# Using Anchored Instruction to Teach Pre-service Teachers to Integrate Technology into Primary Science Education

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## Abstract

*John Dewey's (The Essential Dewey, Vol. 1, University of Chicago Press, Chicago, IL, 1902) proposed that rich and engaged learning requires teachers to "psychologies" their subject-matter.*

*However, this task has proven to be too challenging for pre-service teachers to undertake seriously and widely. In this study, we asked pre-service teachers to design instructional materials using the anchored instructional model so as to empower them with the powerful methods and ideas to make learning science more meaningful to elementary students. According to Bauer, Ellefsen, and Hall (1994), anchored instruction "is a model that can be applied to any grade level or content area. It can serve as both a context within which teachers can practice what they have learned about technology and science education together, seamlessly, in one assignment.*

*A cohort of 77 pre-service teachers from the National Institute of Education in Singapore was involved in this study. Data collection and analysis were conducted through pre and post questionnaires and one-to-one interviews with pre-service teachers. The findings indicated that incorporating anchored instructional approach, as one of the course assignment, enhanced the teachers' skills in technological applications in teaching and learning and also improved their content and pedagogical content knowledge in teaching elementary science. The use of anchored instruction as an assignment in this course had provided a model for the pre-service teachers to apply anchored instruction when they are teaching science in their own classroom.*

## 1. Introduction

Recent research indicates that prospective teachers have difficulty developing opportunities for their students to learn science content in meaningful ways (Putman & Borko, 1997). In a nutshell, their subject-specific pedagogy (McDiarmid et al., 1989) or pedagogical content knowledge (PCK) is limited. The construct of PCK acknowledges that teaching for understanding is a complex cognitive activity that requires the transformation of teacher knowledge from diverse domains, including subject matter knowledge, pedagogical knowledge, and knowledge of context (Grossman, 1990). PCK refers to a teachers' unique knowledge to create learning opportunities that make particular content more comprehensible to others. Such learning opportunities may include metaphors, demonstrations, activities, investigations, and examples that are tailored to the needs of particular groups of learners. The purpose of this study was to qualitatively explore the effects of the anchored instruction assignment, given to first and second year pre-service science teachers, on their beliefs about science teaching, instructional decisions, and changes in beliefs which occur throughout the course. This study will be analysing on two areas, one was placed on content representation while the other is on pre-service teachers' epistemology or their beliefs about how knowledge is constructed and evaluated.

According to Grossman (1990), the development of PCK can be conceptualized into 5 components:

(1) Orientations to science teaching

(2) Knowledge of students' understanding of science topics

(3) Knowledge of science curriculum

(4) Knowledge of instructional strategies for teaching science

(5) Knowledge of assessment in science.

This model is useful in terms of identifying the subset of ideas referred to here as content representations. Magnusson et al. (1999) referred to one aspect of content representation as knowledge of topic-specific instructional strategies, which includes both representations (e.g., analogies, models, examples), and activities (e.g., demonstrations, experiments, investigations) that support student learning. Knowledge of topic-specific strategies includes understanding the strengths and weaknesses of various representations and activities with respect to supporting learning, as well as the ability to create and sequence them in such a way as to scaffold students' developing understanding of science concepts.

There is also a growing recognition in research about the important role the students' epistemology play in helping them construct knowledge. In this study, students' epistemologies can be understood as their beliefs or views about how knowledge is constructed and evaluated. Questionnaires, interviews and the pre-service teachers anchored instruction reflections were used to study the pre-service teachers' epistemology. These data together with additional ones from the anchored instruction presentations (that were videotaped) and anchored instruction package resources (that were submitted for the assignment) were used to study pre-service teachers' development in content representations. Given the importance of discourse in meaning-making by students, there is a need to allow students to discuss at least in pairs their ideas and thoughts about the topic and ways to implement these ideas. The importance of collaboration in society, schools and other educational forms provide a rationale for designing their AI assignment in pairs rather than individually. This assignment has provided these pre-service teachers a unique opportunity to apply the educational theories they have learnt into practice in a meaningful and contextualize way that allowed them to exhibit different forms of creativity not widely observed in the other assignments in other science courses.

In this study, multiple forms of data were collected. This includes audio-taped interviews, written documents and videotaped anchored instruction presentations. By analysing multiple forms of data, the researcher hopes to begin to answer three questions related to the anchored instruction assignment:

(1) What is the effect of Anchored Instruction (AI) on the pre-service teachers' content knowledge and PCK?

(PCK would be monitored through the development of content representations)

(2) How does their epistemological belief evolved through the process of this Anchored Instruction (AI) assignment?

(3) How might their epistemological preference (their use of words to describe on their learning in their reflections or questionnaire) relate to their gains in science content representations?

By examining these relationships, the researcher hopes to investigate if these Anchored Instruction (AI) assignments bring about higher gains in the pre-service teachers' science content knowledge, development in content representation and the development of the desirable forms of epistemological beliefs

## 2. Background and justification

The theoretical origins of the anchored instruction are strongly embedded in the theory of situated cognition. Situated cognition is an important theory concerning the nature of learning. The theory consists of important implication for the design and development of classroom-based instruction. It is also a learning theory that emphasizes and promotes real and authentic learning. In a situated learning environment, such as Anchored Instruction, learning of skills and knowledge occurs in a context that reflects how knowledge is gained and applied in everyday situations (Lave & Wenger, 1991). Whitehead (1929) exert that there were several problems attached to the traditional approaches to instruction which he termed as the inert knowledge problem. Inert knowledge that can be usually recalled when people are explicitly asked to do so, fails to be used spontaneously in a problem solving situation. Information transmitted in schools was likely to be presented in ways that make it inert (Simon, 1980).

Brown et al (1989) have revealed through their studies that what is being learned cannot be separated from the integral part of what is learned. Situations might help to co-produce knowledge through activity. It is crucial for the learner to learn in real-life context whereby the science knowledge to be acquired would be embedded in the experiences of the learner, creating an opportunity for them to interact in the context of real life situation.

Situated cognition has its origins in the works of Gibson's theory of affordances and Vygotsky's socio-cultural and social learning theories. Gibson proposes that environment in which one interact consist of various affordances, which provide the cues that are necessary for perceptions of the properties of the environment. Vygotsky (1978) further proposes that social interaction plays a major role in the development of cognition. Vygotsky's socio-cultural theory contends

that an individual's development cannot be understood without reference to the social environment in which the individual is situated (Driscoll, 2000).

Researchers have characterized personal epistemological beliefs in several ways. Most include beliefs about how knowledge is constructed and evaluated and how understanding occurs. Studying epistemological beliefs is important because they influence motivation and affect the selection of learning strategies by the pre-service teachers. In particular, immature beliefs affect pre-service teachers' ability to integrate their understanding of science concepts. It may also affect the ways they evaluate their own learning. Hofer and Pintrinch (2002) call for more domain-specific research into epistemological beliefs and for it to be situated in a more naturalistic context. Part of this study, aims to fill this need for an epistemological research within the primary science context.

The work on anchored instruction derives from insights by theorist such as Dewey (1933) & Hanson (1970) who emphasized that experts in an area have been immersed in phenomena and are familiar with how they have been thinking about them. When introduced to new theories, concepts and principles that are relevant to their area of interest, the experts can experience the changes in their own thinking that these ideas made. For novices however, the introduction of concepts and theories often seemed like the mere introduction of new facts or mechanical procedures to be memorized. As novices have not been immersed in the phenomena being investigated, they are unable to experience the effects of the new information on their own understanding. One main advantage of anchored instruction package is that the context is usually a visual format rather than text. The visual format allows students to develop pattern recognition skills. Videos allow a more veridical representation of events than texts; it is dynamic, visual and spatial; and students can move easily from rich mental models of the

problem situations (Johnson-Laird, 1985). This is particularly important for low achievement students and for students with little knowledge in the domain of interest (Bransford, Kinzer, Risko, Rowe & Vye, 1989). Another reason for using videodisc technology is that it has random access capabilities. This allows teachers to almost instantly access information for discussion (Sherwood et al; 1987). Since the primary goals of Anchored Instruction (AI) is to help students explore the same domain from multiple perspectives, the random access capabilities are particularly useful for our work. Despite a widespread enthusiasm for video technology in teacher education and a great deal of use of anchored instruction packages designed by experts for the primary science level, very few teachers, especially in Singapore, had embarked in using them as they perceived these materials as irrelevant to the Singapore primary school curriculum.. Relatively little systematic research has been conducted on the feasibility and effectiveness of Anchored Instruction on teacher education. Much of the research that is available on educational application of video technology is focussed on the use of video in primary and secondary schools or in business and industrial training rather than in teacher education. Much less research puts the tasks of designing these AI packages into the hands of the pre-service teachers rather than the instructors or lecturers of the course.

## 3. Methods

*Program Context*

The participants in this study were members of a cohort of 77 pre-service teachers who would be teaching science to primary schools students. These pre-service teachers came from both the diploma and undergraduate teacher preparation programme and postgraduate teacher preparation programme at the National Institute of Education in Singapore. The goal of this programme was to enhance the teaching of science at the primary level. An important feature of this programme was the common AI assignment that every pre-service teachers in the course need to complete to get through the course. As the pre-service teachers were introduced to issues of subject-specific pedagogy, learners and classroom learning environments through the process of completing their AI assignment, they were further supported with pair work and feedback sessions from peers and the tutor.

Pre-service teachers were informed during the course lectures and tutorials that their main objective in designing the AI package was to allow their students to attain first- hand experience, learn what it means to develop from a novice learner in science with only one point of view to an expert who is able to interact with different views in the environment.

Pre-service teachers worked in pairs to complete this assignment in an attempt to foster an environment of collaboration and support. These prospective teachers received guidance not only from their partners but also from their tutors who would discuss content ideas and potential resources to be used in their anchor videos. Each anchor video the pre-service teachers produced was between 5 to 10 minutes and each ends with a complex challenge. To make the video more appealing and authentic, most of the story lines were crafted to have the look and feel that primary school students can relate to, where most of the information the students needed to

solve the problems was contained in the story. Pre-service teachers were expected not only to design an anchor video with a believable story line with interesting characters and a complex and important challenge, they also had to create an extension to relate their video to a variety of subject areas. To solve each video, students (or the target audience) are required to apply scientific concepts and employ problem-solving skills. The knowledge that is being learned is often viewed as a tool to accomplish the task and the learner sees it as a valuable knowledge that can be applied to new situations. Dewey (1933) noted that when people learn knowledge as a tool, they learn what it is and when and how to use it.

For this AI assignment, pre-service teachers were expected to hand in the following items in their package:

(1) A 5 to 10 minute video clip or slide show that shows a problem the pre-service teachers want their students to solve or be able to generate solutions.

(2) A write up (about 1000 words) based on the lesson package. The text should include:

- Detailed lesson plan; with details on the target group of the users and how supporting resources are used
- The framework and rationale of the problem suggested

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(3) Reflection of the anchored instruction package (about 1000 words)[Individual work]
The following are guiding questions for the reflection:

- What are the challenges you have encountered in the design of this package?

(the understandings of topics, content knowledge, technical issues, team working etc)

- What did you learn from this experience?

(the understandings of topics, content knowledge, technical issues, team working etc.)

- How do you think your Anchored Instruction package can achieve inquiry-based learning?
- In what ways can your Anchored Instruction package be improved?

The pre-service teachers' AI assignments were graded in the following areas

**(1) Anchored instruction video/slide and supporting resources** [Pair work](15 marks)

**(2) ICT presentation** [Pair work] (10 marks)

**(3) ICT report** [Pair work] (10 marks)

**(4) Reflection of anchored instruction package** [Individual work] (10 marks)

The details of the rubrics are listed in Table 1. In this course, there are other components that make up to the total marks. Besides anchored instruction (45%), pre-service teachers also had to complete a test construction assignment (45%) and an e-learning reflection component (10%).

**Table 1: the overall marking scheme for anchored instruction which comprises of 45% of the total marks for this course**

| Components | Assessment Criteria | Max Marks |
|---|---|---|
| ICT Resources (15%) | 1. **Content**<br>▪ Appropriateness<br>▪ Relevant story line (logic of story line)<br>▪ Interesting/challenging problem-solving activity<br>▪ Sufficient information to solve the problem | 7 |
| | 2. **Quality of video/slides**<br>▪ Effective use of technology to highlight the concept<br>▪ Good graphics, layout and colours used in video/slides<br>▪ Good videography/slides and sound quality | 6 |
| | 3. **Overall Creativity** | 2 |
| ICT Presentation (10%) | **Introduction**<br>Intended Objectives and Process Skills, Concepts, Level/Stream, Teaching Methods, Teaching Materials<br>• Clarity<br>• Cohesiveness | 3 |
| | **Illustration/Demonstration of ICT package**<br>• Appropriateness<br>• Interesting/challenging activity<br>• Effective use of technology to highlight concepts<br>• Effectiveness of explanation<br>• Solutions to the problem-solving activity | 5 |
| | **Overall presentation**<br>▪ Flow of presentation<br>▪ Communication skills | 2 |
| ICT Report (10%) | **Introduction**<br>▪ Rationale and framework of the problem-solving activity.<br>▪ The Process Skills, Concepts, Level/Stream, Teaching Methods, Teaching Materials, Solutions related to the problem-solving activity | 3 |
| | **Lesson Plans**<br><br>Lesson should include:<br>▪ Lesson objectives, Target audience/Users, Prior knowledge, Media/Resource materials, Lesson developments, Time allocation, and how the supporting resources are used | 5 |
| | **Overall Organisation** | 2 |
| ICT Reflection (10%) | **Effectively applies scientific concepts/principles** | 4 |
| | **Effectively demonstrates science process skills and integrated processes** | 3 |
| | **Effectively shows depth and clarity of communication** | 3 |
| | TOTAL | 45 |

*Study Design*

Qualitative case study design provided the framework for this study (Merriam, 1988). The approach was descriptive and interpretive, and sought to examine meaning in context. The case was bounded by several parameters, including the sub-constructs of content representation of a single pair of pre-service teachers and their evolving epistemological preferences throughout the semester.

Qualitative case study design guided data collection, organization and analysis. Multiple forms of data, including audio-taped interviews, written documents and videotaped anchored instruction presentations were collected. Data on pre-service teachers' content representations were analyzed for their accuracy, sequencing, and connectedness, as well as their attention to the needs of their target audience (learners). Improvements in content representations were noted after the feedback session from both peers and the tutor (the researcher) that was given after the pre-service teachers had done their Anchored Instruction (AI) presentations.

*Participant Selection*

Two pairs of pre-service teachers were purposefully selected as the subject of this case study for several reasons. The first pair collaborated well, meaning that both contributed fairly equally and substantively to the AI assignment. The second pair however did not collaborated well and there is a strong connection to the epistemological beliefs of the pre-service teachers in the pair. Both pairs however were candid about their thinking and experiences and were willing give an interview.

*Data sources*

Multiple sources of data associated with prospective teachers' content representations and their epistemological beliefs were collected across the semester (between July till October 2008) for purposes of triangulation (Merriam, 1988). Primary source of data comes from pre and post questionnaire, individual reflection and one-to-one interview. The AI presentations were video-taped as another source of data. In addition, pre-service teachers AI package resources were used as secondary sources of data.

*Data Analysis*

Data were analyzed in several phases. First, the pre-questionnaire was administered before anchored instruction was taught to the pre-service teachers. Questions asked were intended to sieve their prior knowledge about this model and the perceptions of pre-service teachers towards the anchored instruction assignment. This is followed by participant selection, one-to-one interview and video-taping the AI presentation. The audio taped interviews and videotaped AI presentations were transcribed. For each phase, data would be reviewed for content representation and epistemological beliefs issues.

*Role of the Researchers*

The researcher of this study had special knowledge of the participants deriving from their interactions with them. This researcher serves as the participants' tutors in their tutorial classes for this course. The researcher is also the coordinator for the course, so she had the first hand experience to review and redesign the structure for the assignment for this course with close collaboration from the other tutors in this course.

## 4. Results

Our research findings are encouraging, but it is important to note that the student teachers gained valuable knowledge and skills not just by crafting the AI package but also through discussion with their partners and plenty of discussions with the tutors. We used several examples of science anchored instruction package to help student teachers see the thinking processes that need to be involved in their package in getting their students to solve a complex problem. Student teachers finally understood the required framework for Anchored Instruction lesson that requires effective teaching coupled with the video context, rather than the video alone.

*Measuring Pre-service responses to Anchored Instruction*

As the details of the assignment requirements for the course was being explained, pre-service teachers were given the pre-questionnaire to sieve their prior knowledge and perceptions about anchored instruction. Immediately after completing their assignments, the researcher conducted the post-questionnaire to assess the changes in perception toward this AI model and the insights or difficulties they might have faced in the process.

**Table 2a/2b Pre-evaluation questionnaire on anchored instruction**

| | QUESTIONS | (77 pre-service teachers)<br>Remarks of the responses to the questions that are being analysed | |
|---|---|---|---|
| 1. | Do you know about the anchored instruction model? How is this type of instruction the same or different from the way you have been integrating ICT into your previous science lessons? | Shows a clear understanding of the anchor instruction model | 24% |
| 2 | What do you think are qualities of a good SCIENCE INQUIRY lesson that is integrated with ICT? | Shows understanding in the science inquiry framework | 39% |
| 3 | Do you feel that the Anchored Instruction (AI) assignment in this course is too demanding? If so, what makes you feel that way? | Perceived that Anchored Instruction is too demanding | 26% |

**Table 2b Pre-evaluation questionnaire on anchored instruction**

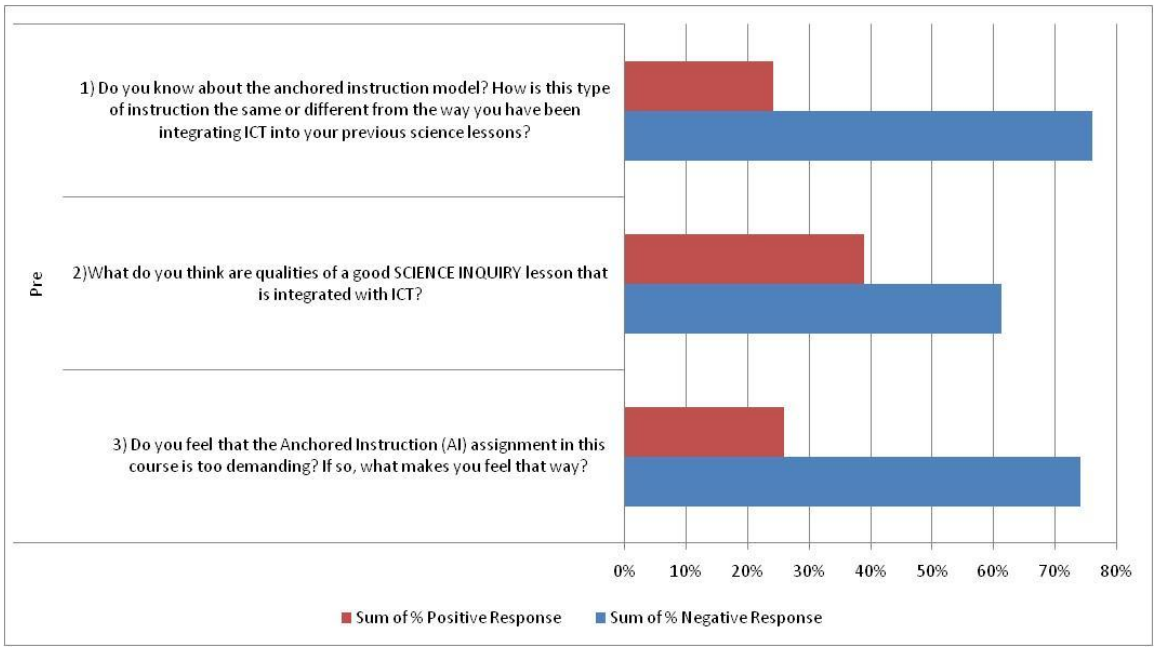


**Table 3a/3b Post questionnaire on anchored instruction**

| | QUESTIONS | (77 pre-service teachers)<br>Remarks of the responses to the questions that are being analysed | |
|---|---|---|---|
| 1. | What is your opinion about using this anchored instruction (AI) model to integrate ICT into primary science? | Positive opinion about AI model | 91% |
| 2 | How does your Anchored instruction (AI) package help primary school students understand the science concept/topic better? | Deep understanding in the benefits of AI | 83% |
| 3 | How does this Anchored Instruction assignment help you understand science inquiry better? | Positive co-relation b/n AI and science inquiry | 76% |
| 4 | What have you learnt (such as science content knowledge, pedagogical or technical skills) as you were designing/crafting your anchored instruction (AI) package? | Desirable epistemology about science learning through the descriptive language used | 87% |
| 5 | What are the benefits or limitations of having this assignment done as PAIR WORK? | Social construction of knowledge being highlighted and valued | 88% |

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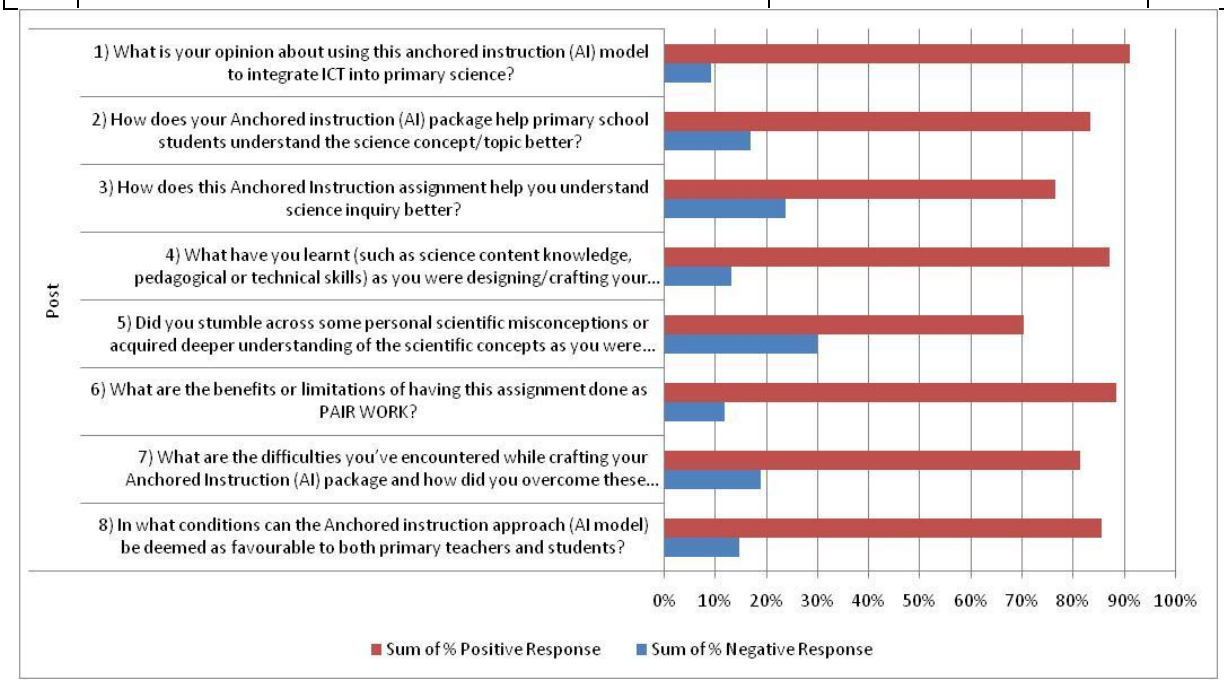
|---|---|---|---|
| 6 | What are the difficulties you've encountered while crafting your Anchored Instruction (AI) package and how did you overcome these difficulties? | The acknowledgement that learning new knowledge and skills can be challenging but are necessary processes in learning | 81% |
| 7. | In what conditions can the Anchored instruction approach (AI model) be deemed as favourable to both primary teachers and students? | Understanding of the importance of the learning environments is observed | 86% |




In general, most pre-service teachers felt more confident at the end of the assignment due to the pair work. Some even cited that "Two brains are better than one". They also learnt from each other, while discussing and debating over the science concepts and the storyline for the anchor video, the pre-service teachers realize their misconceptions or their surface knowledge they had, in the science topic they were give. This motivated them to delve deeper into the content and the pedagogical aspect of anchored instruction. Pair work assignment helps to cultivate team work as the pre-service teachers had to meet, brainstorm and work together for a common assignment. There was also an apparent increase in the quality and student motivation in comparison to the previous year's cohort (2007) when paired work was not implemented. Feedback from pre-

service teachers who did not feel that they benefit from the pair work consisted of a list of problems that are rather common in many pair testing assessment format. In most cases, one of the pair is a sleeping partner, thus the pair testing will not encourage shared learning and thinking. Some pairs were not able to agree on many areas and they spent so much time debating over matters that they could not complete their assignment effectively on time for the AI presentation.

Most pre-service teachers admitted the wealth of skills they have acquired especially related to technological skills as they were trying to use Movie Media player or other alternative software to edit their videos. This assignment actually "forces" them to learn these technical skills that would certainly come handy as they would be teaching "digital natives" students.

The researcher also noted, through her observations that during the process of focusing on everyday cognitive problems, the pre-service teachers were struggling because being novice teachers; they had little chance to develop their pedagogical skills and expand their content knowledge. Some of the other tutors in the course were sceptically at the beginning of the course and they raised the question of whether it was reasonable to assume that the novice would be able to acquire all those skills, including the technological skills in such a short period of time. However, based on the questionnaire analysis, most pre-service teachers took this difficult as a challenge and in pairs they learnt how to use the software and delve into the science content within the time constrain to produce impressive anchor videos, slides or animation.

Table 4 shows some inputs taken from the participants' questionnaires and reflections on the possible areas pre-service teachers felt that they had gained some conceptual knowledge and

pedagogical content knowledge on their science topics through the process of completing their AI assignment:

**Table 4**

| Inputs | Comments |
|---|---|
| (A)I used to think that if someone swallowed "a chewing gum", it will stay in their body for 7 years. After some discussions, I realised that this is a popular myth. My partner on the old hand thought that chewing gum CAN be digested due to the acid in the stomach. Only after our discussions, and research into this topic, was I able to convince her, this is not true. | *This pre-service teacher had shown greater comprehension in her content for her science topic on the digestive system. Through her first stage of research, she was able to sieve the "myth" about the chewing gum staying in the body that she had believed.* |
| (B)I thought it as easy to make a Newton disc so that when we spun it at high speed it will appear white. However, when I've made mine, it appears brown. I realised after consulting my tutor that the shades of the rainbow colours and the lack of speed in the spinning had led to this result. I had to think of alternative ways to bring out this idea. I used my background in designing software to bring out the idea my partner and I had for our video. | *This input had shown how the pre-service teacher's realization the importance of attending to details during scientific experimental set-up. There seemed to be kind of creativity that emerged through this difficulty he encountered that led to some changes in the original story-line intended (Stage 4). This is an example of transient experiential learning as the pre-service teachers were deeply involved in the design of their anchor video.* |
| (C)I have found out that some topics can be linked to other subjects such as Social studies, English, Art of even National Education. I've linked mine | *In order for the pre-service teachers to design an anchor video with more than one solution, they needed to not only understand the topic, but also understand it in several ways. This pre-service* |

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| on water cycles to National Education | *teacher had learnt how to be flexible in her design to relate the given concept to other topics in primary science and to the topics in other subjects as well. The reason simply being that it is rather difficult to have multiple perspectives with several solutions without doing so.* |
| (D)I've realised the urgent need to link the world problems to the Science topics we are teaching in schools. As I researched deeper into my topic on "Plant Reproduction", I came across the urgent world problem of Colony Collapse Disorder. | |
| (E)The metal that we tried to scratch using a nail did not scratch and when we find out, it is due to the fact that the nail was a weaker metal. As such, we need a stronger metal to scratch a weaker metal. Another misconception that surfaced as we did our research on our topic was the confusion we had between strength and hardness. | *The benefits of experiential learning is evident here. Only through experimenting with materials the pre-service teachers had prepared themselves, were they aware of the different hardness in metals.* |
| (F)We had attained a deeper understanding of the topic. I realised that energy is not just kinetic or potential energy. We also begin to appreciate the reasons why energy is important to us before we begin to teach the topic on Energy. | *In order to transform knowledge into "tools" to solve a problem, the pre-service teachers needed a higher level of understanding in their topic. This gave them a purpose to read deeper into the content and think of ways on how to use this content in their everyday life.* |
| (G)The misconception I had was on "Cells". I thought that cells are just a part of the body and it does not combine to make a system. Our content knowledge had definitely increased as we researched more into the topic. | *Insights on certain "errors" in the scientific ideas was evident here. These insights will bring more awareness to pre-service teachers in the difference between the scientific concepts and the layman's concepts in science.* |

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|---|---|
| (H)I did not realise the connection between mouldy rooms and condensation. I did not realise the extent of damage condensation can cause. I've learnt much more in terms of my content knowledge and how to apply them to my everyday life. | *This pre-service teacher is learning the way to connect knowledge from different science topics to understand a certain phenomena. Upon interviewing her, she admitted that she did not realize that there could be a connection between condensation (physical science) with moulds (life sciences).* |
| (I)I thought that plastics are just plastics. I was not aware that the same materials can differ in properties. For example some plastics may be flexible, other plastics can be inflexible. | *Again, another example of "real scientific ideas" versus "perceptual scientific ideas".* |
| (J)Initially I thought doing water cycle is simple until I did some detailed research on how to bring across the information and how much to be given to the kids. At first, I thought water only comes from sea, rivers and lakes. I've discovered it can also come from plants and animals. It is not only that it can come down as rain, if the weather is too cold; it may come down as snow. | *Many pre-service teachers, like this one experienced this "aha" moments when they were doing this assignment. This new comprehension gained about the complexity of transforming knowledge into tools to solve problems would help them plan lessons of higher levels in thinking skills.* |
| (K)I learnt how a fuse and circuit breaker works and why they are important. | *In-depth comprehension gained in the subject matter.* |
| (L)I did acquire a deeper understanding on the principles of inertia. In fact, I've even questioned myself of the physics in the problem. The magician managed to pull out the table cloth | *Insights gained not only in relation to content matter but also with regards to the difficulty students might encounter in understanding this concept.* |

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| without moving the crockery on it. It was quite a brain wrecking experience trying to reason out and understand this concept. | |
| (M)I’ve learnt that there are many carnivorous plants that photosynthesized. I always had the misconception that they consume animals as they cannot undergo photosynthesis. | *Insights gained on certain common misconceptions related to plants. This pre-service teacher had not only discovered her own misconceptions, she would also be more sensitive about her students’ misconceptions when she’s teaching this topic.* |
| (N)I did not know that students were confused about cell growth in comparison to cell reproduction. Then I realized that both are referring to cells replicating, however growth will result in increase in mass and possibly size (of the same generation), while reproduction is the production of new cells for subsequent generation. | *Gained in pedagogical content knowledge. This knowledge is significant in determining the approach the pre-service teacher would take in designing her anchor video.* |
| (O)I didn’t know that the geo-magnetic North and South poles are different from the geographical North/South Pole. I learnt that the geo-magnetic poles will move 3 to 6 degrees off every day due to the molten lava | *This is a common misconception, even among students. Such insights would contribute to better scaffolding during the design of the anchor package.* |
| (P)I’ve gained a deeper understanding about cells. I thought that all animals’ cells in the diploid stage have 46 chromosomes like in humans. I’m aware that plants have different number of chromosomes. | *Similar to the above example, this is a common misconception, even among students. Such insights would contribute to better scaffolding during the design of the anchor package.* |

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|---|---|
| E.g. Tomato has 24 chromosomes in its diploid stage. However, I was not aware that a dog's cell has 78 chromosomes in the diploid stage. | |
| (Q)Through the process, I've learnt more about the concepts on grounding and lighting and how to apply this knowledge. | *Insights on the use of primary science knowledge in the everyday context.* |
| (R)Some metals can be scratched if a harder object is scratched against it. For example aluminium table top scratched by a steel nail. | *Awareness of the common misconception in the topic is essential in helping the pre-service teachers design their lesson more effectively.* |
| (S)I realised that only the nucleus of the sperm fuses with the egg in fertilisation (humans). | *Similar to the above example.* |
| (T)I found out that the flower can be dyed to many colours on different petals. | *In-depth knowledge on this topic will open up a wealth of understanding related to the topic.* |

Through the process of designing an AI package, the pre-service teachers were able to view science teaching as a form of comprehension and reasoning (rather than facts to be memorised) and they were able to transform their understanding of the science topics in a creative and meaningful problem-based story. The forms of transformation addressed here relate to the process wherein the pre-service teachers moved from personal comprehension to preparing for the comprehension of others.

Throughout this process, the pre-service teachers were constantly reflecting about their lesson, as evident in their inputs in the questionnaires and reflections. Pre-service teachers had highlighted their awareness of certain misconceptions related to their topics and a shift from the learner to a teacher's perspective in viewing the knowledge (see inputs in the above table). To achieve this level of understanding about teaching, pre-service teachers must be able to comprehend the subject matter for themselves and also be able to elucidate subject matter in new ways, reorganizing and partitioning it in a meaningful manner for their students to understand.

This anchored instruction assignment had also provided the pre-service teachers with the opportunity to practice "sound reasoning" through its constant reflection structure. Pre-service teachers were required to both think about what they had to do and ensure an adequate base of facts, principles and experiences to design their AI package. They designed their AI package based on this knowledge base. Through their reflections, the researcher could detect some evolving ideas of teaching of these pre-service teachers; that had been probed, shaped and tailored as they experienced designing an anchor video. Instead of just looking at the science syllabus and science textbooks for facts, these pre-service teachers had to transform the knowledge into "tools" to solve a problem in the anchor story. To do so, the pre-service teachers had to scrutinize the teaching materials and in the process discover certain alternative conceptions. Then, they had to structure their anchored instruction package into ways that make it more suitable for their targeted audience. As they ponder upon the question (problem in the anchor story), they were actually re-looking at the objective of the lesson.

**Table 5 shows the details of the stages the pre-service teachers had to take.**

| Stage | Action to be taken | Comments |
|---|---|---|
| 1<br>(Research) | -Mastering content of the topic given to ensure that the concepts to be used in the story are factually sound<br>-Research into the possible alternative conceptions to the topic<br>-Research on areas related to the content and examples that highlight the concepts in the topic | In-depth reading about the topic given that need to be above the primary level to be taught.<br>To identify the relationships of this topic to the other areas. |
| 2<br>(Analyze surrounding) | -Searching for meanings in the content that students could relate to<br>-Developing a story around that meaning with special focus on the problem, embedded data and distracters<br>-Sharing of skills from story-boarding to IT-skills | During this stage, the facilitator needs to provide a platform for the student teachers in the class to discuss. Student teachers will be asked to share with their classmates some IT skills that they might need to make the anchor video. |
| 3<br>(Adding scaffolds) | -Building scaffolds in between the anchor video to "mediate" students' learning process. | Adapting the lesson to students of different abilities by using multiple representations within the anchor video and during the supporting activities linked to the video. |
| 4<br>(Writing scripts, shooting & editing the video) | -Gaining some experiential experience during the process of shooting the video<br>-Adapting certain parts of the story in view of the restrictions it imposed to them in the "real world"<br>-Searching for sounds and other inputs to make the multimedia learning more exciting and meaningful | Real experiential learning that brings science alive. Many pre-service teachers were pleased with the insights they had gained through this stage. Insights include the joy of experiential learning and the understanding gained through the process of integrating topics or subjects. |
| 5<br>(Searching for transcendence) | -Searching for a "global" application using the same concepts or understanding but in a different context. | Example: In a video about the mystery of the dying goldfish, the student teachers linked it to the effects of pollution on the ocean animals. |

Most pre-service teachers who participated in this study, had established a semantically rich, shared environment (see Stage 2 in Table 5) that allowed them to understand on ways to contextualize the knowledge into their students' world. As they were doing so, these pre-service teachers experienced the effects this new knowledge has on their perception and understanding of science in their environment. In this process, the researcher noted a significant improvement of the pre-service teachers content representation development and epistemology preference towards learning science. Through this process, some pre-service teachers were able to "see" how new knowledge can function as tools. This insight would guide them through as they plan other classroom instructions for their class science lessons. These pre-service teachers are able to view new knowledge as tools that shape their students' perception and comprehension rather than as mere facts to be memorised. However, there were also pre-service teachers in this study

who had progressed in their development in content representation in science and similarly their epistemological beliefs did not progress toward the desirable epistemological belief. This desirable epistemological belief would be referring to the pre-service teachers perception on how science knowledge is being constructed. The epistemological belief the researcher hopes her pre-service teachers would attain would be the constructivist views of teaching and learning science. Based on the questionnaire, reflection and interview, the researcher could see a relationship between the degree of insights the pre-service teachers had gained based through the process of this anchored instruction assignment and the type of epistemological beliefs they adopt. This is outlined in Table 6.

**Table 6**

| High gainers with desirable epistemology | Average gainers with approaching desirable epistemology | Low gainers with low epistemology |
|---|---|---|
| Believed science knowledge is conceptual knowledge that need to be leading to acceptable scientific conceptions.<br>Their epistemology enabled them to choose a viable story-line and was helpful for them as they incorporate these concepts to the storyline in a meaningful way | Believed science knowledge is conceptual knowledge however, also believed that this knowledge is scientist knowledge that is only found in lab/rigid experiments taught in an explicit cook book manner.<br>Their epistemology made them design their AI package (in total or some parts of it) in a rather didactic and "documentary" style with little emphasis on the storyline. | Believed that science knowledge involved merely content and facts to be regurgitated. They associated science concepts with facts to be memorize or given as notes in worksheet form.<br>Their epistemology made them see science as complicated experiments and demonstration. They fail to see that conceptual understanding works best in a simple scenario that demands deep thinking. |

Designing the AI package gave insights to the pre-service teachers on how to present new information in a context of meaningful activities rather than an arbitrary set of procedures or facts. Most pre-service teachers believed that video technology can provide the rich context-based experiences needed for practicing the application of scientific skills. There were many reasons for their preference towards this AI assignment compared to the traditional technological integration package the earlier cohort had to do as part of their ICT infusion to primary science teaching and learning.

With the goal of providing context for primary school students to problem-solve, explore and apply their primary science concepts, these pre-service teachers had developed their “anchor” in pairs, a videodisc-based story, enriched with data and a complex problem that requires several steps to solve. They had written in their reflections that they had designed and produced their Anchored Instruction packages to provide a “macro-context” for teaching planning and problem identification. The macro-context is the problem-solving environment in which students must generate, as well as solve, several sub-problems in order to solve the larger overall problem.

Most of their videos, the problems were intentionally complex, reflecting the nature of problems experienced in everyday setting and the need to provide students with the opportunity to practice working with such problems.

Winn (1993) states that instructional designers are challenged by two issues when constructing instructional materials such as the AI packages, that are intended for situated learning environments. Firstly, they need to design instruction in a way that can help transfer the knowledge in various types of situations. Before the pre-service teachers can achieve this, they had stated in both their reflections and questionnaires that they realized their lack the depth in the content knowledge in the science topics they were allocated to. Most of them, did not realize that they had to upgrade their content knowledge beyond what is necessary for the primary science syllabus. Conceptual understanding and the ability in scientific reasoning provide a firmer foundation for effective teaching than the superficial learning of more advance material (Mc Dermott, 1990). As the researcher was scaffolding the pre-service teachers understanding of AI, she realized that most of them were struggling with the story-line for the anchor. They needed much guidance to understand the complexity of good stories, and they did so by focusing their attention on the characters, their motives for action and on conflicts that lead to attempts to solve the problems.

**Summary and Conclusion**

Imagine being a film writer and producer who need to produce a science anchor video with great scientific accuracy. First, the movie producers must do a great deal of research in order to evaluate their scripts. Second, a good movie writer needs to create interesting stories that comprise of interrelated sets of sub-stories. By analyzing what these are like in various movies, these "novice" producers begin to understand how to produce their own story with science embedded to it. Third, actions and dialogue in the movies need to be well-motivated, hence scenes related to science need to make sense from a factual perspective. Fourth, the scriptwriter needs to eventually write their own scripts. The fifth stage will involved the shooting of the video itself and the crew might encounter some difficulties and adapt to the situation. Last but not least, is the editing process whereby all the long hours of planning and shooting of the video are weaved beautifully into a meaningful package. These are the very steps the pre-service teachers had to do as they were completing the Anchored Instruction assignment. This assignment might be "laborious", nonetheless, the immense gains in learning pre-service obtained through this process made this assignment one was the assignments pre-service teachers found worth while doing.

The result of the data analysis suggests that pre-service teachers had shown some improvements in their content representation through this AI assignment. By analyzing the answers in the open-ended questions in the questionnaire and individual reflections, the researcher found a correlation between the students' conceptual gains and their ability to reflect on their learning. May and Etkin (2002) also used open-ended journals to investigate students epistemological self reflection to access pre-service teachers conceptual understanding and problem-solving ability. The more conceptual gains these participating pre-service teachers attained the better their development in content representation would be. Most of the low conceptual gainers tend to

write very little about how they learned. However, they were exceptions. In these exceptions, the participants may not have the quantity in their reflection, but their short reflection was of high quality.

From the AI resource packages submitted for the assignment, the researcher could also conclude that low conceptual gainers or pre-service teachers who had a limited level in their development of content representations were also more likely to design video with learning activities, problems or story lines that were epistemologically less desirable. As their focus would be more on learning from authority, their videos are designed in a didactic manner with limited story line. Furthermore, their videos lack the complex problems needed in an AI package to be able to develop the students' higher level thinking skills. However, most of these pre-service display an evolving epistemological belief as they view their peers AI presentations, especially from those who are "high conceptual gainers".

High conceptual gainers produced anchor videos that require their "audience" to reason and interpret their data and the designers showed more concern to the coherence of knowledge than their counterparts. A more extensive research is needed to verify these tentative relationships. However, there is a possibility, based on this exploratory case-study, that pre-service teachers with desirable epistemology would gain greater development in content representations compared to their counterparts.

**Implication for Instruction**

This study has shown the benefits of this Anchored Instruction assignment, on the pre-service teachers' conceptual development, pedagogical content knowledge and changes to the epistemological beliefs of these teachers. Most admitted that they have learnt more from this AI assignment, as it enables them to understand the meaning of scientific inquiry better, through the struggles the pre-service experience in searching for knowledge to use them as"tools" to design an AI package. There is also a pattern seen in the data. The degree or amount of gains depend on the epistemological beliefs the pre-service teachers brought in with them at the beginning of the course. Through this Anchored Instruction assignment study, it suggests to us a significant initial finding that as educators to prospective primary science teachers, we might be able to enhance our students' conceptual gains and development in content representation by encouraging appropriate epistemologies. More research is definitely needed to link together these three aspects of learning development in content representation, epistemology and self-reflection. The questions ringing in the researcher's mind is whether developing desirable epistemology and self reflection would enhance content learning, or should learning of science content be viewed as a "tool" or "vehicle" to develop desirable epistemologies and higher order thinking skills in our primary school, science, pre-service teachers. With science inquiry being introduced to our 2008 Primary Science syllabus in Singapore, the second choice is also equally, very important.

## 5. References


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