b> <input type="text"/>	
<b>Instruction :</b>	There are 40 multiple-choice items in this quiz. Please complete <u>ALL</u> the items. The purpose of this quiz is to find out how well you understand the multimedia design principles you have learnt. The results of this quiz will <u>not</u> count toward your final grade. It is used only as a form of self-assessment. As we are conducting a study on the effectiveness of the multimedia lesson you learned, we need your consent to use your quiz score in our study. By taking this quiz, you agree to allow us to use your quiz score. Otherwise, please feel free to opt out of the system by using the button below. Please note that participation is not compulsory and you are in no way disadvantaged should you choose not to take part in the study.
<b>Time given :</b>	<b>40 minutes.</b> A pop-up clock will be displayed to help you keep track of your progress. The quiz will be disabled once the time is up.
<b>Submission :</b>	Once you have finished, please click the “Submit” button to end the quiz. After this, you are not allowed to access the quiz anymore.
1.	You learned ____ principles in the multimedia design lesson. <input type="radio"/> a. 5 <input type="radio"/> b. 6 <input type="radio"/> c. 7 <input type="radio"/> d. 8
2.	Which of the following screen resolutions conforms to aspect ratio of 4:3? <input checked="" type="radio"/> a. 640x480 <input type="radio"/> b. 820x640 <input type="radio"/> c. 1024x786 <input type="radio"/> d. 1150x860
3.	When a screen is divided into two equal halves to display its content, a _____ is likely to happen. <input type="radio"/> a. visual interference <input type="radio"/> b. visual vibration <input type="radio"/> c. visual stagnancy <input type="radio"/> d. visual equality
4.	The Rule of Thirds requires <input type="radio"/> a. virtually dividing the screen display into nine cells. <input type="radio"/> b. using three primary colors and three frames to organize the presentation. <input type="radio"/> c. that content material be presented into three subdivisions. <input type="radio"/> d. materials to be presented to have introduction, body and conclusion.

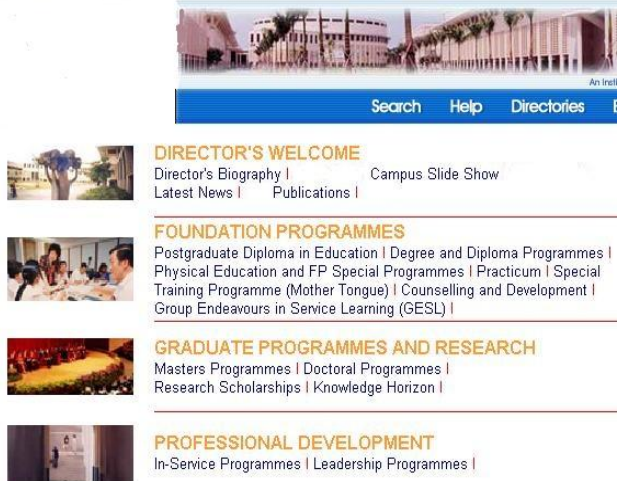

## APPENDIX F

5.	Which of the following is NOT a criterion used to ensure a clear fore-and background contrast?
<input type="radio"/>	a. foreground objects must be much brighter than the background
<input type="radio"/>	b. foreground objects must be much darker than the background
<input type="radio"/>	c. foreground objects must be more symmetrical than the background
<input type="radio"/>	d. foreground objects must be much smaller than the background
6.	When we need to conserve space on a screen display in order to accommodate more elements, we can
<input type="radio"/>	a. apply strong figure-ground contrast on the elements
<input type="radio"/>	b. apply reverse figure-ground contrast on the elements
<input type="radio"/>	c. group all symmetrical elements at the foreground
<input type="radio"/>	d. group all asymmetrical elements at the background
7.	In general, which of the following is not suitable for applying strong figure-ground contrast?
<input type="radio"/>	a. Title of a page
<input type="radio"/>	b. Keyword
<input type="radio"/>	c. Caption of a figure
<input type="radio"/>	d. Special term
8.	Why do newspapers and most textbooks use black text on white paper? (i) White background is the easiest background to go with the other colours. (ii) Black-and-white combination gives the greatest contrast. (iii) Black ink and white paper are the most economical materials
<input type="radio"/>	a. (i) only
<input type="radio"/>	b. (ii) only
<input type="radio"/>	c. (i) and (ii) only
<input type="radio"/>	d. (i), (ii) and (iii)
9.	Color matching does not only affect contrast, it also plays an important role in maintaining the _____ and _____ of a website.
<input type="radio"/>	a. balance, theme
<input type="radio"/>	b. hue, balance
<input type="radio"/>	c. harmony, appeal
<input type="radio"/>	d. weight , symmetry

## APPENDIX F

10.	<p>On the right shows a color wheel. What are the secondary colors?</p> <p><input type="radio"/> a. yellow cyan magenta</p> <p><input type="radio"/> b. green purple cyan</p> <p><input type="radio"/> c. blue green orange</p> <p><input type="radio"/> d. red green blue</p>	
11.	<p>Refer to the color wheel in Q10. Possible tertiary colors are obtained by mixing</p> <p><input type="radio"/> a. yellow and blue</p> <p><input type="radio"/> b. red and magenta</p> <p><input type="radio"/> c. green and blue</p> <p><input type="radio"/> d. cyan and yellow</p>	
12.	<p>Which of the following refers to color coordination that is pleasing to the eyes?</p> <p><input type="radio"/> a. Appeal</p> <p><input type="radio"/> b. Temperature</p> <p><input type="radio"/> c. Harmony*</p> <p><input type="radio"/> d. Texture</p>	
13.	<p>Using the color wheel in Q10, what color scheme is use for the chart on the right?</p> <p><input type="radio"/> a. Adjacent color scheme</p> <p><input type="radio"/> b. Analogous color scheme</p> <p><input type="radio"/> c. Primary color scheme</p> <p><input type="radio"/> d. Homogeneous color scheme</p>	
14.	<p>14. Which of the following is NOT a Cool color?</p> <p><input type="radio"/> a. Yellow</p> <p><input type="radio"/> b. Green</p> <p><input type="radio"/> c. Blue</p> <p><input type="radio"/> d. Violet</p>	
15.	<p>Refer to the color wheel on the right, what color will go with blue to give a high level of color contrast?</p> <p><input type="radio"/> a. Red</p> <p><input type="radio"/> b. Yellow</p> <p><input type="radio"/> c. Green</p> <p><input type="radio"/> d. Cyan</p>	

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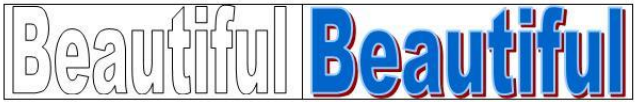
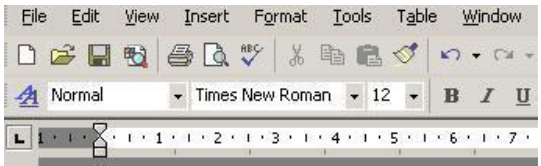
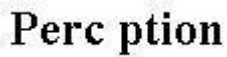
16.	Content organization can be categorized into intra-arrangement and inter-arrangement. Which of the following does not come under inter-arrangement?	
	<input type="radio"/> a. Proximity <input type="radio"/> b. Similarity <input type="radio"/> c. Symmetry <input type="radio"/> d. Continuity	
17.	Proximity refers to	
	<input type="radio"/> a. the limit in which two objects can be placed close to each other <input type="radio"/> b. putting objects close together to create a concept of a whole. <input type="radio"/> c. how close the meaning given by a description next to a graphic. <input type="radio"/> d. the use of one object as a metaphor to the other.	
18.	The web page shown on the right is for Q18 to Q20. Which of the following is correct with regard to the use of proximity on the web page?	 <p>The screenshot shows a university website with a blue header containing 'Search', 'Help', and 'Directories'. Below the header, there are several sections with headings and lists of programs:</p> <ul style="list-style-type: none"> <li><b>DIRECTOR'S WELCOME</b>: Director's Biography   Campus Slide Show   Latest News   Publications</li> <li><b>FOUNDATION PROGRAMMES</b>: Postgraduate Diploma in Education   Degree and Diploma Programmes   Physical Education and FP Special Programmes   Practicum   Special Training Programme (Mother Tongue)   Counselling and Development   Group Endeavours in Service Learning (GESL)</li> <li><b>GRADUATE PROGRAMMES AND RESEARCH</b>: Masters Programmes   Doctoral Programmes   Research Scholarships   Knowledge Horizon</li> <li><b>PROFESSIONAL DEVELOPMENT</b>: In-Service Programmes   Leadership Programmes</li> </ul>
19.	Refer to the web page in Q18. Which of the following is/are used to enhance proximity?	
	<input type="radio"/> a. space <input type="radio"/> b. line <input type="radio"/> c. color <input type="radio"/> d. all of the above	
20.	The color scheme used in the graphic in Q18 is probably Split Complementary. What is the main advantage of this color scheme?	
	<input type="radio"/> a. The color gives a warm feeling. <input type="radio"/> b. Easy to attain a good harmony balance. <input type="radio"/> c. High degree of color contrast.* <input type="radio"/> d. All of the above.	
21.	The figure on the right is confusing because	
	<input type="radio"/> a. there is insufficient background area. <input type="radio"/> b. black and white color are used. <input type="radio"/> c. the graphic is too small. <input type="radio"/> d. black is used as background.	

## APPENDIX F


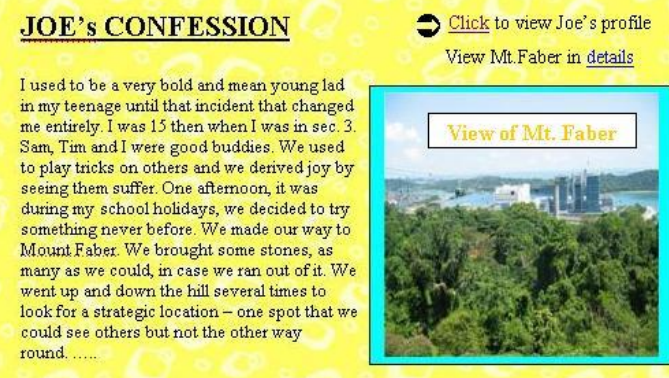
22.	Grouping similar objects together tend to help learners	
	<input type="radio"/> a. produce a sense of organization. <input type="radio"/> b. associate a meaning for the arrangement. <input type="radio"/> c. interpolate the pattern of presentation. <input type="radio"/> d. arrange the intra-relationship of objects.	
23.	Symmetrical objects tend to stand out against	
	<input type="radio"/> a. dull background. <input type="radio"/> b. text-based background. <input type="radio"/> c. irregular background. <input type="radio"/> d. graphic-based background.	
24.	The main factor causing you to see columns of circle alternating with columns of square in the figure on the right is because of	
	<input type="radio"/> a. Proximity <input type="radio"/> b. Similarity <input type="radio"/> c. Closure <input type="radio"/> d. Symmetry	
25.	25. How do we make the users see circles alternating with squares in the figure in Q24?	
	<input type="radio"/> a. Increase the space between each row <input type="radio"/> b. Increase the space between each column <input type="radio"/> c. Lighten the color of the circles <input type="radio"/> d. Lighten the color of the squares	
26.	Which of the following is NOT a factor for symmetrical balance?	
	<input type="radio"/> a. Size of an object <input type="radio"/> b. Density of the text area <input type="radio"/> c. Type of font for the text area <input type="radio"/> d. Relative position of an object	
27.	Which of the following is the most important element that makes you instantly recognize the intended meaning of the graphic?	
	<input type="radio"/> a. high symmetry <input type="radio"/> b. high figure-ground contrast <input type="radio"/> c. objects proximity <input type="radio"/> d. objects closure	
28.	You can easily recognize the pattern from the figure on the right mainly because of	
	<input type="radio"/> a. similarity <input type="radio"/> b. proximity <input type="radio"/> c. closure <input type="radio"/> d. continuity	



## APPENDIX F

29.	<p>If we have a concept which is made up of several units with each contains several components and we need to organize it into a menu, we should</p> <ul style="list-style-type: none"> <li><input type="radio"/> a. lay all the component headings on a single page and provide each component with a hyperlink.</li> <li><input type="radio"/> b. group the relevant components into a sub-menu and provide hyperlinks to the components</li> <li><input type="radio"/> c. present each important page by page according to their importance.</li> <li><input type="radio"/> d. reorganize all the components into a single document and present it in a single page.</li> </ul>
30.	<p>The graphic on the right is not visually balanced in the left-right orientation. How would you make it balanced?</p> <ul style="list-style-type: none"> <li><input type="radio"/> a. Leave more spacing between the blue word and the center line</li> <li><input type="radio"/> b. Leave more spacing between the white word and the center line</li> <li><input type="radio"/> c. use red color for the word on the left</li> <li><input type="radio"/> d. All of the above</li> </ul> 
31.	<p>The items on the right are arranged according to the principle of</p> <ul style="list-style-type: none"> <li><input type="radio"/> a. similarity</li> <li><input type="radio"/> b. symmetry</li> <li><input type="radio"/> c. continuity</li> <li><input type="radio"/> d. proximity</li> </ul> 
32.	<p>The principle of closure when applied to multimedia design means to</p> <ul style="list-style-type: none"> <li><input type="radio"/> a. avoid using incomplete message in concept building.</li> <li><input type="radio"/> b. use incomplete message to motivate concept building.</li> <li><input type="radio"/> c. always have complete conclusion at the end of the presentation.</li> <li><input type="radio"/> d. close up any unnecessary gap between objects to achieve a tight grouping.</li> </ul>
33.	<p>How well we can complete missing parts of a pattern (e.g. the word on the right) is largely dependent on</p> <ul style="list-style-type: none"> <li><input type="radio"/> a. the figure-ground contrast of the parts.</li> <li><input type="radio"/> b. the probability of guessing.</li> <li><input type="radio"/> c. our past knowledge of a similar word.</li> <li><input type="radio"/> d. our ability to learn new word.</li> </ul> 
34.	<p>We have a preference for continuity means we</p> <ul style="list-style-type: none"> <li><input type="radio"/> a. have a natural inclination to interpolate.</li> <li><input type="radio"/> b. like description to be smooth flowing rather than intermittent.</li> <li><input type="radio"/> c. like objects that have continuous arrangement.</li> <li><input type="radio"/> d. want to see information on one single page rather in several pages.</li> </ul>

## APPENDIX F

35.	<p>You don't find a mistake easily in the figure on the right because of our inclination for</p> <ul style="list-style-type: none"> <li><input type="radio"/> a. long sentences.</li> <li><input type="radio"/> b. upper case words.</li> <li><input type="radio"/> c. proximity.</li> <li><input type="radio"/> d. closure.</li> </ul>	
36.	<p>The principle that suggests concept development should follow a smooth natural flow with small incremental advancement is the</p> <ul style="list-style-type: none"> <li><input type="radio"/> a. principle of closure</li> <li><input type="radio"/> b. principle of continuity</li> <li><input type="radio"/> c. principle of flow</li> <li><input type="radio"/> d. principle of proximity</li> </ul>	
37.	<p>The graphic on the right is for Q37 and Q38. The design of the graphic needs improvement. Which of the following is the first in the list that needs your attention?</p> <ul style="list-style-type: none"> <li><input type="radio"/> a. The layout continuity</li> <li><input type="radio"/> b. The object proximity</li> <li><input type="radio"/> c. The arrangement for similarity</li> <li><input type="radio"/> d. The figure-ground contrast</li> </ul>	
38.	<p>Refer to the graphic in Q37. There are still other areas that need to be improved. Which of the following does NOT need improvement?</p> <ul style="list-style-type: none"> <li><input type="radio"/> a. The balance between the main text area and the graphi</li> <li><input type="radio"/> b. The positioning of text containing the hyperlinks</li> <li><input type="radio"/> c. The graphic caption</li> <li><input type="radio"/> d. The grouping of objects</li> </ul>	
39.	<p>When arrows are used to provide association between objects in a chart, _____ lines are preferred.</p> <ul style="list-style-type: none"> <li><input type="radio"/> a. angled</li> <li><input type="radio"/> b. thick</li> <li><input type="radio"/> c. curly</li> <li><input type="radio"/> d. smooth</li> </ul>	

## APPENDIX F

40. I see \_\_\_\_\_ from the figure on the right. This is due to our preference for \_\_\_\_\_.

- ☐ a. a shape of a cross
- ☐ b. a shape of a cross
- ☐ c. four "V" shapes with apexes joint together
- ☐ d. four "V" shapes with apexes joint together
- ☐ a. closure
- ☐ b. continuity
- ☐ c. closure
- ☐ d. continuity



[Submit your response](#)

[Opt out](#)

Thank you.

**Cronbach Alpha Value and Item Analysis for the Performance Quiz****Computation of Cronbach Alpha value for the Initial 40-item Performance Quiz:**

257 participants took part in the test. The Cronbach Alpha for the first version of Performance Quiz is found to be .725 which is lower than the required value of .75 by Tuckman's (1999, p. 445) criterion.

Table G.1 Cronbach Alpha value for the Initial 40-item Performance Quiz

Cronbach Alpha	No. of Items
0.725	40

To improve the reliability, an item analysis was carried out. Below is a correlation matrix showing the correlations between the score of each item and the total score of all items.

**Item Analysis:**

Table G.2 Item-Total Correlations for the 40-item Performance Quiz

Performance Score	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Item with $r > .20$ ?
item1	0.387	0.710	Yes
item2	-0.008	0.732	-
item3	0.408	0.710	Yes
item4	0.401	0.709	Yes
item5	-0.018	0.731	-
item6	0.020	0.728	-
item7	0.165	0.723	-
item8	-0.079	0.736	-
item9	0.405	0.709	Yes
item10	0.272	0.717	Yes
item11	0.431	0.708	Yes
item12	0.137	0.724	-
item13	0.235	0.719	Yes
item14	0.279	0.717	Yes
item15	0.236	0.719	Yes
item16	0.365	0.711	Yes
item17	0.402	0.710	Yes
item18	0.190	0.721	-
item19	0.084	0.726	-

## APPENDIX G

item20	0.335	0.713	Yes
item21	0.327	0.714	Yes
item22	0.218	0.720	Yes
item23	0.371	0.711	Yes
item24	0.197	0.721	-
item25	0.265	0.717	Yes
item26	0.175	0.722	-
item27	0.062	0.726	-
item28	0.207	0.720	Yes
item29	0.006	0.731	-
item30	-0.034	0.730	-
item31	0.171	0.722	-
item32	0.177	0.722	-
item33	0.327	0.716	Yes
item34	0.386	0.711	Yes
item35	0.375	0.711	Yes
item36	0.198	0.721	-
item37	-0.102	0.737	-
item38	-0.109	0.736	-
item39	0.287	0.716	Yes
item40	0.253	0.718	Yes

### Computation of new Cronbach Alpha value after removing the Defective Items:

The items left after removal of defective ones are: 1, 3, 4, 9, 10, 11, 13, 14, 15, 16, 19, 20, 21, 22, 23, 25, 28, 33, 34, 35, 39, 40. They form the new 22-item Performance Quiz. The new Cronbach Alpha value is calculated as follows:

Table G.3 Cronbach Alpha value for the new 22-item Performance Quiz

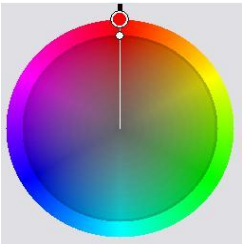
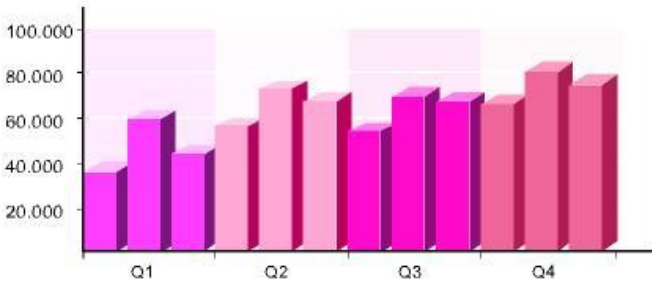

Cronbach Alpha	No. of Items
0.775	22

The Cronbach Alpha value for the new 22-item Performance Quiz is found to be .775.

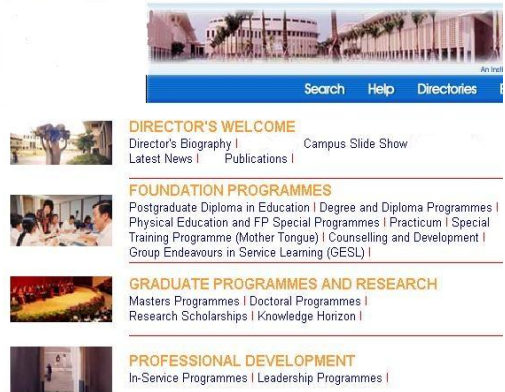

**Final Version of Performance Quiz****Performance Quiz**

<b>Your Student No:</b> <input type="text"/>	
<b>Instruction :</b>	There are 22 multiple-choice items in this quiz. Please complete <u>ALL</u> the items. The purpose of this quiz is to find out how well you understand the multimedia design principles you have learnt. The results of this quiz will <u>not</u> count toward your final grade. It is used only as a form of self-assessment. As we are conducting a study on the effectiveness of the multimedia lesson you learned, we need your consent to use your quiz score in our study. By taking this quiz, you agree to allow us to use your quiz score. Otherwise, please feel free to opt out of the system by using the button below. Please note that participation is not compulsory and you are in no way disadvantaged should you choose not to take part in the study.
<b>Time given :</b>	<u>25 minutes</u> . A pop-up clock will be displayed to help you keep track of your progress. The quiz will be disabled once the time is up
<b>Submission :</b>	Once you have finished, please click the “Submit” button to end the quiz. After this, you are not allowed to access the quiz anymore.
1.	<p>You learned ____ principles in the multimedia design lesson.</p> <p><input type="radio"/> a. 5</p> <p><input type="radio"/> b. 6</p> <p><input type="radio"/> c. 7</p> <p><input type="radio"/> d. 8</p>
2.	<p>When a screen is divided into two equal halves to display its content, a _____ is likely to happen.</p> <p><input type="radio"/> a. visual interference</p> <p><input type="radio"/> b. visual vibration</p> <p><input type="radio"/> c. visual stagnancy</p> <p><input type="radio"/> d. visual equality</p>
3.	<p>The Rule of Thirds requires</p> <p><input type="radio"/> a. virtually dividing the screen display into nine cells.</p> <p><input type="radio"/> b. using three primary colors and three frames to organize the presentation.</p> <p><input type="radio"/> c. that content material be presented into three subdivisions.</p> <p><input type="radio"/> d. materials to be presented to have introduction, body and conclusion.</p>
4.	<p>Color matching does not only affect contrast, it also plays an important role in maintaining the _____ and _____ of a website.</p> <p><input type="radio"/> a. balance, theme</p> <p><input type="radio"/> b. hue, balance</p> <p><input type="radio"/> c. harmony, appeal</p> <p><input type="radio"/> d. weight , symmetry</p>

## APPENDIX H

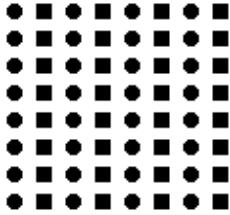

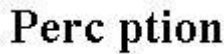
5.	<p>On the right shows a color wheel. What are the secondary colors?</p> <ul style="list-style-type: none"> <li><input type="radio"/> a. yellow, cyan, magenta</li> <li><input type="radio"/> b. green, purple, cyan</li> <li><input type="radio"/> c. blue, green, orange</li> <li><input type="radio"/> d. red, green, blue</li> </ul>	
6.	<p>Refer to the color wheel in Q5. Possible tertiary colors are obtained by mixing</p> <ul style="list-style-type: none"> <li><input type="radio"/> a. yellow and blue</li> <li><input type="radio"/> b. red and magenta</li> <li><input type="radio"/> c. green and blue</li> <li><input type="radio"/> d. cyan and yellow</li> </ul>	
7.	<p>Using the color wheel in Q5, what color scheme is use for the chart on the right?</p> <ul style="list-style-type: none"> <li><input type="radio"/> a. Adjacent color scheme</li> <li><input type="radio"/> b. Analogous color scheme</li> <li><input type="radio"/> c. Primary color scheme</li> <li><input type="radio"/> d. Homogeneous color scheme</li> </ul>	
8.	<p>Which of the following is NOT a Cool color?</p> <ul style="list-style-type: none"> <li><input type="radio"/> a. Yellow</li> <li><input type="radio"/> b. Green</li> <li><input type="radio"/> c. Blue</li> <li><input type="radio"/> d. Violet</li> </ul>	
9.	<p>Refer to the color wheel on the right, what color will go with blue to give a high level of color contrast?</p> <ul style="list-style-type: none"> <li><input type="radio"/> a. Red</li> <li><input type="radio"/> b. Yellow</li> <li><input type="radio"/> c. Green</li> <li><input type="radio"/> d. Cyan</li> </ul>	

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10.	Content organization can be categorized into intra-arrangement and inter-arrangement. Which of the following does NOT come under inter-arrangement?	
	<input type="radio"/> a. Proximity <input type="radio"/> b. Similarity <input type="radio"/> c. Symmetry <input type="radio"/> d. Continuity	
11.	Refer to the web page on the right. Which of the following is/are used to enhance proximity?	 <p>The screenshot shows a university website with a blue header containing 'Search', 'Help', and 'Directories'. Below the header, there are several sections: 'DIRECTOR'S WELCOME' with links to 'Director's Biography', 'Latest News', 'Publications', and 'Campus Slide Show'; 'FOUNDATION PROGRAMMES' with links to 'Postgraduate Diploma in Education', 'Degree and Diploma Programmes', 'Physical Education and FP Special Programmes', 'Practicum', 'Special Training Programme (Mother Tongue)', 'Counselling and Development', and 'Group Endeavours in Service Learning (GESL)'; 'GRADUATE PROGRAMMES AND RESEARCH' with links to 'Masters Programmes', 'Doctoral Programmes', 'Research Scholarships', and 'Knowledge Horizon'; and 'PROFESSIONAL DEVELOPMENT' with links to 'In-Service Programmes' and 'Leadership Programmes'.</p>
12.	The colour scheme used in the graphic in Q11 is probably Split Complementary. What is the main advantage of this color scheme?	
	<input type="radio"/> a. The color gives a warm feeling. <input type="radio"/> b. Easy to attain a good harmony balance. <input type="radio"/> c. High degree of color contrast. <input type="radio"/> d. All of the above.	
13.	The figure on the right is confusing because	
	<input type="radio"/> a. there is insufficient background area. <input type="radio"/> b. black and white color are used. <input type="radio"/> c. the graphic is too small. <input type="radio"/> d. black is used as background.	
14.	Grouping similar objects together tend to help learners	
	<input type="radio"/> a. produce a sense of organization. <input type="radio"/> b. associate a meaning for the arrangement. <input type="radio"/> c. interpolate the pattern of presentation. <input type="radio"/> d. arrange the intra-relationship of objects.	



## APPENDIX H

15.	<p>Symmetrical objects tend to stand out against</p> <ul style="list-style-type: none"> <li><input type="radio"/> a. dull background.</li> <li><input type="radio"/> b. text-based background.</li> <li><input type="radio"/> c. irregular background.</li> <li><input type="radio"/> d. graphic-based background.</li> </ul>	
16.	<p>How do we make the users see circles alternating with squares in the figure on the right?</p> <ul style="list-style-type: none"> <li><input type="radio"/> a. Increase the space between each row</li> <li><input type="radio"/> b. Increase the space between each column</li> <li><input type="radio"/> c. Lighten the color of the circles</li> <li><input type="radio"/> d. Lighten the color of the squares</li> </ul>	
17.	<p>You can easily recognize the pattern from the figure on the right mainly because of</p> <ul style="list-style-type: none"> <li><input type="radio"/> a. similarity</li> <li><input type="radio"/> b. proximity</li> <li><input type="radio"/> c. closure</li> <li><input type="radio"/> d. continuity</li> </ul>	
18.	<p>How well we can complete missing parts of a pattern (e.g. the word on the right) is largely dependent on</p> <ul style="list-style-type: none"> <li><input type="radio"/> a. the figure-ground contrast of the parts.</li> <li><input type="radio"/> b. the probability of guessing.</li> <li><input type="radio"/> c. our past knowledge of a similar word.</li> <li><input type="radio"/> d. our ability to learn new word.</li> </ul>	
19.	<p>We have a preference for continuity means we</p> <ul style="list-style-type: none"> <li><input type="radio"/> a. have a natural inclination to interpolate.</li> <li><input type="radio"/> b. like description to be smooth flowing rather than intermittent.</li> <li><input type="radio"/> c. like objects that have continuous arrangement.</li> <li><input type="radio"/> d. want to see information on one single page rather in several pages.</li> </ul>	

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20.	<p>You don't find a mistake easily in the figure on the right because of our inclination for</p> <ul style="list-style-type: none"> <li><input type="radio"/> a. long sentences.</li> <li><input type="radio"/> b. upper case words.</li> <li><input type="radio"/> c. proximity.</li> <li><input type="radio"/> d. closure.</li> </ul>	
21.	<p>When arrows are used to provide association between objects in a chart, _____ lines are preferred.</p> <ul style="list-style-type: none"> <li><input type="radio"/> a. angled</li> <li><input type="radio"/> b. thick</li> <li><input type="radio"/> c. curly</li> <li><input type="radio"/> d. smooth</li> </ul>	
22.	<p>I see _____ from the figure on the right. This is due to our preference for _____.</p> <ul style="list-style-type: none"> <li><input type="radio"/> e. a shape of a cross</li> <li><input type="radio"/> f. a shape of a cross</li> <li><input type="radio"/> g. four "V" shapes with apexes joint together</li> <li><input type="radio"/> h. four "V" shapes with apexes joint together</li> </ul> <ul style="list-style-type: none"> <li><input type="radio"/> e. closure</li> <li><input type="radio"/> f. continuity</li> <li><input type="radio"/> g. closure</li> <li><input type="radio"/> h. continuity</li> </ul>	
<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 5px 10px; background-color: #f0f0f0;">Submit your response</div> <div style="border: 1px solid black; padding: 5px 10px; background-color: #f0f0f0;">Opt out</div> </div>		

Thank you.

## Perception of Learning Scale

<b>Instruction</b>	The items below are for finding out your perception on the multimedia lesson you have learnt. The information collected will be used strictly for our study only. We will ensure the confidentiality of the information. Please feel free to opt out by using the button below if you do not wish to take part in this survey. Otherwise you may begin by entering your answers to each item shown below. Please note that you will not be disadvantaged for not taking part in the survey. Thank you.	
<b>Student No:</b>	<input type="text"/>	
1.	<p>I learn a lot from the lesson.</p> <p> <input type="radio"/> Strongly Disagree             <input type="radio"/> Disagree             <input type="radio"/> Somewhat Disagree             <input type="radio"/> Somewhat Agree             <input type="radio"/> Agree             <input type="radio"/> Strongly Agree         </p> <p>Please tell us the reason for your choice:</p> <div> <div></div> <div> <div></div> <div></div> <div></div> </div> <div> <div></div> <div></div> </div> </div>	
2.	<p>I like the presentation of the lesson.</p> <p> <input type="radio"/> Strongly Disagree             <input type="radio"/> Disagree             <input type="radio"/> Somewhat Disagree             <input type="radio"/> Somewhat Agree             <input type="radio"/> Agree             <input type="radio"/> Strongly Agree         </p> <p>Please tell us the reason for your choice:</p> <div> <div></div> <div> <div></div> <div></div> <div></div> </div> <div> <div></div> <div></div> </div> </div>	
3.	<p>The lesson is interesting.</p> <p> <input type="radio"/> Strongly Disagree             <input type="radio"/> Disagree             <input type="radio"/> Somewhat Disagree             <input type="radio"/> Somewhat Agree             <input type="radio"/> Agree             <input type="radio"/> Strongly Agree         </p> <p>Please tell us the reason for your choice:</p> <div> <div></div> <div> <div></div> <div></div> <div></div> </div> <div> <div></div> <div></div> </div> </div>	
<input type="button" value="Submit your response"/> <input type="button" value="Opt out"/>		

Thank you.

## APPENDIX J

### **Suggested Answers for Scoring the Final Version Performance Quiz**

Table J.1 Suggested Answers for scoring items in the Final Version Performance Quiz

Item No.	Suggested Answer	Item No.	Suggested Answer
1	c	12	c
2	b	13	a
3	a	14	b
4	c	15	c
5	a	16	a
6	b	17	a
7	b	18	c
8	a	19	a
9	b	20	d
10	d	21	d
11	d	22	b