



Arguing Online: Case Studies of Pre-Service Science Teachers' Perceptions of Online Tools in Supporting the Learning of Arguments

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ABSTRACT

Argumentation as a form of scientific discourse has been advocated as a fruitful method in science teaching. Information and communication technology (ICT) has been proposed as a vehicle to achieve pedagogic objectives in scientific argumentation. However, ICT as a new tool is likely to be ineffective when other factors are not taken into consideration. The empirical study described in this paper aims to investigate the use of ICT to support teaching and learning of argumentation from the users' perspectives. Four science pre-service teachers training as teachers at a postgraduate certificate in education programme in England have been introduced to a computer software called Belvedere 4.1, a tool designed particularly for supporting argumentation. The participants were tasked to produce a concept map with Belvedere 4.1, and subsequently they were invited to comment on the utility of Belvedere. Interviews with the participants explored their personal factors, pedagogic beliefs and experiences of using ICT in general in their teaching practice. The results indicate that the external conditions will limit the possibility of the use of ICT to improve teaching and learning of argumentation. Both the design and the structure of Belvedere, as well as the participants' personal factors contribute to the usability of the tool.

Keywords: Information and Communication Technology; Belvedere; Pre-Service Science Teacher; Online Tools; Arguments.

INTRODUCTION

Over the past few decades, with advance of teaching and learning science as inquiry, researchers have promoted the “interpretative, cultural, and deliberate aspects” in learning science and encourage students to “sort out, evaluate, and organize diverse aspects of scientific phenomena” (Linn, 2003). A significant aspect of this line of research has been evidence-based argumentation (e.g., Driver, Newton & Osborne, 2000). For instance, Erduran and Jimenez-Aleixandre (2008), “reasoning becomes public and students are expected to explicitly back their statements with evidence and to evaluate alternative options or explanations” (p.7). According to Driver and colleagues (2000), scientific argumentation as discursive practices “...include evaluating evidence, assessing

alternatives, establishing the validity of scientific claims, and addressing counter-evidence” (p. 289). The recommendation is that argumentation be taught through suitable instruction, task structuring and modelling. Tools generated through information and communication technology (ICT) have been considered as promising in facilitating the teaching and learning of argumentation in science classes (e.g., Clark et al., 2008; Evagorou & Avraamidou, 2008). However, whether the use of ICT can achieve the designed objectives depends on range of factors, such as the context, the property of the tool and the user. Research reported here investigated how ICT tools could support the teaching and learning of argumentation in science classes from users’ perspectives.

a) Argumentation in Science Education

According to Erduran, Simon and Osborne (2004) “arguments concerning the appropriateness of experimental design, the interpretation of evidence, and the validity of knowledge claims are at the heart of science, and are central to the everyday discourse of scientists” (p.916). The development of argumentation is based on the philosophical and cognitive foundations and socio-cultural perspectives (Erduran, Simon & Osborne, 2004; Evagorou & Avraamidou, 2008). Firstly, contemporary perspectives in the philosophy of science emphasize that scientific theories are open to challenge and science progresses through argumentation rather than agreement. Secondly, argumentation, from a cognitive aspect, requires the public exercise of reasoning which involves students in externalizing their thinking and cultivating their critical thinking in a scientific context (Driver et al., 2000; Kuhn, 1991). Thirdly, from a socio-cultural perspective, argumentation can engage students in the appropriation of community practices including scientific discourse (Duschl & Osborne, 2002). Argumentation is a key element involved not only in the “scientific culture” of the citizen but more largely in a trans-disciplinary view of culture (Erduran & Jimenez-Aleixandre, 2008: p. xii).

Implementation of argumentation has been promoted to “account for the social practice of science or promote skills necessary for the evaluation and defence of scientific theories or findings” through science education (Sadler, 2006, p.329). Through discussing scientific issues in everyday life or debating the social problems scientifically, the essential ability in terms of decision-making and problem-solving would be developed to face the challenge and demands in daily life where social practices are constantly examined and reformed in the light of scientific evidence (Kuhn, 1993). Argumentation as an important component of scientific literacy is introduced into science class not only to cultivate students’ critical and scientific investigation skills and establish appropriate images of science but also to bring practical meaning for students’ development. “An effective science education program not only requires active involvement on the part of students in terms of scientific investigations, but also the development of discursive practices that enable students to apply their understanding of science to personal decision making and engage in public discourse about issues related to science” (Sadler, 2006, p.331).

Numerous studies have suggested that students have a number of difficulties while engaging in the process of argument construction (Bell, 2004; Reiser, 2004). Driver et al., (2000) attributed students’ failure in presenting good arguments to their lack of opportunity in the classroom to discuss ideas. The difficulties in practice are partially associated with the context of science education. The discourse in the school classroom focuses mostly on knowledge acquisition (Evagorou & Avraamidou, 2008). Teachers have also been found to face challenges to organize the teaching and learning of argumentation in science classes (Erduran & Dagher, 2007). Teaching argumentation challenges their pedagogic beliefs and content knowledge. Teachers tend to assume the role as authority

figures providing right answers rather than as facilitators and collaborators encouraging and guiding students to challenge and justify the statements (Simon, Erduran & Osborne, 2006). It is indicated in the literature that teachers tend to present knowledge as concrete outcomes and they don't have sufficient skills to help their students in learning argumentation (Simon, Erduran & Osborne, 2006).

b) ICT in Science Education

Substantial literature (e.g. Hennessy, 2006; Linn, 2003; Webb, 2005) indicate through empirical studies that ICT is a powerful tool that could facilitate instruction and engage students in critical and interactive learning in science classes. In terms of teaching and learning of argumentation in particular, the technology-based argument construction tools have been recognized for their potential advantages in supporting both teachers' instruction and students' learning. For example, Linn (2003) stated that ICT tools could help students to identify, connect and evaluate evidence for the purpose of supporting a point of view. Furthermore, the use of technology can offer a scaffold to teachers to support argumentation practices in their classrooms (Clark et al., 2008; Evagorou & Avraamidou, 2008).

However, whether or not the potential advantages offered by ICT tools could have an impact on learning environments is affected by both external constraints and internal resistance. For example, Hennessy, Ruthven and Brindley (2005) maintain that "[teachers'] evident commitment to incorporating ICT was tempered by a cautious, critical approach and the influence of external constraints operating" (p.165). The influence of the conditions beyond the teachers also needs to be taken into consideration when it comes to the use of ICT in the classroom (Cuban, 2001; Hennessy, 2006). Reiser (2004) pointed out that "the design of the tool itself is an important constituent in defining tasks" (p.282). Tool, in this case, refers to the ICT tool designed to support teaching and learning of argumentation in science class. The potential affordance of using ICT tools to support teaching and learning in argumentation in science class can be summarised as follows:

- Scaffold students restructuring their explanations and organizing more coherent and better supported causal explanations;
- Provide suggested structure of the process of investigation for students;
- Make students' thinking visible;
- Engage students in a group discussion;
- Facilitate teachers to exemplify the nature of science discourse.

Resier (2004) also maintained that the utility of the tool also relies on other factors such as teachers' expectations and class norms. As Conole & Dyke (2004) asserted, the affordance of ICT tools refers to the perception of what that technology makes possible/dis-allows. How teachers perceive the pedagogic use of ICT tools greatly influence what actually achieved by using of ICT (Webb, 2005). First, teachers' belief has been identified to contribute to their use of ICT in class. Moreover, teachers' competence and familiarity of ICT tools conditioned how they perceive the usability of new tools. Based on the research on pre-service teachers' technology-enhanced pedagogical content knowledge (TPCK), Niess (2005) proposed four strands to examine TPCK as following: (a) An overarching conception of what it means to teach a particular subject integrating technology in the learning; (b) Knowledge of instructional strategies and representations for teaching particular topics with technology; (c) Knowledge of students' understandings, thinking, and learning with technology in a particular subject; (d) Knowledge of curriculum and curriculum materials that integrate technology with learning in the subject area. In this research, participants' understanding of argumentation in science as their

specific subject content knowledge would be explored to examine the relation to their perception of the utility of the ICT tool. Niess attributed his participants' under-use of ICT in teaching to their limited experience of learning their subject within a technology framework.

c) Role of instruments and models in supporting teaching and learning of argumentation

Trouche (2004) defined an instrument as a tool in the sense that an instrument has both the objective property of a tool and subjective usability of the tool.

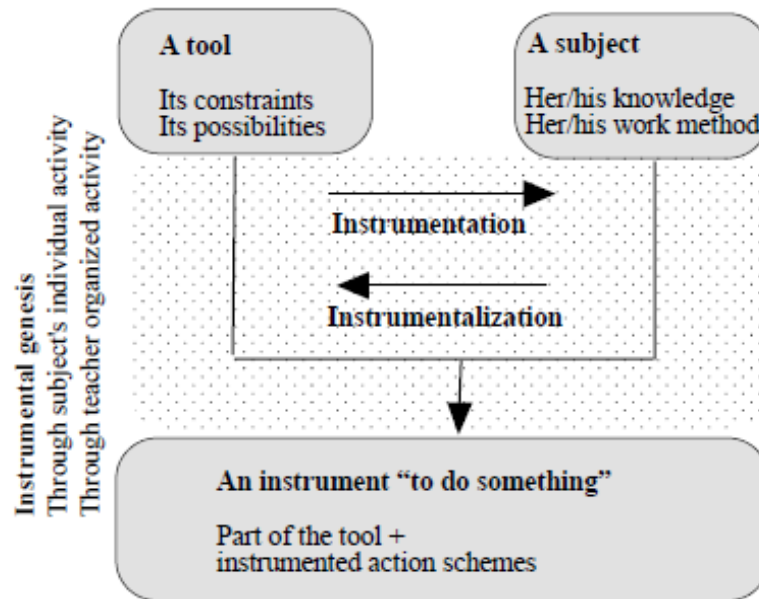


Figure 1. Instrumental Genesis As a Combination of Two Processes (Trouche, 2004, P.299).

As illustrated in Figure 1, there are instrumentation and instrumentalization processes in instrument theory, which show the human activity mediated by use of tools. The processes include both a response to the given tool through instrumentation (i.e. to understand what the tool is and how to use it) and an active reconstruction of the given tools through instrumentalization, (i.e. choose and adapt the tools to personal use). "By the instrumentalization of the artifact, subjects adapt and give form to the artifact proposed. By instrumentation, they will develop or adapt utilization schemes." (Rabardel & Bourmaud, 2003, p.688).

Toulmin's (2003) argument pattern (TAP) (illustrated in Figure 2) model has been used as a basis for characterizing argumentation in science lessons. For instance, Erduran Simon and Osborne (2004) have explained that "TAP illustrates the structure of an argument in terms of an interconnected set of a claim; data that support that claim; warrants that provide a link between the data and the claim; backings that strengthen the warrants; and finally, rebuttals which point to the circumstances under which the claim would not hold true."(p.918). Therefore, the analysis of argumentation concentrated on specific features: the extent to which students and teachers have made use of data, claims, warrants, backings, qualifiers, and rebuttals; and the extent to which they have engaged in claiming, justifying, and opposing the arguments of each other. The analysis also focused on the epistemic and argumentative operations; that is, their reasoning functions and strategies for constructing valid arguments (Simon, Erduran & Osborne, 2006).

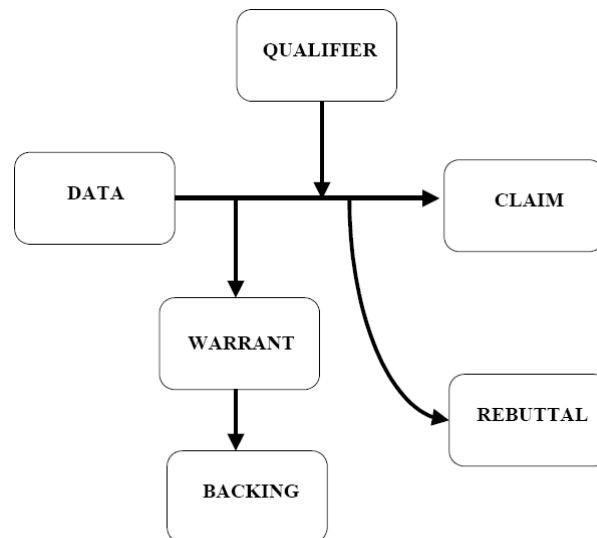


Figure 2. *Toulmin's Argument Pattern* (Toulmin, 2003).

Claims: Assertions about what exists or values that people hold.

Data: Statements that are used as evidence to support the claim.

Warrants: Statements that explain the relationship of the data to the claim.

Qualifiers: Special conditions under which the claim holds true.

Backings: Underlying assumptions that are often not made explicit.

Rebuttals: Statements that contradict either the data, warrant, backing or qualifier of an argument.

In the study presented in this paper, we have used an ICT tool, Belvedere software, to facilitate pre-service teachers' framing of arguments with reference to Toulmin's model of argument.

METHODOLOGY

a) Research questions

The research reported here aimed to explore pre-service science teachers' perceptions of how ICT influences the teaching and learning of argumentation. An ICT tool called Belvedere was used as an example in exploring the participants' perceptions. In particular, we addressed two research questions:

1) *What are the participants' perceptions of the pedagogic utility of using ICT in teaching argumentation in science classes?*

The empirical study explored the ways in which ICT could offer support in practice for users. In this case, how could Belvedere be used to support teaching and learning of argumentation in science classes from their perspectives? For instance, from student teachers' point of view, how might the software influence teaching and learning of argumentation? What were their concerns of implementing the software in their classes?

2) *What factors may influence the use of ICT?*

According to theoretical framework, related aspects in the context, tool and subject were explored in interviews with participants. For example, what are student teachers' views and experiences of using ICT in science classes? What are the design objectives of the tool? What are the conditions of implementation of argumentation in science class? What is the context of using ICT in science class?

b) ICT Tool

A knowledge presentation tool called Belvedere¹, which designed to support evidence based argumentation in science education has been introduced to participants. As the snap-shot² is shown in Figure 3, Belvedere offers ‘students visual "knowledge mapping" function to construct "inquiry diagrams"' (ibid). Informed by its designer, the designed pedagogic objective of Belvedere is³:

Cognitive development: inspire and guide students to offer explanation, reification and reflection of the claims or assumptions they hold

Social interaction: offer shared context for students to do shared activity such as negotiation and evaluation

According to Reiser’s (2004) scaffolding strategies, the designers of Belvedere proposed to scaffold the learning process 1) by constructing task in order to reduce the complexity due to the open-ended nature of task and 2) by problematizing to provoke students to think about what they usually neglected. The design of Belvedere geared to help learners improve skills and/ or understanding of content regarding argumentation in science in process: 1) It helps structure the task of problem solving. Provide structure and focus learners on important constituents of tasks such as argument structure; 2) It provokes learners to devote resources to issues they might not otherwise address, in this case refers to non-reflective work and superficial analysis.

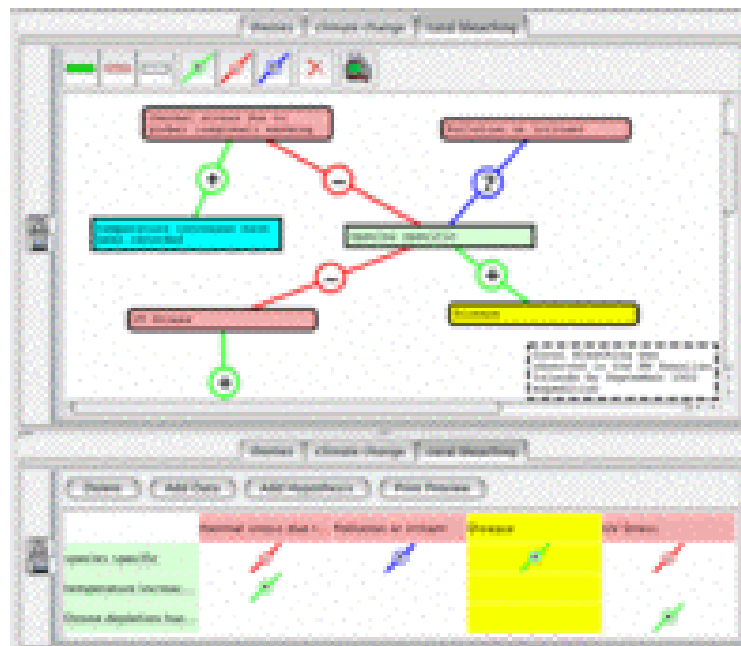


Figure 3. *Belvedere Software.*

The choice of Belvedere is based both on the validation concerns of representativeness and the practical issue of access. Since all of the participants did not know any particular software to support teaching and learning of argumentation, they would be introduced to the software in interview. Due to the participants’ limited available time of participation of the study, which requires the software should be straightforward

¹ <http://belvedere.sourceforge.net/> retrieved on 23/06/2008.

² <http://lilt.ics.hawaii.edu/lilt/software/belvedere/index.html> retrieved on 26/06/2008.

³ <http://lilt.ics.hawaii.edu/lilt/software/belvedere/knowledge-mapping.html> retrieved on 23/06/2008.

and easy to learn. Belvedere is open source software which offers free-download from the internet to teachers. Based on using experience of researcher (as a female post-grad student with common knowledge about ICT), it is easy to operate. Confirmed by pilot study with other post-grad students, Belvedere would be suitable for using in one-hour-interview. Moreover, introduced in Evagorou and Avraamidou's review (2008), Belvedere is one of tools to facilitate the construction of arguments and contributions. According to instruction on its website, "Belvedere 4.1 is designed to help support problem-based collaborative learning scenarios with concept and evidence models, and provides multiple representational views (tables and graphs) on those models. Belvedere was originally intended to help secondary school students learn critical inquiry skills that they can apply in everyday life as well as in science, but can be adapted to other applications as well."⁴ Specifically, Belvedere is designed to guide users to re-construct the argument through following functions:

- *Representation*: visually represent the structure of argument and relations between data and claim.
- *Linkage*: requires reference of the data or relations, such as url address.
- *Evaluation*: reliability of the data and relations represented by different visual effect.

c) The Participants

The four participants come from the PGCE science course in an English university that has been evaluated as top grade in terms of teaching quality by Ofsted 2007/08. At the time for the study, they had just finished their teaching practice of 20 weeks in total in two different local secondary schools. They had lectures in the university about argumentation in science and ICT courses which qualified them to use ICT in teaching. All of them have self-evaluated themselves as competent and confident users of ICT in teaching science. Details of the participants will be reviewed in conjunction with the interview data analysis.

Informed by case studies reported by Erduran and Dagher (2007), "teachers' existing knowledge and conceptualization of science teaching" should be taken into account. Therefore, the participants have been asked to write one argument on their own before interview to show their existing knowledge regarding argumentation. Moreover, to explore teachers' pedagogic beliefs in the potential of technology for facilitating teaching and learning in science, according to Hennessy, et al (2005; p.267), "teachers' commitment to integrating use of ICT and the perceived constraints operating in the working context" should be examined. This involves "identifying the key 'affordances' of using technology and describing teachers' caution and concerns about what accommodating its use may displace or threaten. (ibid, p.268)". Ertmer (2005) also maintained that teachers' perceptions and classification of ICT would result in vastly differences regarding when, and how to use the tool.

In addition, based on empirical studies, researchers (e.g., Ertmer, 2005; Athanassios & Vassilis, 2007; Matzen & Edmunds, 2007) pointed out that teachers' personal experience may influence their belief, including their understanding of the nature of subject and their personal beliefs about curriculum and instructional practice. Considering these perspectives, the participants have been asked to express their understanding of argumentation, their belief in science and science teaching, and clarify their perceptions of using ICT in science class, as well as exploring their related personal experience in interviews. Furthermore, researchers (e.g. Hennessy, 2006; Linn, 2003; Webb, 2005) asserted that the use of ICT varies on which tool has been used in what way and Johnson

⁴ <http://lilt.ics.hawaii.edu/lilt/software/belvedere/index.html> retrieved on 23/06/2008

et al (1998) have pointed out that task-centred analysis helps in investigating peoples' actions and procedures (including strategies) when carrying out tasks.

d) Methodological Approaches

Since both task context and educational context are important determinants of users' perceptions of educational technologies and effectiveness (Tolmie, 2001), case study methods have been employed (Cohen et al., 2000). Case studies focus on a case rooted in its context and aim to represent reality via giving a sense of 'being there' (Stake, 2000). Thus, case studies enable researchers to conduct in-depth portrayal and analysis of the complexity and situatedness of individuals and situations (Yin, 2003). However, the case study approach offers no inductive generalisations and may be influenced by the limited access to field. The research did not have the aim of generalising to all teachers' perceptions how the participants in this study perceived the use of ICT in teaching argumentation. Rather, the study aimed to provide an in-depth look at the qualitative aspects of student teachers' perceptions. In this study, we used Belvedere 4.1 and assigned specific task to participants in order to prompt their discussion of the perceived enhancement of subject learning and the qualitatively different experiences through use of Belvedere. The details of research design are as follows:

i) Pre-interview Task

Participants are assigned to build up one scientific argument within 150 words on their own before they attend the interview.

ii) Interview

We investigated the participants' beliefs of science and teaching science, opinions of argumentation in science classes and identify problems they met or perceive in practice; explored their perceptions of ICT tools and their experiences of using them. The interviews also explored their perception of ICT in argumentation; the affordance/constraints they have perceived of ICT; and how their pedagogic goal would be achieved or not with ICT. During the interview, we introduced Belvedere 4.1 and asked the participants to build one concept map of their argument with Belvedere 4.1. Finally we invited them to evaluate Belvedere 4.1. The interviews were audiotaped and transcribed. The participants pre-interview task responses and their concept maps generated by Belvedere were collected.

e) Data Analysis

Through comparisons cross cases, the potential factors or elements of influencing teachers' perceptions were identified. Both transcripts of observations and interviews were analyzed as the process of "data management, descriptive accounts, explanatory accounts" (Ely, et al., 1997; Lewis, 2003). The initial concept index was set after the interviews based on the research questions. Different from the grounded theory to generate the codes from the data (Ryan & Bernard, 2000), identifying coding and categorizing the primary patterns in the data (Patton, 2002) have been used in content analysis. The pre-determined categories are based on literature review. For example, according to the literature reviewed, the property of ICT tools would be explored from the aspects of whether or not it enriches presentation, it is easy-to-use and it is compatible to existing learning environment. The initial codes have been summarized as the following table:

Table 1. *Initial Codes*

Teacher factor		ICT factor	
ICT Competence of using IT Experience of teaching with IT Perception of using ICT in science classes	Argumentation Self-identification of science teacher Knowledge of subject Pedagogic belief	Technique Property Function Usability Interface Compatibility Adaptability	Argumentation Support Access to data Evaluation of data Argument construction

Subsequently the indexing of the transcripts has been carried out and the data have been sorted by theme and across individual interviews. After the summarizing and selecting of these data, the relations between the data were derived from interviews of what participants thought and why, and their concept maps have been explored. During this analysis, the codes have been modified and specific sub-categories emerged. As Lewis (2003) pointed out, codes and categories will be changing by the new discovering patterns and themes to judge about what is significant and meaningful in data. For instance, the themes of “presentation” and “visualization” have been repeatedly mentioned by the participants in commenting on Belvedere, and “future citizen”, “imbalanced” and “engagement” are also the codes stem from the transcription.

f) Case Studies

We cross examined the interview transcripts of participants’ opinions of Belvedere and their personal related factors in order to explore the relations among context, tool and subject. Before the detailing these relations, we will begin our discussion by describing the teachers’ to provide an extended overview of the participants.

Case 1: Sam

Sam is a male who majors in physics with experience of teaching before he took the PGCE course. His idea about the nature of science is that scientific knowledge is tentative.

Science is one of the ways to see the world...The way we see the world does change with increased knowledge. The instruments that are used in studying the world also changes and therefore the knowledge we get will change

His practice in school impressed him in particular with respect to students’ attitudes to learning science. Therefore, his commitment to teach science is to inspire his students and satisfy their curiosity of knowledge.

Case 2: Sharon

Sharon is a female student teacher who did her PhD on theoretical physics before she took the PGCE course. She aims to improve students’ understanding of science and scientists. A significant issue for Sharon at the early staged of her teaching was behaviour management:

Students’ behaviour strikes me. Some students are just so fond of destroying things in experiment classes which really surprised me and annoyed me at first.

She perceived that the skills of handling class management have improved during school teaching practice. She valued students’ initiatives in learning of science and she weighed skills over the content of science in teaching.

Case 3: Laura

Laura is a North Irish female who majors in physics, and studied Engineering in her undergraduate education in Scotland. Since she likes to deal with people, particularly with young people, she decided to become a teacher of science. She would like to teach useful and applicable knowledge to her students.

She thought the practice in school is a very helpful process in terms of learning from practice.

As you go along (in practice), you learn, as long as you've tried your best. You did feel a bit difficult to deal with some students at first, and then you learned from it.

Case 4: Zina

Zina is a female who is doing her PGCE on biology after she graduated from university. She went to girls' school for her middle school study. She hoped her students could enjoy learning of science. She found 20- week teaching practice enjoyable and identified it as being critical in preparation for her teaching career:

You know what exactly means teaching in school, in front of kids. You learned something from lectures in university but these techniques will not really become yours until you tried in practice.

Based on her experience, she thought teachers' confidence of content and teaching is important.

"You have to be confident of your knowledge, and then you can think about better way of doing it, trying something new."

g) Interview Data

The participants' views on science, pedagogical beliefs and perspectives on the teaching and learning of argumentation are summarised in Table 2.

Table 2. *Overview of Student Teachers' Perceptions*

		Sam	Sharon	Laura	Zina
Teaching science	Belief in science	Tentative/ changing	Not black and white	Explanation of world/ changing	An attempt to describe and explain
	Pedagogic belief	Aims to have better skills to interact with the world; Teacher should inspire students' interests and satisfy their needs	To have a better understanding of the world; Students' initiated opinions should be valued	Should teach useful and applicable knowledge; Teacher should be as a leader in group	Teacher should be a "learning coach", bringing enjoyment of learning science to students
	Comment on context	Exams: summative/ simple Curriculum: over-loaded	Assessment could not encourage students to try hard	Too many exams to think and enjoy science learning	Pressure from assessment; the conflict needs in curriculum
	Experience of practice	Supervised by students' interest in science	Behaviour control was a problem at first	Professional improvement through practice	Teacher's confidence and competence is important

Table 2. Continued..

Teaching of Argumentation	Justification	Necessary skills to respond to the changing scientific knowledge; justify and clarify their belief	Necessary skills to interact with flood of information; required skills in understanding of science	Through challenging of the belief to understand science concepts better	Do not be misled by media and have a right attitudes to and understanding of science and scientists
	Definition	Offer a good reason of their belief	Balanced argument	Putting forward your view based on solid evidence	A process of discourse; cross-discipline skills
	Students' learning	Ill-justified claims	Not clear about what argument should be; imbalanced claims	Unjustified belief/claim	Have some intrinsic ideas of argument
	Difficulties	Discourage from the assessments; Limit time due to the over-loaded curriculum	Concern of losing control; constraints from present assessment and curriculum	Lack of resources and time	Not taught enough due to constraints from assessment and curriculum
	Experience	Disagree with other teachers' offering argument frame to students	One success class, impressed by students' initiated ideas/ topics	Scattered in teaching units	"Critical thinking" in A-level
Using of ICT	Justification	To engage students	Due to its common use in scientific research	Personal preferred way of working; engage students	common tools; motivate students
	Experience	simulations	Data-logger; simulation	Simulations, some specific software	PPT; simulation
	Concerns	Keep students on-task; cost much more time and efforts; negotiation with technician	Students' incompetence of using ICT for science learning specifically	Keep students' on-task; due to her competence of using ICT, she can usually manage well.	Technique support; students' lack of abilities of using ICT in science learning
	Comment	Should relate to specific education objective	Situation varies in schools; effectiveness depends on how it being used	ICT offers immediate result and sort of application of knowledge	Appreciate the advantage in presentation offered by ICT tools

Most of the participants, based on their experiences in schools, acknowledged the conflict between the context of too much summative assessment and over-loaded curriculum, and their own pedagogic objective of inspiring students in science and exploring the nature of science. For example, Zina said that "*Ideally, you want to be a 'learning coach' or guider to your students. Most of teachers would like students to enjoy science, to have better understanding of the world they live in. ...However, students have to learn to pass exams, and there is pressure on teachers for doing that. The current assessment is too focused on scientific concept to encourage students' high-order thinking skills such as critical thinking and over-look the nature of science.*" This is accordance with the literature (e.g, Erduran & Dagher, 2007; Simon, Erduran & Osborne, 2006; Evagorou & Avraamidou, 2008).

The participants maintain that students should be equipped with the ability to judge the claims and to critically evaluate the information they encounter. They have justified teaching of argumentation from different perspectives: 1) it is important to develop students' high-order skills such as critical thinking; 2) it opens up to discuss what students believe and why, and then explore the nature of science concept and scientific investigations; 3) it is a necessary skill for future citizen. For instance, Zina regarded teaching argumentation as a way to cultivate public understanding of science:

“Argumentation, in every subject, is important and has a role to play, e.g., truth in history. As for science, it is important to help general public to understand science in society issues. For example, the media released some statistic, but might be no relation between two events which happened at the same time, the way news presented would mislead general public. There is such big scandal in this country, e.g., mad cow disease. ...people trust neither the government nor scientists. They think scientists are told what to do, like the investigation of Iraq’s nuclear massive weapons. That’s why debate on science in the news has been introduced [into curriculum].

... I believe argumentation is a process among any kind of discourses that involve making claims, justifying and validating the claims and at the meantime being able to oversee the limitations accompanying them.” (Zina)

From a different point of view, Laura justified the necessity of teaching argumentation as follows:

“I think it’s probably good for students to argue a little bit in class. There are things we know or we think we know, but there are lots of things we don’t know. People don’t like this (un-know). It’s good for them to argue, even just think about why they think and what they think. It [argumentation] would be a way of helping students to think twice about what they believe, what they think they know... help them to understand the differences between fact and opinion, ideas and evidence (for example, in 21st century science P1 unit).” (Laura)

Both Laura and Zina as well as Sharon have also identified students' learning needs in argumentation such as unbalanced argument and/or uncritical acceptance of information. Thus, they agreed that argumentation in science needs to be taught explicitly:

“I agree that argumentation should be more explicitly recognised in science classes. Often, children argue without having any reasons for their viewpoint or are unable to back up their statements. Teaching the basic argumentation skills will greatly improve their critical thinking and understanding of scientific approach.” (Laura)

“... the process of how to argue should be taught to the students. I think it is important that students are aware of what argumentation is and know how to apply them in class.” (Sharon)

“Argumentation is a way of putting forward your own view, which is backed up by solid evidence. It’s important to challenge what they believe, even if it ends up re-enforcing some wrong ideas. They should be able to find evidence to support their ideas.” (Zina)

In order to answer the research questions of whether the use of ICT could be regarded as a vehicle to improve teaching and learning of argumentation, the participants' experience and opinion of using ICT in science classes have also been explored in the interviews. Based on experiences in schools, they acknowledged that use of ICT in school varies. However, their responses to this context are different, which would be attributed to

their different competence and experience of using ICT. Similarly, the participants justified their use of ICT in science classes differently. Some accounts are based on the notion that ICT is commonly used in research science topics while others use ICT in class to respond to the popularity of using IT in daily life. As for pedagogic value of using ICT in science class, generally, they regarded ICT as a tool and the use of ICT is to add value on the existing way of teaching and learning, rather than bringing or inspiring new ways of teaching and learning. When they decide whether to employ ICT in teaching, they usually consider whether it can offer what the other tool could not do. They agreed that ICT helps to engage students and make abstract concepts more visible to students.

“ICT generally could be used to enhance students’ involvement and engages students.” (Sam)

“ICT could help me to do something I could not do with other media. I use PPT quite a lot and I found animation quite helpful.” (Laura)

“It is quite difficult of learning science, since lots of abstract ideas, lots of things you can’t see. Compared to picture in text books, animation used in science classes, e.g. presents the structure of particle or offers 3-D image. And it [Animation] can also show movement.” (Zina)

However, they all stressed that effectiveness of using ICT depends on what ICT is and how it is being used.

“ICT could be just a tool to do something better or it could mean a more student-centred method of teaching. It depends on how you use it and what ICT is. Decision of using ICT or not is more related to specific tasks or goals I would like to achieve. For example, I would like to teach in a more student-centred way, I would first to find out the most suitable content to teach or topic they could discuss. and the class could be IT-based, if certain ICT tool let me to do what I want to do.” (Sharon)

“If you had a class scheduled in IT room, it usually would be a failure if it is not necessary. Because they [students] just found a way round, if the class in rout of ICT room was pointless to them. If you have it when you wanted, it will be successful. For example, I bring the networked laptop into my year 7 Class, when I wanted them to do something with the aid of computer, it fit quite well.” (Sam)

“Students will like it [using of ICT] only when they think it is useful, e.g., they like the animation to show them how molecule works. They don’t like teacher using ICT just because it is there. It should be have reasons why it is there. It should link to some particular teaching purpose.” (Laura)

Their concerns in using ICT also include how to keep students on-task. In addition, the participants have pointed out that students’ skills in playing computer games at home are not necessarily transferable to science classes.

“For example, in one class, I gave them spreadsheet to ask them to fill the value of energy consumption by searching the internet. I thought it would be hot for them to do, since they are so good at computer generally, but they struggled with search information in the internet. I found them didn’t know where to go. Then I realised that their use of computer at home does not mean they could take on ICT application in science classes spontaneously.” (Sharon)

“Students are quite good at using Word-processing software. For example my Year 7 students teach me how to use Publisher. But if comes to do math or particular science, like Excel, they have difficulties.” (Zina)

In this study, Belvedere as an example of ICT tools designed to support teaching and learning of argumentation. For about 30-40 minutes, the participants were introduced to the software and offered a task-sheet (see Appendix 1) to build one concept map or represent their pre-interview argument in a concept map. All of the participants found the operation of the software easy. Their opinions of the software, specifically in terms of both its usability and pedagogic values have been explored based on their experience of using Belvedere.

Table 3. *Student Teachers' Views On The Software Belvedere*

Aspect of Belvedere	Sam	Sharon	Laura	Zina
Usability	Easy operation; adaptability	Simple to operate; Limit functions to keep students on-task	Easy use; Adaptability; restrict functions to keep students on-task	Functions are straight forward
Affordance	Visualization; presentation	Scaffolding; visualization; flexibility	Scaffolding; presentation	visualization
Pedagogic value	Inspire students to critically exam their claims and go in-depth; Visualize the structure of the argument and trace down the thinking process	Visualize the abstract relations; Guide/ inspire users to weigh up the evidence/ resource; Shows the flow of thinking and enable accommodation of user's initiated ideas	Scaffold users to be aware of how evidence support claims; Inspire users to understand the nature of science argument	Guided to construct coherent and balanced argument.
Comment		More specific sub-headings		

Their criteria of evaluating Belvedere are in accordance with their concerns of general ICT use and teaching of argumentation mentioned previously. As for the practical aspects, all participants appreciated the usability of the software. They also appreciated the restricted functions of editing in order to prevent students' wasting time on off-task activities. As for the pedagogic value regarding argumentation, all of the four participants noted the visual aid offered by Belvedere to address the problems of teaching and learning of argumentation in class. They agreed that the structure of Belvedere guides users to evaluate the reliability of the information. The visibility of relations between data and hypothesis helps users to be aware of the structure of the argument. It is also indicated that the use of Belvedere offers teachers a media to discuss argumentation with their students in a more straight forward way.

OVERVIEW OF KEY RESULTS

a) Use of argumentation

All student teachers maintained that argumentation in science classes has not been properly addressed.

"Argumentation should be taught before using it, however, it is not [being taught] at the moment."(Zina)

Consistent with the study with in-service teachers (e.g. Erduran & Dagher, 2007; Evagorou & Avraamidou, 2008), the participants have acknowledged the constraints from

external conditions in terms of the discouragement from unrelated tests and neglect in current assessment and time limit due to the overloaded curriculum, as well as high demands on teachers.

“At the moment ... exams with multiple choices could not assess what should be valued... I felt that a bit too much summative assessment, in which you get one mark, that’s it. [But] What does that mean? Where do we go?” (Sam)

“The present exams...could not encourage students to try hard.” (Sharon)

“There are too many exams/works in GCSE...that they don’t have enough time to think and enjoy. They are tired of preparing for exams.” (Laura)

“The curriculum keeps changing: discussion and debate about science in news has been added in new GCSE curriculum. At present, schools are “consumer of science”. [“consumer”, do you mean that students are more likely to receive science passively?]yeah, focus on so called “scientific concepts”. New curriculum comes from different view point. So at the moment, there is a big controversy whether GCSE is to teach for general public about science, in which they could understand the news story and not be scared about science. And the other argument which is GCSE also has to lay foundation for students who will be scientists in the future. So there is a conflict there. I just don’t know whether one qualification could do that.” (Zina)

These practical constraints have been identified as obstacles for teaching of argumentation.

“So far, argumentation has not been taught formally. There is only ‘Critical thinking’ in A-level [related to argumentation]. ... it is not highly regarded by university for science courses. The selecting criteria from University or assessment methods have not been addressed enough on such high-order thinking skill.”(Zina)

“ ... the content, in GCSE, there is so much. Although there are bits of saying students need to have the ability to search information and evaluate information in the internet, they will not actually examine you in that. Your argument skills or ability in searching information will not appear in multiple choices in exams. Thus, teachers sometimes unintentionally reduce efforts in classes [on argumentation].” (Sam)

Although argumentation skill is neither the focus in assessment nor curriculum, the teachers’ responses to these external constraints are quite different. This can be exemplified in the examples raised by Sam and Sharon:

“Although there are bits [in curriculum]of saying students need to have the ability to search information and evaluate information in the internet, they will not be actually exam you in that. Your argument skills or ability in searching for information will not appear in multiple choices in exams. Thus, teachers sometimes unintentionally reduce efforts in classes [on argumentation]. We had one course work that involved argumentation, but teachers just had no time to discuss it in class. So the teacher comes up with writing frame for students to use, which in my opinion means that students have been deprived of half of the skills of argumentation it should offer. [so do you mean, under the issues of curriculum and time limit, teachers still put the responsibility of transmitting knowledge to students as priority?] Well, assessment matters. Current assessment methods are not sufficient to measure these high-level abilities or inexplicit skills.” (Sam)

“One quite successful example is I asked them to discuss about how new technology is changing. I just wanted them to discuss. It turns out to be a good debate about “how much technology people would want”. They had come up with really good ideas as to why that would be good and why it would be bad. For example, about incorporated technology into their bodies, what could people do to you and would it be available to everybody... They are involved in such intelligent discussions.” (Sharon)

Limited by the time, Sam's colleagues came up with argument writing frames instead of classroom discussions; whereas Sharon successfully organized students to discuss science concept related social issues and was impressed by students' initiatives. This could be associated with Sharon's pedagogic belief that she valued higher-order thinking skills over the learning of scientific concepts. Apart from practical constraints, Sam attributed his colleagues' insufficient teaching of argumentation in class as contributing to their fear of losing control over students.

"However, we didn't see argumentation as the central in classes. I think many teachers are scared about what the consequence will be after start doing it. They are worried about the control of class." (Sam)

Student teachers' different pedagogic beliefs were exposed during the discussion on the science curriculum. For example, Sharon positively referred to the shift in curriculum to explicitly integrate argumentation related content. *"...curriculum will be changed soon; in the new curriculum, teachers may be able to have more time for students developing these high-level skills."* On the contrary, Laura, who is more concerned about practical scientific knowledge being taught properly, was conservative about the changes and did not see much meaningful change occurring.

"Curriculum is changing, but content in curriculum does not change much nor fundamentally... it [change of curriculum] is usually like a circle. I am not totally convinced by such a modern idea of student-led class. I think, every group should have a leader, and the teacher is an expert. I think the teacher should teach; I am not saying the teacher should teach in a very didactic way, but I am not sure about the idea of the teacher as a facilitator and students to learn themselves. I think particularly for young children, they need more direction and more help. They don't even know how to start [without teacher's direction]." (Laura)

These conditions of teaching argumentation in science were related to participants' particular requirements for ICT tools. For example, Zina has asserted that, *"In practice, it [argumentation] is not being systematically taught, but it might be scattered in different units. I think we should do it more if we have enough resources and supports, or we can do it in new ways."* This constrained condition requires the flexibility of the software. After she used Belvedere, she commented that, *"I like it ...it is flexible and could be easy to adapt to your needs. For example, you can use it in different units of curriculum [to do argumentation] or in different class settings, like demonstration to whole class or small group working."* The possibility of using particular ICT tool in class is also influenced by the context of using ICT in general.

b) Use of ICT

Although the participants acknowledged the situation of using ICT in school varies in terms of available equipment, the enthusiasm of the head of department and support from the IT technician, their perceptions on the use of ICT are rather different. When Sam would put off by the extra work load and troubles in negotiating with IT support, Zina claimed that she could not imagine how to work without ICT and Laura never took technical support into her account owing to her ability in using ICT.

"To prepare one successful class with ICT takes so much time and also you need to negotiate with the technician about the equipment. It just causes so much trouble and took so much time. [so do you think it worthwhile to use ICT?] it depends on what

you want ICT to do. If the effect achieved by ICT is not that critical or could be replaced by other traditional means, probably you may not bother.” (Sam)

“I am that sort of person who use it as a very natural way of working... There are problems with shared ICT equipment. I usually used my own laptop in class, and No One [stress] is allowed to touch my laptop... I don't know much about tech-support issues. Usually I can manage it by myself in class, and I can deal with little problems students meet when they are using computers, so tech-support is not an issue in my class.” (Laura)

“ICT is being used as normal and standard in science classes. I used ICT in every science lesson. If some one removed ICT from me, it would really cause a problem for me.” (Zina)

Consistent with this situation of the general use of ICT, the participants' evaluation of Belvedere is also related to the context and personal factors. For instance, Sam examined Belvedere with the concern of the adaptability to the practical situation and requirement of technical support.

“It's very easy to operate. Within 10 minutes you can get it on... it [Belvedere] is open source software which allows you to change it or have someone to change it for you. So, you can adapt it to what you need. Since it's free to download from the internet, it would be easier to negotiate with the technicians.” (Sam)

Laura focused on the issue of keeping students on-task, which is her general concern of using ICT tools in science class:

“I quite like the restricted function on editing staff, such as, you know, the interface, the font, etc. It helps students to focus on task. But children still have enough freedom that they could do some creative thing in terms of the way they build the map.” (Laura)

The student teachers perceptions are consistent with the literature that on the one hand the condition will shape the use of ICT tools, and on the other hand, the user's different responses to the condition will also lead to a varying result in adaptation of the tool (e.g. Cuban, 2001; Hennessey, 2006).

c) Software Design

The advantage in the scaffolding of learning argumentation offered by Belvedere identified by the participants relate to the design strategies of “problematize” and “construct task” (Resier, 2004). For example, in Belvedere 4.1, the user has to decide whether an assertion is a “hypothesis” or “evidence” and indicate the relation between “evidence” and “hypothesis”. Through this design, according to the participants, users grapple with decisions they might otherwise overlook by paper and pencil, such as classifying the way evidence connects to positions in an argument.

“It seems their learning of argumentation takes place when pupils are forced to consider what evidence supports an idea, and when they are encouraged to think about How Science Works.” (Laura)

“.. [in Belvedere] when you scroll down the page, you can see how argument is developed. It helps students to think about what scientific argument is, what the claim is, how data is being used to support/against the claim and the reliability of data and argument. It encourages and guides them to actually use evidence to support their claim rather than simply claim like ‘I believe...’ or ‘some one said that’.” (Sharon)

Reiser (2004) explained that the principle of “problematize” helps to identify and implement aspects of the process users may otherwise neglect to perform. This feature also reduces the complexity by providing additional structures and prompts. *“It [Belvedere] helps to show them [students] examples of argument, which are different to simple claims some students hold and it inspires them [students] to discuss and evaluate the arguments together.”* (Sharon)

“Construct task” as a strategy of scaffolding could help users to encounter and grapple with important ideas or processes (Reiser, 2004). For instance, the feature “property” serves as an aide to help users in critically evaluating the data and tracing down the source. Sharon also valued the “url” entry in the “property” of the “data”. *“It enables you to track down the data resource via the internet. It inspires students to evaluate the data they got and critically think about the source.”* Moreover, problem solving is more tractable via the visual aid in Belvedere. As participants acknowledged that it helps users to uncover the deeper argument structure embedded in verbal essays which may not create the same in a general tool like a word processor (Reiser, 2004).

“Most people probably do similar things when they put forward their opinion, they weigh up evidence, etc, however, you do not necessarily know what process you are going through. It [Belvedere] enables visibility. It makes more explicit and clear the structure of argument. You can visibly see ‘for/against’ evidence and see different colours, different thickness of line and frame to present the data and relationship. To evaluate argument is kind of a higher-order skill, the software offers an intermediary which allows students to work step by step rather than evaluate the whole argument or construct a balanced argument at once.” (Sam)

Visualization tools that provide conceptually meaningful representations are designed to help users form deep models of an underlying system (Hollan, Bederson & Helfman, 1997). Consistent with Pea & Gomez (1992)’s results, the participants have pointed out that visualisation can serve as a catalyst for negotiation of ideas. *“To visualize your structure of the argument helps you to organize your thought. In this way [aided by Belvedere], they [students] have been guided and inspired to weigh up the source of data and critically think about why or why not the data is reliable.”* (Zina)

As Reiser (2004) asserted, “the structure of a tool shapes how people interact with the task and affects what can be accomplished” (p.280). It is also confirmed in this study, for instance, that the participants pointed out students’ uncritical acceptance of information, and that they valued the function of Belvedere to visualize the reliability of the data (and to inspire students in weighing up the evidence).

“It [Belvedere] makes the structure of argument straightforward... It turns the relationship of how data/info support or are against to the claim to visible “+”, “-” or “?” signs. And it also helps you to weigh up how strong the relationship would be presented by how thick the line is. And how thick the frame of data is presents the reliability of data.” (Sharon)

Moreover, their experience of using Belvedere also confirmed the influence from the structure of the Belvedere on student teachers’ views on learning of argumentation. For instance, Laura thought students might construct a more coherent argument with this visualized relation map than with other methods of teaching argument.

I find it makes relations more explicit, and when I think as a child, I find it is easier to talk about how evidence support ideas and it raises my awareness of the issue of reliability of the data and its source. You could do similar things without this software. You could always do it with paper and pen. But it [Belvedere] does offer some function, such as “property” of the data and relation, which inspires students to discuss why they are strongly support certain assumption or not. I think they will enjoy doing it. You know, some students like this visualized ways. And they also could print their maps out. They [students] could do some independent study on certain topic. They can find information, as much as they can, and they can put them all in the map. They can then move the data frames around and relate some of them. They can also weigh up the reliability of the information they got. It [Belvedere] helps them to track down the source of the data, say web address or newspaper.

The Belvedere concept maps produced by the participants also illustrated how the structure of Belvedere helps them to present or represent their arguments. For example, Sam and Laura who did not finish the pre-interview task chose the same topic during the interview and presented in different ways. Laura, from an Y9-student point of view, presented the topic in a comparatively linear way. On the contrary, Sam added extra ideas which he thought were related to the claims, and he also examined the relationships between the data. His knowledge is represented as an interconnected complex structure. This map represented his understanding of scientific arguments with the complicated relations of the data and claims.

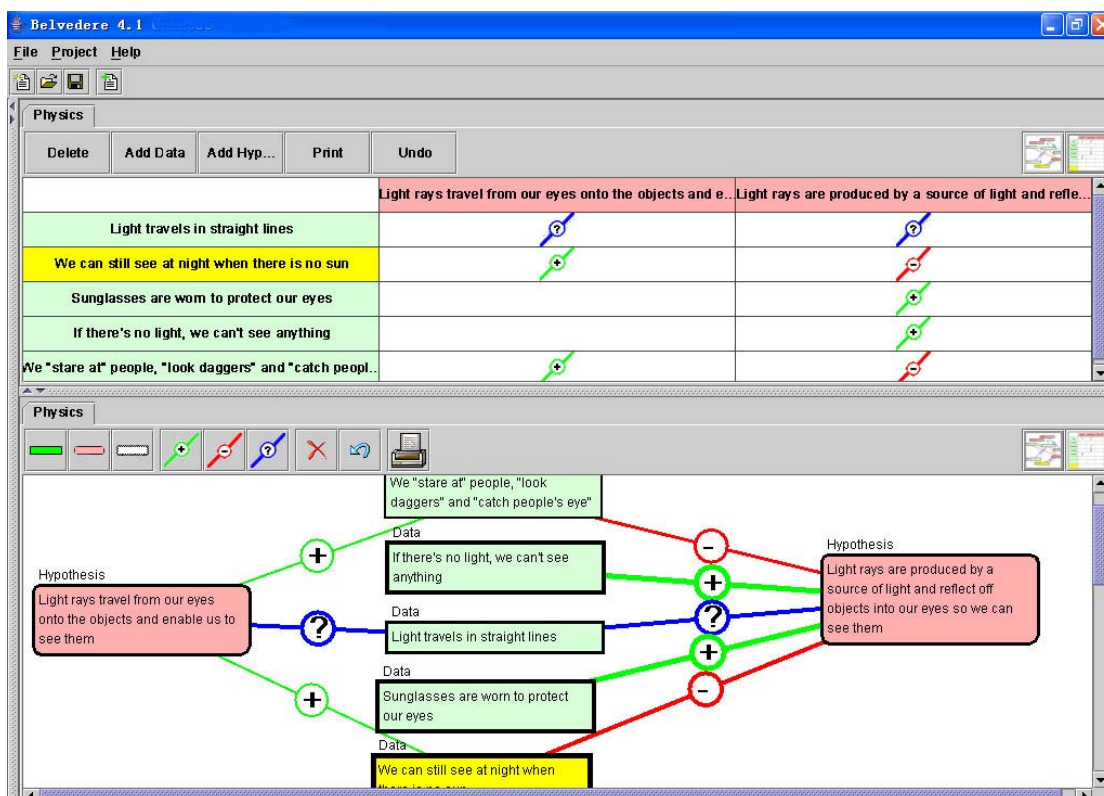


Figure 4. Laura's Concept Map.

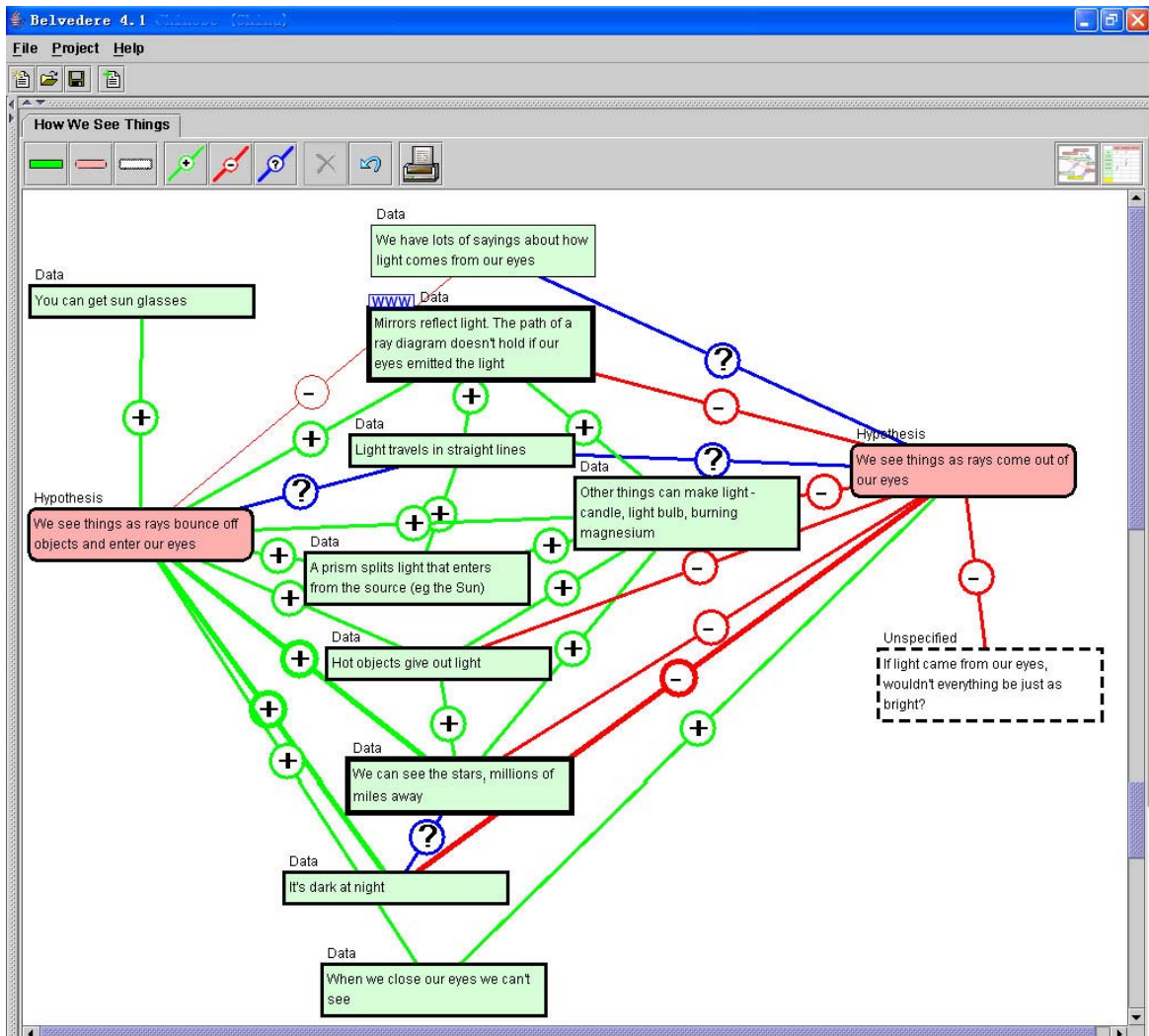


Figure 5. Sam's Concept Map.

The difference between these two maps implied that the understanding of science would be reflected in the concept map produced, whilst the personal background will also lead to different use of the tool. Sam's concept map is also consistent with his claims that use of Belvedere could inspire users to extend the topics and trace down their flow of thinking.

"I like it that you can scroll down the page, which allows you to expand your argument and go into depth. You can discuss with your students about their map such as: "why are we talking about this and what is your assumption of this? what evidence would support it?" ...you could go to your hypothesis and then from there you could give a list /flow of your argument and justification.

Sometimes argument would be quite complicated that you don't know the structure or relation between the information and claim. Free to arrange the blocks enables children to think about the relation or pattern. And they could re-arrange the data/info into a different order. ...it might inspire their critical thinking about their evidence and reflection." (Sam)

The consistency of the affordance identified by participants and the designers' objectives implied that the properties of the tools conditioned by the affordance of the

tools could be recognized. Sharon's and Zina's maps, for instances, confirmed this observation. Sharon and Zina both chose socio-scientific topics which might be in accordance with their justification of teaching argumentation in class as a way to improve public understanding of science through societal issues. There are no right or wrong answers to such questions. Compared to their written arguments (see Appendix 2), both of them extend their topics to involve more information and explore the topic in more depth. For example, Zina linked the issue to the energy and economic rewards in her concept-map. She asserted that *"The visual representation helps you to see the issue more clearly."*

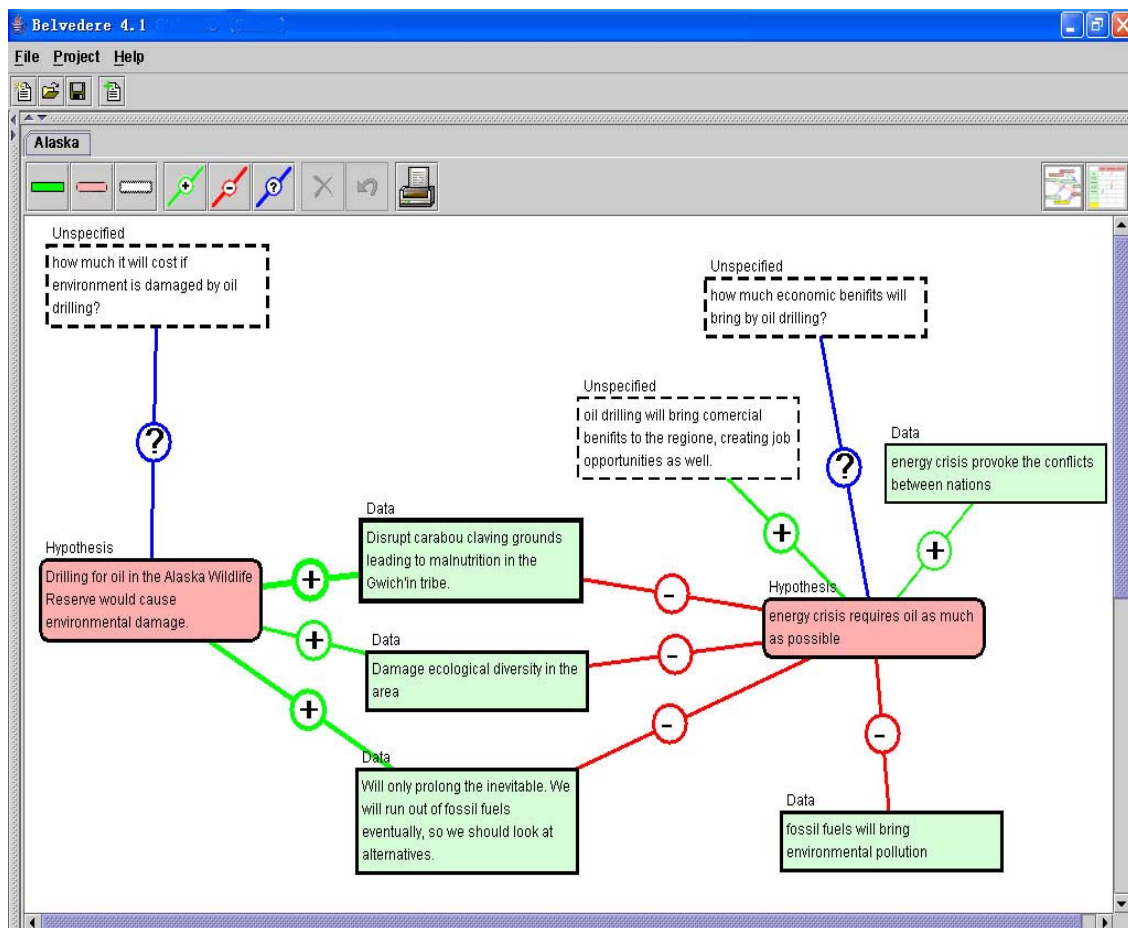


Figure 6. Zina's Concept-Map.

However, in light of Toulmin's Argument Pattern (TAP), we can spot a deficiency in both of their concept maps. For instance there is a missing warrant between "Data" – "Manned missions rarely makes it onto news" and "Hypothesis" – "Manned missions to Mars are not cost effective". As Sharon also identified some minor deficiency in the software:

"I would like to have more headings of blocks to sub-group the data into, such as backings, assumption, evidence... and this software only represents the structure or relations of argument rather than actually helps you to build one written argument literately. The teacher still needs to help students to write their argument based on this map of concepts." (Sharon)

According to Reiser's (2004) design principles one should "organize tools and artefacts around semantics of the discipline" and "make disciplinary strategies explicit in the artefacts learners created" (p.283). The design of Belvedere would be improved through a more explicit use of the TAP model into its structure. This implied that the property of the tool will limit its affordance in communicating a comprehensive model of an argument such as Toulmin's model.

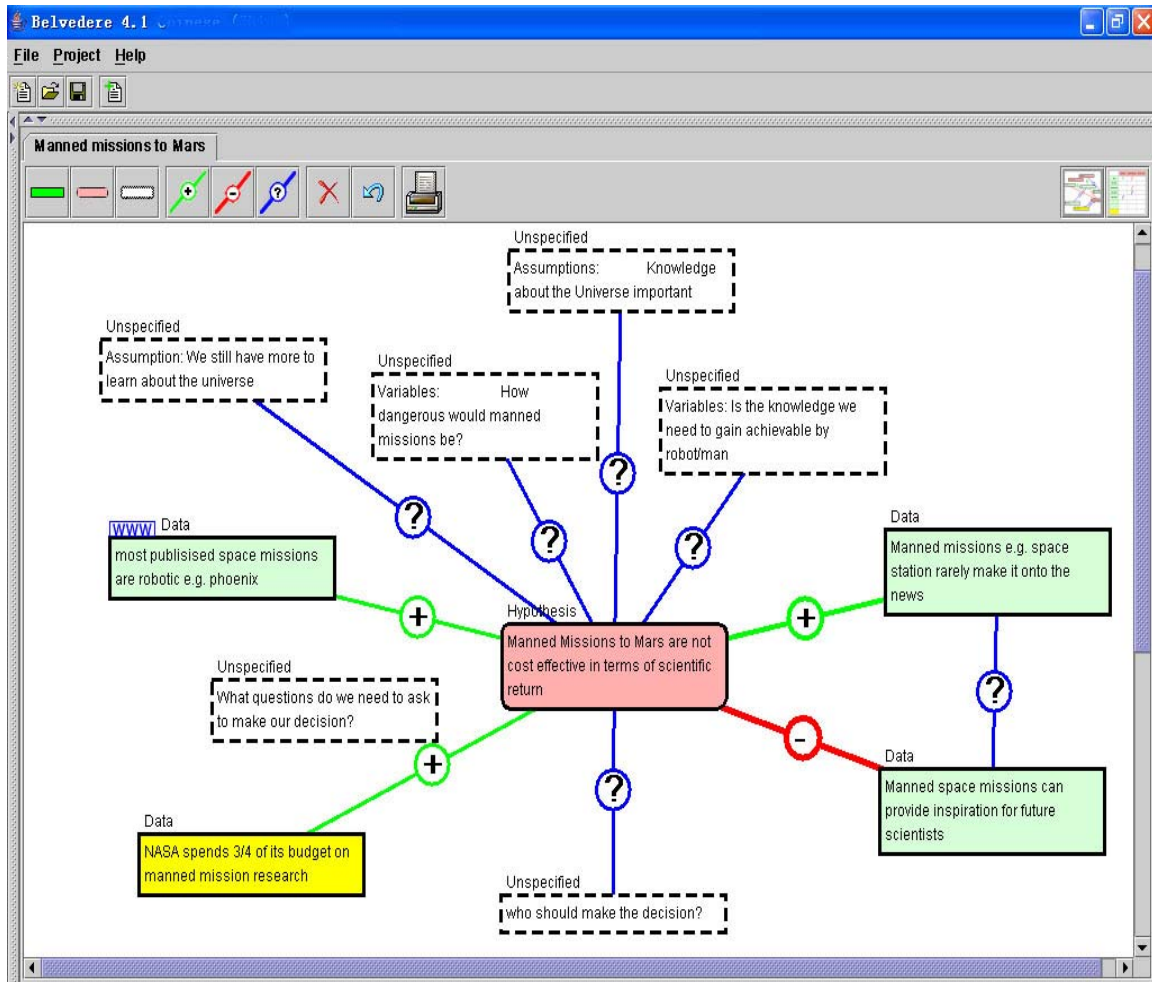


Figure 7. Sharon's Concept-Map.

SUMMARY

The cross examinations of the cases in this study has indicated that whether the use of ICT could achieve a certain pedagogic goal depends on the context, the tool and the people (Figure 8).

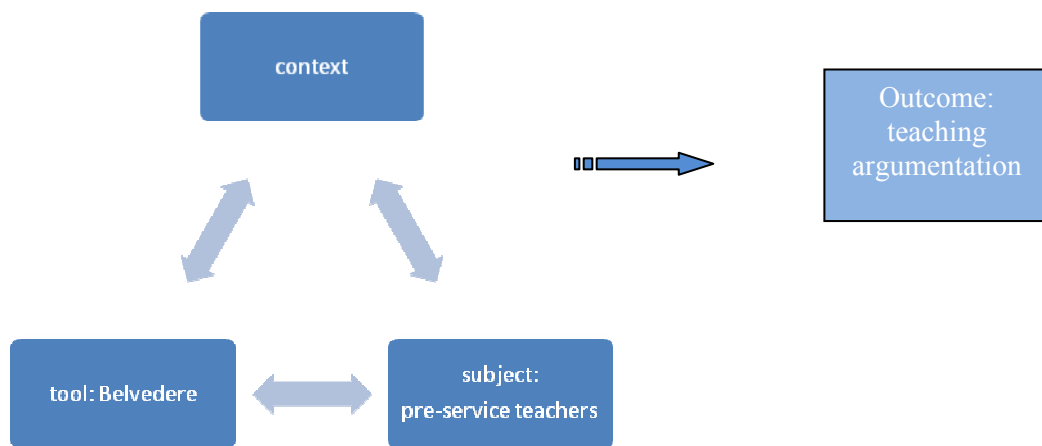


Figure 8. *Model of Interactions Between Tool, Context And Subject.*

As Trough (2004) asserted how the user responds and/or makes sense of the given tool will be influenced by the environment. In this study, teaching of argumentation in science class is conditioned by the pressure from examinations and constraints from the curriculum. The use of ICT tools to support teaching and learning of science is also influenced by the situation regarding the equipment, the technique support and the initiatives in department and school. It is implied that the external conditions limit the possibility of using ICT tools to support teaching and learning of argumentation, which is consistent with the literature (Cuban, 2001; Hennessy, et al, 2005) on the general use of ICT in science classes. In the case of Belvedere, the participants took adaptability to the context into consideration. The participants have acknowledged that Belvedere has its pedagogic value. The participants agreed that Belvedere could offer a good starting point for opening up discussions on argumentation and students' collaboration in science classes. The advantage of presentation and visualisation offered by Belvedere has also been acknowledged. However, there are differences in the participants' comments of Belvedere in terms of their concerns and their focus. The participants' evaluation of using Belvedere in supporting teaching and learning of argumentation could be associated with their personal factors, including their opinion and experience of general use of ICT tools in science classes, their understanding of argumentation and the problems of teaching and learning of argumentation in practice identified by them. For example, the participants' different experience and competence of using ICT could account for their concerns in using of Belvedere. The different aspects they focused on when they evaluated Belvedere might be related to their opinions of using ICT and the problems they identified in specific teaching and learning needs. This is in accordance with constructionism: the use of the given tools is based on the user's previous experience (Rabardel & Bourmaud, 2003). In this study, the participants are more likely to regard ICT as a tool of "adds-on" existed teaching practice rather than a new way of teaching. They expected the ICT tools could address students' difficulties and problems of learning argumentation in limited class time.

This case study also shows the structure of the software could limit the utility of the tools and influence the outcome of the activity mediated by the tool. In this study, the pedagogic affordance identified by the participants is consistent with the design of the software. The participants' comments confirmed Reiser's scaffolding strategies (2004) in

design. According to the participants, the structure of Belvedere inspires the user to critically think about the data and reliability of the source of the data and also guides the user to be aware of the relations and constructions between the data and the claim. However, the deficiency spotted in the participants' concept maps under TAP and the participant's improvement suggestions all implied that the design of the software should be based on solid pedagogic content. Both the positive feedback and the spotted deficiency exemplified what researchers (see, Rabardel & Bourmaud, 2003) have asserted that the properties of the tool form its utility. Implied by this exploratory study, although ICT tools could have the potential to support teaching and learning of argumentation, the initiative of using ICT needs to be justified cautiously in terms of the compatibility to the context, the specific design of the tool and the teachers' personal factors.

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Appendix 1: Student Teachers' Written Work

ZJ:

My teaching subject is Science, with a specialism in Chemistry. I think my use of ICT in class teaching is very good.

Make one argument:

We should not drill in the Alaska National Wildlife Reserve

There are several reasons why drilling for oil in the Alaska Wildlife Reserve should be opposed.

The first reason is the negative impact drilling would have on the indigenous peoples living in the area. 60 to 70% of the Gwich'in tribe's diet is provided by the caribou and they fear that drilling will negatively affect the important caribou calving grounds.

Secondly, the US Fish and Wildlife Service has stated that "because of its compact size, the area has a greater degree of ecological diversity than any other similar sized area of Alaska's north slope". Losing this diversity due to oil drilling would surely be an unsatisfactory outcome.

Finally, drilling for more oil is only the prolonging the inevitable; we will run out of fossil fuels. A more sensible approach, therefore, would be to investigate alternative sources of energy instead of drilling in the Alaska National Wildlife Reserve.

L.

Subject: science (Physics)

How do you think your use of ICT in teaching : very good

Make an argument:

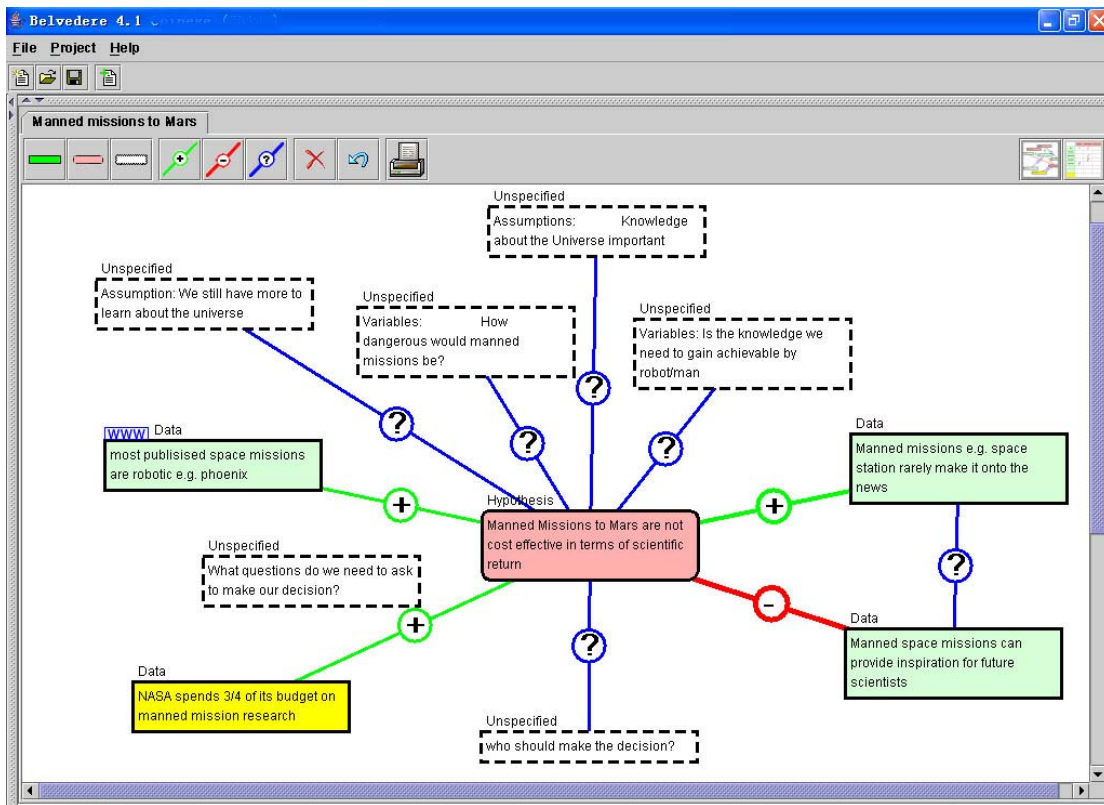
The United States should/ should not attempt to send astronauts to Mars.

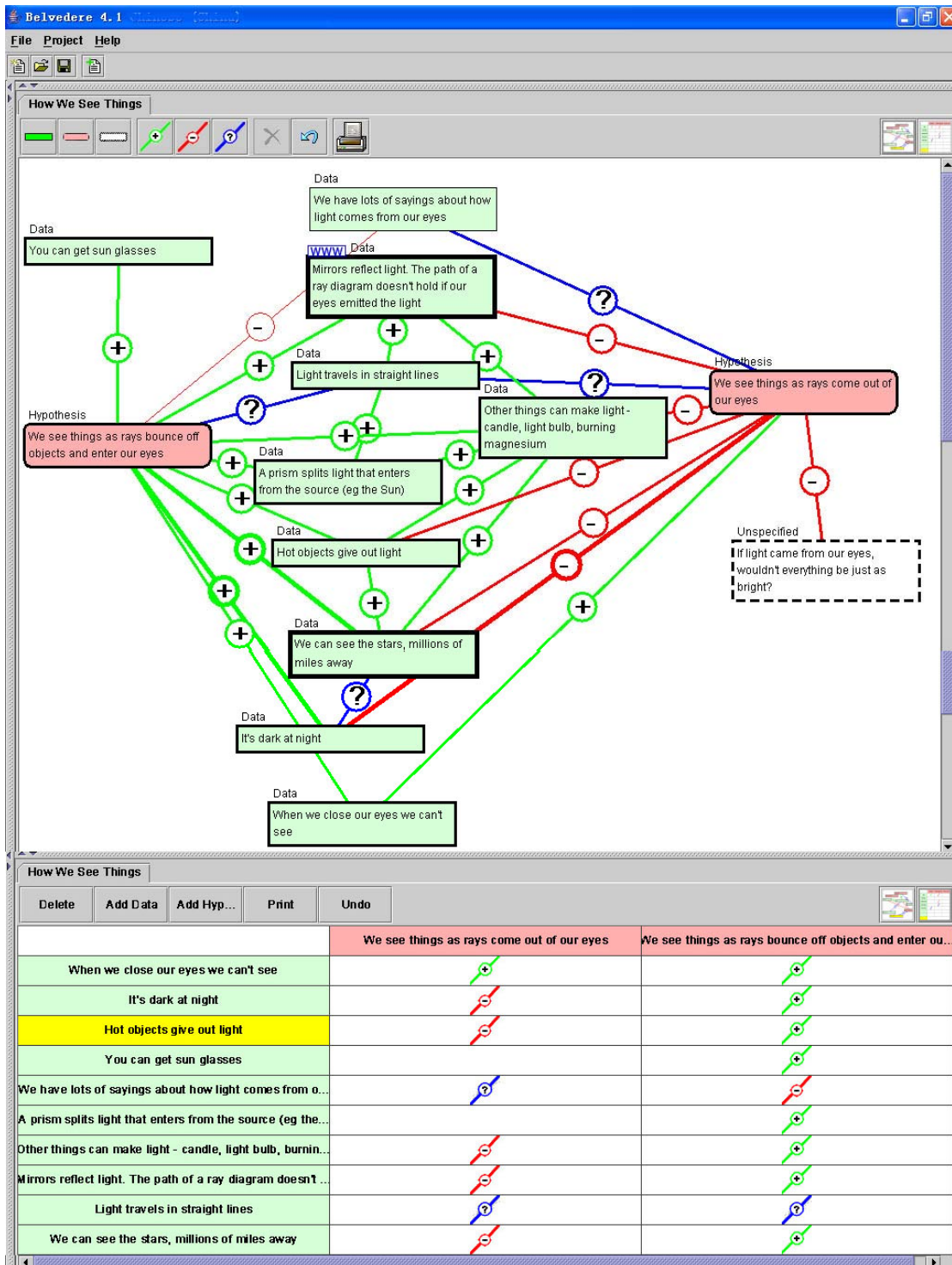
I think that the United States should not send manned spacecraft to Mars as I believe that it is not a cost effective way of extending our knowledge of the Universe. I believe that the future of space exploration lies in unmanned robotic missions.

NASA currently has a budget of \$17 billion and nearly three quarters of it is spent on research into manned space flights however I believe that the scientific payback for such missions does not justify the cost. I also believe that funding from private companies will finance manned space missions in the future since more and more companies are claiming that they may soon be offering space tourist tickets. This also means that the technological benefits that come along side manned space exploration will still develop.

one argument being proposed in favour of manned space missions in that they provide inspiration for young people and instil an interest in science however news of the space station or shuttle launches rarely make it into the news headlines whereas images from Hubble or other robotic space missions are often seen in the media.

Appendix 2: Student Teachers' Concept Maps





Belvedere 4.1

File Project Help

Physics

	Light rays travel from our eyes onto the objects and e...	Light rays are produced by a source of light and refle...
Light travels in straight lines	?	?
We can still see at night when there is no sun	+	-
Sunglasses are worn to protect our eyes	+	+
If there's no light, we can't see anything	+	+
We "stare at" people, "look daggers" and "catch peopl...	+	-

Physics

Belvedere 4.1

File Project Help

Alaska