Implementing Web Knowledge Forum in Secondary Science Classrooms: Teachers' Initial Experiences and Effects on Students' Thinking and Learning Processes

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ABSTRACT

Web Knowledge Forum (WKF) is one of the most well-known computer supported collaborative learning and inquiry programs available on the online learning market today. Previous studies have demonstrated significant relationships between the use of WKF and students' thinking and learning processes. To be effective, however, use of the program must be well-imbedded within teachers' pedagogical approaches. First-time users of WKF may experience issues in integrating the program with their day-to-day teaching practices. Despite this, little research has been done to explore the initial experiences of teachers using WKF, to explore the consequences of varying practices on students' thinking and learning processes, or to provide recommendations for avoiding common pitfalls within initial implementations. The research program reported in this thesis comprised three interrelated studies.

In Study I, a self-report metacognition inventory, including both closed- and open-ended questions, was developed to assess students' planning, monitoring, cognitive strategy use, and evaluation skills. The purpose of developing this instrument was to later evaluate the impact of WKF on students' metacognitive skill levels. Three hundred twenty three Year 7 to 12 students in two secondary schools in Western Australia participated in the validation. While confirmatory factor analyses indicated that the closed-ended questions did conform to the proposed factor structure, scores from this section were poorly correlated both with answers to the open-ended questions and with teachers' ratings. As a result, only the open-ended section of the instrument was used in study II.

Study II documented and evaluated one teacher's approach to using WKF within two Year 9 Chemistry units, participants were 72 students from three classes in a private girl's college in Western Australia. A quasi-experimental design was used to address the latter goal, with classes assigned randomly either to the WKF condition or to a more traditional collaborative condition. There were two phases in the study. In Phase I, students studied the topic Elements either under WKF or the more traditional approach. In Phase II, the teacher modified the pedagogy used in the WKF condition, and students studied the topic Compounds under either method. In Phase II, two of the classes also reversed in condition from Phase I, to provide an additional control for class effects. A

broad range of measures was used in the study, which included achievement and higher-order thinking skills tests, ratings on a standardized attitude scale, the researcher-developed metacognition measure, and analyses of students' critical thinking skills based on research summaries and WKF interactions. Results for Phase I indicated no significant differences between classes in terms of achievement and attitudes. In Phase II, however, there were significant differences favouring the WKF class in terms of preferences for ill-structured tasks, cognitive strategy use, and reduced use of lower-order thinking skills.

In Study III, semi-structured interviews were conducted to explore teachers' experiences and views on the effectiveness of WKF in classroom teaching. Results indicated that two teachers were unconvinced of WKF's merits as a tool for facilitating students' learning processes. The third was generally positive about the program, but believed that its use would be effective only under certain conditions. Amongst the problems identified by these teachers were issues to do with time and preparation factors. A number of suggestions are made for addressing these issues in future implementations of WKF within secondary level classrooms.

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DECLARATION

I declare that this dissertation does not incorporate, without acknowledgement, any material previously submitted for a degree or diploma in any university and that, to the best of my knowledge and belief, it does not contain any material previously published or written by another person where due reference is not made in the text.

Sharinaz Abu Hassan, July, 2007

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Chapter 1.

INTRODUCTION

Over the past two decades, educators have expressed concerns that traditional school contexts often fail to equip students with the generic skills that they will need to advance in their post-school lives, particularly in a technology-rich, "knowledge society" (e.g., Tapscott, 1998; Tynjala, 1999). Specific skills mentioned frequently in this context include critical thinking and problem-solving abilities, technological literacy, and the ability to work within teams (e.g., Jonassen, 2003; Light & Maverech, 1992; Scardamalia & Bereiter, 1996). This notion is clearly supported by Shelly, Cashman, Gunter and Gunter (2004):

> Traditional twentieth century education practices will no longer provide you with the necessary skills you need to teach your students effectively on how to become productive citizens in today's high-tech global workplace (p.1.02)

The availability of Information Communication Technologies (ICTs) within schools has led to the development of new approaches to knowledge creation within classroom learning environments (McMurray & Dunlop, 1999). The use of web-based teaching and learning systems has now come to be viewed as an essential component of instructional environments at all levels of education (Scardamalia & Bereiter, 1994). In Western Australia, the present state government is making considerable efforts and committing significant resources toward strategies and approaches which support the use of ICT at various levels of education and training (Department of Education Science and Training, 2003). The department's draft plan for Government schools (2004-2007) stated that the key features for the development of future government schools in Western Australia will be associated with network learning communities. The primary goal of this initiative will include the use of technology as an integral part of the teaching and learning program. Students will have access to more learning options through technology, via “virtual classrooms”, flexible modes of delivery and quality online curriculum content. Schools, in this view, will become network learning communities (Department of Education Science and Training, 2003).

The new focus on integrating the use of ICTs within schools has, in turn, led to an increasing emphasis on the use of constructivist approaches in education. In general, these approaches emphasize the need for schooling to be based on authentic, challenging projects that engage students, teachers, and experts in the learning community. Collaborative learning methods are widely viewed as a key element of constructivist learning environments (Johnson & Johnson, 1990). Collaborative methods provide students with opportunities to engage in a broad range of shared experiences such as modeling and decision making, as well as the negotiation and creation of shared meanings and understandings through social discourse.

Several researchers on collaborative learning and ICT in education have suggested that these two methods can be reciprocally augmentative in their effects on cognitive development (Warschaeur, 1997). Both are based on theories of social cognition that emphasise the role of student interaction in active learning processes (Light & Maverech, 1992). Clements and Natasi (1988) also suggested that engaging computer environments are likely to produce a higher frequency of quality interactions between members of a collaborative group. Finally, as the tools available to collaborative group members can restructure the manner in which cognitive activities are carried out (e.g., the processes involved in classifying and ordering information), they also have the potential to mediate new forms of social interaction amongst learners and to moderate the nature and quality of the interactions that occur within these exchanges.

Roschelle (1992), however, indicated a need to distinguish between different types of technology in their relationship to the collaborative process. He defined a collaborative technology as a tool that enables individuals to engage in the active production of shared knowledge. In this view, good collaborative technologies function by becoming a highly visible part of shared experience.

Web Knowledge Forum (WKF) represents one example of a collaborative technology that meets these criteria. This system is designed to support students in purposeful, intentional, and collaborative learning within a local network environment. Students can select different communication modes (e.g., text, graphics) to generate hypermedia database that contain information relating to the topic under study. WKF offers learners the opportunity to engage in a higher level of discussion that contributes to the accumulation of knowledge. Text and graphic notes that represent students' ideas and questions in all curriculum areas are entered into the same database, where they can be accessed by all members on the network. Intellectual interaction occurs as student comments on each other's notes and authors are notified when comments have been made or when changes in the database have occurred.

Although WKF has been found in several studies to produce positive effects in a range of key learning areas, these studies are generally conducted under relatively controlled conditions. In order to meet contextual constraints, however, teachers will need to adapt their own lesson plans to incorporate the use of this program. As discriminating between "optional" and critical components can be difficult, this can lead to unsystematic adaptations, reduced effects and, ultimately, loss of community or administrative support for the approach. At present, little research has been conducted to document how teachers within the field make use of tools such as WKF in their initial implementations, and the impact that these field-based applications have on student learning outcomes and processes. The overarching goal of this research was, therefore, to document, evaluate, and develop recommendations from, the efforts made by one ICT-rich secondary school to implement WKF for the first time. Ultimately, it is hoped that this will open channels of communication between teachers on their initial experiences with implementing WKF, so that common pitfalls can be avoided in subsequent applications.

Chapter 2

LITERATURE REVIEW

This chapter summarizes previous research on the use of ICTs within education systems, both internationally and in the Australian context. Section 2.1 provides a general orientation to the current status of ICT integration in education. Section 2.2 summarizes previous research on the specific use of ICTs to support classroom cooperative and collaborative learning processes. Section 2.3 provides an in-depth discussion of WKF as a tool that is widely used for such purposes, including key principles underpinning WKF, and effects documented on student learning outcomes, student learning processes, and teaching approaches. Section 2.4 introduces potential barriers to the effective integration of ICTs in classroom teaching. Section 2.5 then summarizes the rationale for, and aims of, the current research program.

2.1. ICT INTEGRATION IN EDUCATION

The potential role of ICTs in education has been the subject of significant research activity since the late 1980s. This developing field is currently among the most highly active within education research (e.g., Hepp, Hinostroza, Laval, & Rehbein, 2004; Selwyn & Fitz, 2000). Increased interest in educational applications of ICTs can be ascribed to several interrelated factors, most prominent amongst which are the potential advantages of these tools for facilitating improvements in teaching and learning processes.

2.1.1. ICTs and Constructivist Learning Environments

Several studies in recent years have demonstrated that ICT-based tools can provide a powerful means by which teachers can foster and enhance teaching and learning processes (e.g. Barnard & Thompson, 2000; Johnston-Wilder & Pimm, 2004). A major potential role of ICTs within education is to support the design of constructivist learning environments, in which students take an active role in gathering information and constructing their own knowledge. Constructivist learning environments are assumed to provide students with enhanced opportunities to develop the generic attributes that they will need to advance in the "knowledge society". This notion is strongly supported by Todd (2002, p.161), who stated that:

> The information age school is one that is distinguished not by its networked information technology nor its access to multiple resources of information, but by its capacity to develop students who are able to interact with and utilise this rich information environment to develop their own understanding and knowledge, and who are able to actively contribute to the ongoing development of a thinking, knowledgeable, creative and empowered society.

The generic attributes that students can develop through the use of ICTs include decision-making and problem-solving processes, collaborative teamwork skills, and skills required for experimentation and scientific investigation (e.g., Crosby & Iding, 1997; Pedaste & Sarapuu, 2006; Prins, Busato, Hamaker, & Visser, 1996). The next two sections provide a brief overview of the history and current status of ICT integration within education, both internationally and in the Australian context.

2.1.2. Provisions for ICT Use in Education

In the United States (US), the use of computers within schools and other education sectors increased dramatically from 1981 to 1987. During this period, the percentage of schools in the US with at least one computer grew dramatically: In elementary schools, from 10% to 95%; in junior high schools, from 25% to 97%; and in senior high schools, from 43% to 98% (Office of Technological Assessment, 1998). Similar trends were reported in most developed countries around the world, including the United Kingdom (UK), Canada, France, Italy, Germany and Australia (Vitalari, 1990). Since then, the trends have continued exponentially, owing largely to increases in the range, user-friendliness, and affordability of education-related ICT tools.

The governments of several developed countries have also invested significant resources into supporting technology integration across all sectors of their education systems. For example, the Department for Education and Skills (2005) in the UK expressed the view that technology investments are essential in higher education, which constitutes a marketable commodity. Similarly, the US government emphasized the long-term benefits that enhancing ICT skills would have by raising educational standards and preparing students more effectively for the workforce (Office of Technological Assessment, 1998).

In Australia, several nationwide efforts have been initiated to enhance teachers' integration of ICT within their classroom practices. For example, in the late 1990s, the University of Sydney engaged in a major ICT-based collaborative project with the Victorian Department of Education to support technology innovations in public schools (Cuttance, 2000). In 1998 and 1999, the Federal Government funded a large-scale national program, known as The Innovations and Best Practices Project (IBPP), in which a major theme was to support and evaluate ICT innovations in 107 Australian schools (Cuttance, 2000). A follow-up three-year project (The Successful Integration of Learning Technologies, or SILT) was then funded by the Australian Research Council to research the effective use of technology in science classrooms.

Since that period, ICT use in schools has continued to attract significant funds from the Australian government at both the state and federal levels. In Western Australia, the present government is committing considerable resources toward the development of strategies and approaches to support ICT integration in education and training (Department of Education Science and Training, 2003). Further, in the Department of Education and Training's *Draft Plan for Government Schools: 2004 to 2007*, network learning communities are listed as a key element of the current strategies in place to advance and progress Western Australian government schools.

Despite the level of funding that has been allocated to improve ICT integration in Australian schools, these tools remain underutilized across all levels of education (Baylor & Ritchie, 2002). The Ministerial Council on Employment Education Training and Youth Affairs (1999) noted that teachers lack effective models of how to make use of these tools within their regular classroom practices. Eisenberg and Johnson (2002) also noted a need for greater understanding of the role that ICTs can play as organisational, communication, research, and problem-solving tools.

2.2. ICTS AND COOPERATIVE/COLLABORATIVE LEARNING

In recent decades, the efficacy of traditional learning approaches for supporting students' collaborative learning processes has been questioned. According to Nisbet and Shucksmith (1986), the traditional curriculum concentrates on learning products or information, which emphasizes skill development in reading, writing, mathematics, and special subjects. They argue that in this approach, developing students' skills in problem-solving, decision-making, and general learning strategies are too often ignored. Airasian and Walsh (1997) further argued that in traditional approaches to instruction, students often do not contribute much to the development of lesson materials, leaving teachers alone to act as information providers. Learners' roles in these contexts are as passive recipients and as "knowledge receivers".

As noted previously, in the last few decades, constructivist approaches in education have increasingly gained favour. Constructivist theory is defined as "the idea that learners construct knowledge for themselves — each learner individually (and socially) constructs meaning — as he or she learns" (Hein, 1991, p.1). This definition is consistent with ideas expressed by Bloom (1980), who referred to learners as active agents who construct new meaning within the context of their existing knowledge, previous experience and social environments. In this view, learning is an internal process of interpretation, rather than a process of transmission (Airasian & Walsh, 1997). Cunningham (1992, p.36) further supported this idea:

> … learners do not transfer knowledge from the external world into their memories; rather, they create interpretations of the world based upon their past experiences and their interactions in the world. How someone construes the world, their existing metaphors, is at least as powerful a factor influencing what is learned as any characteristic of the world.

In general (e.g., Bloom et al., 1999; Hein, 1991) constructivist approaches to classroom instruction emphasize (i) student-centered rather than teacher-centered instruction, (ii) inquiry-based and active rather than passive learning, (iii) information exchange rather than information delivery, (iv) critical thinking rather than fact-based acquisition, (v) proactive rather than reactive responses, and (vi) collaborative rather than isolated or independent work.

2.2.1. Cooperative/Collaborative Learning and Constructivism

Cooperative and collaborative learning methods are widely viewed as key elements of constructivist learning environments. Cooperative learning is defined as having small, mixed-ability groups of students learn together on academic tasks (Slavin, 1991). While cooperative learning can involve having students work in teams on different subtasks, collaborative learning refers to a specific form of cooperative learning in which students work together on the same task (Slavin, 1991). According to Light and Maverech (1992), cooperative groups can vary in term of size (from a pair of students to small groups of four or even six students), structure (heterogeneous or homogeneous), gender (single or mixed), and types of collaboration (from team-assisted individualized learning to collaboration on every aspect of a task).

Cooperative and collaborative learning methods provide students with opportunities to engage in a broad range of shared experiences which include the negotiation and creation of shared meanings through social discourse. Collaboration is an active learning process in which students need to be able to identify problems, understand existing solutions, explore creative possibilities, consult with peers and mentors, and then implement and disseminate results (Hazemi, Hailes, & Wilbur, 1998). Collaboration can contribute to the active construction of meaning, by prompting students to engage in idea generating (divergent thinking), idea linking (convergent thinking), and idea structuring (categorization and classification) (Gaddis, Napierkowski, Guzman, & Muth, 2000). As such, these methods are viewed as essential in the design of effective constructivist learning environments.

2.2.2. ICTs and Cooperative/Collaborative Learning

Several researchers have recently suggested that the processes of collaborative learning may be augmented through the use of ICTs (Warschaeur, 1997). Harasim (1990) noted that electronic communication enhances a sense of community in the classroom, which is an important element of collaborative learning environments. Clements and Natasi (1999) also suggested that engaging ICT-rich learning environments are likely to produce a greater frequency of quality interactions between members of collaborative groups. These tools are available for the collaborative group members to restructure the ways in which cognitive activities are carried out (e.g., the processes involved in classifying and ordering information).

Computer-Mediated Communication, or CMC, holds particular promise for enhancing collaborative learning processes. CMC is broadly defined as a process in which people situated in different contexts use computers to communicate and engage in the process of collaboratively shaping media for a variety of purposes. Harasim (1990) argued that CMC has the potential to radically transform learning processes within classrooms. In the traditional classroom, a small group of students will often monopolize the discussion and conversation. CMC, however, has the potential to provide opportunities for all students to participate in classroom discussions by providing sufficient time for students to make such contributions. As a result, CMC may enhance peer-to-peer interactions and distribute group participation more fairly within the classroom (Jonassen, Davidson, Collins, Campbell, & Haag, 1995). It has also been found that CMC may increase student-directed conversation and participation because the teacher's role shifts from that of content expert to facilitative guide (Gaddis et al., 2000). According to Wagner and McCombs (1995 p.2):

> …instructors are able to observe students' contributions to discussion, obtain a record of the discussion for future feedback, participate in the discussion to model critical-thinking skills, and ask questions to coach critical thinking, providing expertise when necessary.

A large body of research has now accumulated on the effects of CMC on student learning processes. In one recent study by Jeong (2003), group interactions and critical thinking were examined in online threaded discussions. The purpose of this study was to conduct a preliminary test of a software tool (The Discussion Analysis Tool, or DAT) designed to perform complex and extensive computations required in event sequence analysis. The participants were 34 Masters of Business Administration graduate students (10 women, 24 men) enrolled in a face-to-face course in Business Ethics at a major Midwestern university in the United States. The findings indicated that interactions which involved conflicting viewpoints promoted more discussion and critical thinking. It was suggested on the basis of these results that tools such as DAT will be useful for empirically testing interactions and structures that enhance online discussions, providing the basis for more systematic testing of instructional interventions and computer–conferencing technologies.

The integration of computers and collaborative learning has prompted the development of a new area known as Computer Supported Collaborative Learning (CSCL). In general, CSCL is viewed as facilitating flexible, open, and cooperative learning (McConnell, 1994). CSCL can be conducted either synchronously or asynchronously. In synchronous discussions, all participants must be online at the same time. In asynchronous discussions, learners can participate at any time or place. Asynchronous learning holds major benefits for learners. As there is no pressures to respond immediately, learners take advantage of unlimited time constraints to develop a better understanding and produce a significant contribution to the group discussion. Conversely, the asynchronous approach can hinder "on the spot" discussions, since learners are not required to be online simultaneously.

The combination of collaboration and computer support may enhance student performance and outcomes, particularly in terms of cognitive processes, self–esteem, social development, and learning motivation. The intersection of these two domains (collaborative learning and computer-assisted learning) has led to the development of a body of research focused specifically on the effects of peer interaction within ICT-rich learning environments.

Several studies have indicated positive effects for students who participate in CSCL environments in terms of cognitive processes and outcomes. Cuthbert (1996) investigated the role of internet resources in collaborative design from an educational perspective. In this study, 140 secondary level students searched the World Wide Web (WWW) for information relevant to a design task involving the storage of heat and the regulation of temperature. A collaborative environment was then added where sites selected by students were automatically added to a publicly accessible and searchable

Web form. Findings showed that the methods used were effective in improving students' skills in problem definition, decision-making and justification.

Other research has demonstrated links between high student engagement rates and collaborative online learning environments. For example, McMurray and Dunlop (1999) conducted a study to examine the extent to which online collaborative technologies improve the quality of learning in distance education programs. A pilot program was employed, involving the design, delivery and evaluation phases of a suite of courses offered to off-campus undergraduate students at Southern Cross University. A "learning space" was then created that allowed online collaboration as well as self-paced individual learning using multimedia materials. Results indicated positive effects of online collaboration on skills such as critical thinking, problem-solving, and the ability to work collaboratively. The asynchronous communication initiated and sustained by student-to-student interaction proved to be a highly successful feature of this pedagogy.

CSCL has also been used to facilitate specific collaborative learning processes. For example, McDonald and Relan (2003) examined the effects of peer modelling through CSCL on performance and cognitive monitoring skills among high- and low-achievers. It was hypothesized that exemplary verbal modelling (articulation) of metacognitive skills by high-achieving students, while learning in cooperative learning groups would enhance the development of such skills amongst both high- and low-achievers. One hundred and eighty seven sixth-graders were assigned to work either in heterogeneous ability pairs (one high and one low achiever) or homogenous ability pairs (high-high and low-low achievers). Pairs then worked either in an articulation or a no articulation condition. Data gathered through pretest and posttest in computer- based lesson in cooperative learning groups. Results indicated that requiring articulation improved performance in the heterogenous groups, but hindered the performance of high–achieving students working in homogenous groups. It should be noted that in this study, however, students were assigned to groups using a median split. It is possible, therefore, that some of the students placed in the “high” and “low” achievement categories were in fact in the middle of the distribution. It is difficult to judge, therefore, what the actual effects on high-achieving students were on the basis of these outcomes.

Other studies have examined the use of CSCL combined with more traditional collaborative methods. For example, Gaddis, Napierkowski, Cuzman and Muth (2000) examined differences in collaborative learning between the online and the network classroom version of English writing composition classes. Both classes used the same technology, but one included a face-to-face component while the other did not. The study specifically focused on how the collaborative experience differed in these two environments and how any differences would be projected in the writing processes and products. Participants were 18 on-campus student and 15 online students at the University of Colorado at Colorado Springs. Data were gathered through pre-post surveys and research-based papers. Results indicated that students enrolled in the online class tended to be more independent learners, valuing collaboration less than did on-campus students. This suggests that, in order to build values in collaboration, collaborative exercises should not be conducted exclusively through the use of ICT – instead, some combination of ICT communication and face-to-face interaction may be optimal. However, Gaddis et al. (2000) cited several limitations for this study. Most importantly, students were not randomly assigned to conditions – they had the choice of entering either the network or the online classes. Therefore, it is possible that the differences observed in the study existed before the students participated in the collaborative exercises.

2.3. WKF AS A COLLABORATIVE LEARNING TECHNOLOGY

Researchers such as Crook (1990) and Roschelle and Teasley (1995) have argued that different types of educational software may facilitate different forms of interaction and learning outcomes amongst students working in cooperative or collaborative situations. In particular, Roschelle and Teasley (1995) argued that good collaborative technologies function by allowing the members of a group to find a coherence and organization that provides clear direction for future action.

Computer Supported Intentional Learning Environments (CSILE) represents an example of a collaborative technology that meets Roschelle's (1995) criteria for an effective collaborative technology. CSILE is an electronic group workspace designed to facilitate student learning by providing support for thinking, understanding, and knowledge building. CSILE is the first network system to provide across-the-curriculum support for collaborative learning and inquiry. The latest version of CSILE is known as Web Knowledge Forum (WKF). In this present paper, the term CSILE is used in describing and reviewing the former version of WKF.

In WKF, students use a communal database to collaborate with other students and with teachers on curriculum and ideas. WKF is grounded in the notion of cognitive-based research projects. Students generate *nodes* (a function available in the network to construct, gather and replicate ideas), that contain information relating to the topic under study. Nodes are available for others to comment on, leading to dialogues and an accumulation of knowledge. Text and graphic notes in all curriculum areas are entered into the same database, where all members on the network can access them. Participants may comment on each other's notes and authors are notified when comments have been made. Unlike in traditional learning approaches, where the discussion takes place in the classroom and finishes at the end of the lesson, WKF provides a permanent record of the discussion that can be assessed by anybody at any place and time through network facilities.

WKF differs from other online collaborative learning programs such as Blackboard. WKF is designed to build knowledge collaboratively and this process is supported with selected scaffolds to develop higher levels of thinking (Scardamalia, 2004). The lists of scaffolds offered in WKF are: (i) My theory, (ii) I need to understand, (iii) New information, (iv) This theory cannot explain and (v) Putting our knowledge together. The scaffolds notes allow the students to represent their ideas systematically based on their knowledge.

Blackboard is another technology learning tool that offers online collaborative discussion facilities to enhance students' learning outcomes (http://www.blackboard.com). The program allows students to engage in asynchronous as well as synchronous interaction and build threaded discussion. However, Blackboard does not provide a set of 'thinking labels' that can assist students' understanding and thinking processes. This contrasts with what is offered in WKF, in which the scaffolds significantly facilitate students' deep analysis of the materials discussed, increasing the likelihood of engagement in critical thinking.

For several years, the WKF team at the Ontario Institute for Studies in Education (OISE) has been exploring the impact of WKF on student learning processes and outcomes, as well as on teachers' instructional approaches. WKF is well documented and illustrated, and is viewed to have great potential for use at the school level. Studies have also suggested that WKF is able successfully to support the teaching of several disciplines across various levels and also at the postgraduate level.

2.3.1. Key Principles Underpinning WKF

One of the main principles of WKF stems from the notion of distributed cognition within collaborative contexts. Hewitt and Scardamalia (1998) argued that distributed cognition can be viewed from three different perspectives: the situative, the cognitive, and a mixture of these two. From the situative perspective, learning occurs in relation to the specific context or environment in which it occurs (Accetturo, 1996). From the cognitive perspective, cognition is a result of one's mental processes and internal understanding (Hewitt & Scardamalia, 1998). The integration of these two concepts intertwines individual cognition together with the situation, people and tools which mediate the learning processes. WKF sustains the principle of distributed cognition, in which it enables learners to perform individually through collective contribution.

Several aims of WKF are aligned directly with principles implicit to distributed cognition. These include the need to:

(1) support educationally effective peer interactions,

(2) integrate different forms of discourse,

(3) focus students' attention on communal problems of understanding,

(4) promote awareness of participants' contributions,

(5) encourage students to build on each other’s work, and

(6) emphasize the work of the community in learning processes.

The concept of distributed cognition was elaborated by Scardamalia (2002) in an article on WKF roles in fostering collective cognitive responsibility for the advancement of knowledge. In collective responsibility, students share the same responsibility to complete learning tasks. These responsibilities no longer fall exclusively to the group leader/s. In traditional classroom learning, teachers tend to have sole cognitive responsibility. As a result, learning is not collectively demonstrated. This recognition led Scardamalia to explore possibilities for integrating technology and collaborative learning in classrooms. WKF was developed as a tool with the potential to address these issues. WKF prompts students to build knowledge constructively together as a group by implementing twelve education core principles:

1) Real ideas and authentic problems – students build knowledge based on real questions about the outside world. These questions can be raised by the students themselves, representing topics they themselves wish to explore further.

2) Improvable ideas- the ideas are not static and answers can be improved and changed. This is the principle of building knowledge in which students “build” and improve on the knowledge generated by themselves and others.

3) Idea diversity – in the process of building knowledge, it is common for students to diversify their ideas. For example, there will typically be parts of an assignment which is not fully understood by particular students, which will prompt new discussions. Diversification can result from the solving of such problems.

4) Rise above – by improving ideas which will generate new understandings and concepts, students develop more comprehensive and detailed views of given topics.

5) Epistemic agency – students can, and should, organize how to enhance their own knowledge by working together and monitoring their own progress. This is part of cognitive strategy use within collaborative learning contexts.

6) Community knowledge, collective responsibility – students must understand that it is their responsibility to improve their knowledge together as group, not as individuals.

7) Democratizing knowledge – All students should have the equal chances to participate and contribute to ongoing discussions.

8) Symmetric knowledge advancement – individuals and communities should work parallel to gain and build knowledge.

9) Pervasive Knowledge building – students' skills in fostering knowledge building as a group can extend to other contexts, such as daily problem-solving tasks.

10) Constructive uses of authoritative sources – in contributing information, tools such as WKF can encourage students to construct knowledge based on authoritative sources.

11) Knowledge building discourse – The structure of knowledge building supports the advancement of knowledge through discourse facilities.

12) Concurrent, embedded and transformative assessment – students are able to monitor their own progress and give evaluations on their own work. They can later proceed to the next level by assessing their own progress.

Over the past two decades, a significant body of research has accumulated on the effects of WKF on student learning processes and outcomes across a broad range of levels and contexts. These studies have largely examined effects in terms of learning outcomes, learning processes, and teaching and learning processes.

2.3.2. Effects of WKF on Student Learning Outcomes

Several studies have examined the effects of WKF on students' learning outcomes. Early studies on WKF focused on examining the effects of this program in promoting in-depth understandings of learning tasks and collaborative learning processes. For example, Woodruff and Brett (1993) examined the effects of CSILE/WKF on the learning achievement of six to eight year old students. In this study, students worked either under CSILE/WKF or a traditional approach over one school term. Students in the CSILE/WKF condition comprised 6 first grade, 11 second grade, and 8 third grade students. In the traditional group, there were 6 first grade, 5 second grade, and 11 third grade students from the same school. Data analyses were taken from teacher interviews, survey and classroom experiment. Teacher interviews indicated that, in general, while CSILE/WKF students engaged in fewer activities over the period of the intervention, they covered each activity in more depth and for longer periods of time than did those in the traditional class. Significant differences were also found in favour of CSILE/WKF on measures of feedback and substantive guidance at three levels of knowledge (high, low and general), and on measures of constructive collaboration.

Shortly after the study conducted by Woodruff and Brett (1993), Lamon, Chan, Scardamalia, Burtis and Brett (1993) examined the effects of CSILE/WKF on learning outcomes in text comprehension. One hundred and ten elementary school students participated either in two-non CSILE/WKF or three CSILE/WKF classes. Results showed that from Fall to Spring, CSILE/WKF students' conceptions of learning became more mastery-oriented. These students also improved more in both problem-solving and recall of central concepts than did non-CSILE/WKF students. It was concluded that CSILE/WKF promoted superior understanding, rather than memorization of facts, than did the alternative, more traditional approach. Similar results were reported by Van Aalst (1999) in a study of WKF with fifth- and sixth-graders in science.

In a longitudinal study conducted by Lamon, Reeve and Scardamalia (2001), the impact of WKF on primary-level classroom learning processes were studied over a one-year period. Participants were 22 fifth- and sixth-grade students, including 11 boys and 11 girls in a physical science class. Data analyses were based on the discourse sessions recorded in the database, videotapes of student discussions, student activities recorded in the database, and pre–posttest knowledge. The findings indicated that students who engaged in knowledge building discourse around central features of physical science improved and gained significantly over the one-year period. There was, however, no comparison group within this study. It is difficult, therefore, to determine the extent to which WKF produced *additional* benefit over more traditional methods on the basis of these results.

The role of WKF in fostering scientific inquiry was studied by Hakkarainen (2004), in a unit focusing on force, electricity and cosmology. Each of the projects conducted by students extended over four to six weeks, with the intervention as a whole extending over an entire school year. Participants were 28 fifth and sixth grade public school students in Toronto. Students' written entries in the WKF database were then analysed using both qualitative and quantitative analysis methods. Results indicated that under

WKF, students demonstrated higher levels of inquiry-driven questions and generated superior scientific theory explanations.

Oshima (2005) also conducted a longitudinal study of WKF effects on 5th graders within a Japanese elementary school. In the first year study, 41 grade fifth students learned a science topic on “genetically modified foods” for 23 classes. The second study involved the same teacher with another class of 5th graders. Results indicated that students posed significantly higher level questions when working under WKF, as well as posing more explanation-based questions. Students also demonstrated higher levels of self-regulation in monitoring their own knowledge levels. This study suggests that WKF has the potential to promote higher level thinking skills and strategies in a range of different cultural contexts.

Also in science, Oshima et al., (2002) explored the effects of WKF on 4th and 5th graders in a Japanese elementary school over a two-year period. In the first year of the study, the 4th grade lesson plans were designed together with the classroom teacher to suit WKF. Students' learning activities were assessed, and showed little evidence of deep understanding over this time period. In the following year, however, the 5th grade lesson plans were modified to emphasize understanding of concepts and explanations. Results in this year showed that students were significantly more engaged in higher-level cognitive processes than they were in the previous year. This study suggests that WKF is likely to be more effective as a knowledge-building tool when lessons are structured to encourage higher level cognitive processes.

WKF has not, however, been found to produce positive effects on students' learning outcomes in all studies. Korbak (1997) examined reflective processes on written composition in fifth/sixth grade classes in three experimental groups: One CSILE/WKF group, and two traditional comparison groups. Opinion essays written in 45-minute sessions in each class were rated on 13 dimensions using a three-point scale. No significant difference between the classes was found for CSILE/WKF on an essay score. Further comparisons indicated significant results in favour of CSILE/WKF, but only on the reflection factor. This result suggests that the efficacy of CSILE/WKF can vary, depending possibly on the nature of the tasks assigned to students working under the approach.

Interestingly, little research has been reported on the effects of WKF at the secondary school level. In one study by Tan, Yeo and Lim (2005), the potential for WKF to foster scientific inquiry processes within collaborative groups of 7th graders was examined. Based on an eight-week implementation with a science research course, findings indicated that students employed more in-depth inquiry and demonstrated more confidence in learning science under WKF than under other methods. This study suggests that although many implementations of WKF have been relatively long-term, it is possible to see effects from this program over shorter time periods.

2.3.3. Effects of WKF on Student Learning Processes

Several studies have also been conducted to explore students' learning and thinking processes under WKF. In a series of five studies designed to explore whether WKF could facilitate inquiry processes in 10-11 year old children, Hakkarainen (1998) found that with the introduction of CSILE/WKF, classroom cultures changed from being dominated by factual learning to a focus on in-depth explanations with collaborative interaction, with students demonstrating the ability to engage in increasingly deep levels of explanation. The finding suggests that CSILE/WKF can have a significant positive impact on students' inquiry processes.

WKF has also been explored as a means by which teachers can promote active and self-regulated learning. Caswell and Lamon (1998), for example, conducted a two-year study to investigate the impact of CSILE/WKF on children's scientific literacy. Grade four students from the Institute of Child Study in Toronto studied under CSILE/WKF for two full school years. Students' videotapes, interviews, written work in CSILE/WKF and research journals while working on Biology unit were used for data collection. Results indicated significant gains made throughout the CSILE/WKF intervention period in terms of students' learning, thinking and motivation processes.

A number of previous studies on WKF have examined its effects on students' metacognitive processes. Metacognition generally refers to a student's knowledge of, and ability to regulate, their own thinking processes (Biehler & Snowman, 1997; Weinert, 1987). In one study of the impact of CSILE/WKF on metacognitive processes, (Oshima, 1993), 30 students in the 5th and 6th grades studied "Gravity and the Solar System" either in a face-to-face collaborative group or through collaboration via CSILE/WKF. Qualitative analysis of the data collected showed that metacognitive activities (monitoring and coordinating other students work) in CSILE/WKF classes improve significantly over the intervention period. Quantitative results further indicated a significantly higher level of some forms of metacognition in the CSILE/WKF versus the face-to-face collaborative groups. Similar findings have been reported more recently in other subject areas (e.g., Hurme & Jarvela, 2001).

2.4. BARRIERS TO SCHOOL-BASED ICT INTEGRATION

Despite the significant advantages that have been found for the use of ICTs in promoting classroom teaching and learning processes, these tools are unlikely to have favourable effects unless their use is integrated fully into teachers' normal classroom practices. Although the potential of ICT to transform teaching and learning processes in classroom is widely recognised, large-scale surveys have indicated consistently that the majority of teachers do not regularly incorporate the use of ICT into their regular classroom activities (Alfred & Marcus, 2002; Baylor & Ritchie, 2002).

As Norton and Wiburg (2003) argue, this is likely to hinge largely on a combination of technical factors and teachers' ability to incorporate ICTs effectively into their lesson plans. To reap the full benefits of ICTs as learning tools, it is necessary to operate on a comprehensive model of all the factors that can influence integration efficacy within schools. Earlier studies have suggested that lack of comprehensive ICT application is related to two main types of factors: (i) teachers' beliefs and skill levels, and (ii) school infrastructure and technical resources.

2.4.1. Teachers' Beliefs and Skill Levels

Teachers' self-confidence, interest and willingness to use ICT in their classrooms have been found to significantly impact the outcomes of ICT integration (Galanouli, Murphy,

& Gardner, 2004; Yoon, Ho, & Hedberg, 2006). For example, Edmonson and Fisher (2002) found that teachers' attitudes towards ICTs can lead them to construct their own understandings about the extent to which these should be integrated in the classroom. Teachers with positive attitudes are more likely to be open and willing to explore the possibilities of what ICT can offer for them.

Other key factors in the efficacy ICT integration include teachers' beliefs about their own skill levels, and their actual ICT-related skill levels. McCoy (1999) noted that teachers who have computer skills generally feel more confident in their ability to implement computer based lessons. Further findings also suggest that teachers who believe that their own ICT skills are lacking may not make use of these tools for fear of appearing incompetent to their students (Tuovinen & Sweller, 1999). Actual skill levels have also been found to act as an important moderator of outcomes from ICT integration efforts. The National Education Performance Monitoring Workforce (NEPMW) report, for example, showed that low ICT skill levels in teachers is a major barrier to promoting students' ICT skills and knowledge (Minesterial Council on Education Employment and Training and Youth Affairs, 2000).

In light of the above findings, it is critical that teachers be given sufficient time in which to modify and adapt their lesson plans to include the use of ICT-related tools. Despite this, time constraints are frequently cited as a major barrier to ICT integration by teachers (e.g. Mortan, 1996; OFSTED, 2002; Preston, Cox, & Cox, 2000). With the rapid development of ICT-based classroom tools, many teachers may feel unable to cope with latest innovations in the area, and are thus unlikely to make full use of these tools within their own classrooms.

A further factor that can hamper teachers' efforts to integrate ICTs in the classroom is lack of professional development and training (Galanouli et al., 2004; Hennessy et al., 2007; Lim, Pek, & Chai, 2005). Teachers typically report that having access to adequate ICT training can increase their self-confidence and assist them to see the full potential of ICT tools in teaching and learning (Dunmore, 2000; McCarney, 2004; Williams, Wilson, Richardson, Tuson, & Coles, 1999). Frequently, however, financial and time constraints make it impossible for teachers to receive specific training on particular ICT-based tools and/or programs. This also, then, can reduce the efficacy of teachers' efforts to make use of these tools in the classroom.

2.4.2. School Resourcing and Infrastructure

Poor resourcing (e.g., inadequate technical advice) within schools has also been found to act as a major barrier to ICT integration efforts. In a 2005 interim report on ICT integration in Scottish schools (HM inspectors of Education, 2005), the committee highlighted the need for schools to provide computers in every classroom. This report also highlighted the need for all computers to be connected to the Internet. This can, however, be difficult when classroom sizes are small.

This report further stressed the need for schools to provide adequate technical support for all teachers who wish to make use of ICTs in their teacher. Again, however, financial constraints can impact the extent to which individual schools are able to provide these facilities. Reliability of the ICT equipment and other difficulties with networks, as well as insufficient technical support, can also impact ICT integration efforts dramatically. Katz (2002) emphasized that technological infrastructure is critical for the success of ICT integration.

2.5. STUDY RATIONALE AND AIMS

All of the barriers mentioned above are likely to have a dramatic impact on the efficacy with which WKF can be implemented in classrooms. Therefore, although many ICT-based tools described in the literature have been found to produce positive effects on students' learning outcomes and processes under some circumstances, these effects are likely to vary considerably across field settings. Teachers must frequently adapt programs to suit various constraints imposed upon them within specific settings (e.g., resourcing). In the use of sophisticated tools, this can render the program/s ineffectual, and lead to a loss of confidence in the tool itself.

Many ICT-based tools can be difficult to use for first-time implementers. Although most programs provide standardized guidelines for use, teachers frequently do not have access to the in-depth and hands-on training required to become fully fluent in the use of these tools. Again, this can render the tool/s ineffectual and lead to a loss of confidence in the tool itself.

The overarching aim of the current research was, therefore, to examine how one school that had never previously been exposed to WKF chose to use the tool, and the impact that this use had on students' learning outcomes and processes. Three studies were conducted to address this overarching aim:

- Study I was a preliminary study. This study was conducted solely to produce a reliable and valid means by which to assess changes in students' metacognitive skills over the intervention period in Study II.

- Study II was designed to document and evaluate one teacher's efforts to integrate WKF within his normal classroom practices. This quantitatively-based case study was designed to highlight key factors that might impact outcomes obtained within field applications of WKF, and on that basis, to provide a list of recommendations for other first-time users of this program.

- Study III was conducted to further explore beginning teachers' perspectives on their efforts to use WKF for the first time, and to seek recommendations from these teachers for others who might make such efforts in the future.

The research reported in this thesis makes an original and significant contribution to research on WKF for several reasons. Most important the study was *not* designed as another evaluation of what WKF *can* do under idealized conditions – the goal of the study was to document, evaluate, and develop recommendations from, the efforts made in a real field setting to implement WKF for the first time. Thus, the recommendations made on the basis of the study results are likely impact future teachers' efforts to integrate this popular learning tool into their own practices.

Chapter 3

STUDY I: DEVELOPMENT AND VALIDATION OF METACOGNITION MEASURE

3.1. INTRODUCTION

A major benefit cited previously for WKF lies in its ability to prompt the development of students' metacognitive skills. Generally, metacognition is defined as knowledge about one's cognitive functioning (Flavell, 1979). de Jong and Simons (1992) define metacognition more specifically as a "concrete, observable cognitive activity in which students explore their learning tasks and monitor and regulate their learning processes during task construction" (p. 21). From an educational perspective, metacognitive skills are well aligned with the criteria listed for self-regulated, independent and active learning. All emphasize higher-level thinking skills such as planning and goal monitoring, analysing and evaluating information, and applying these principles to make effective learning decisions.

Although metacognition tests and inventories have been used widely in school settings, there remain few reliable and valid instruments available to assess metacognitive skills and knowledge at the middle and secondary school levels (Mokhtari & Reichard, 2002). Further, few of the instruments developed thus far have been evaluated thoroughly for their correlation with key external criteria such as teachers' ratings and actual knowledge of metacognitive strategies based on open-ended tasks. Study I, therefore, was conducted to first establish a valid and reliable means by which any changes in students' metacognitive skills under WKF could be assessed.

Several instruments have been developed to assess metacognitive skills in college and university students. One example is the 52-item Metacognitive Awareness Inventory (MAI), constructed to measure adults' metacognitive awareness levels (Schraw & Dennison, 1994). Validation studies with undergraduate students have suggested that this instrument comprises two major factors: knowledge of cognition, and regulation of cognition. Knowledge of cognition is related to what students know about themselves and the conditions under which they should apply their strategies. Regulation of cognition is associated with students' knowledge about their planning strategies, monitoring, error-checking, and evaluation. These factors were found to be highly reliable in the validation studies. Despite this, the complexity of the language used in the inventory would make it unsuitable for use at the secondary level.

Another widely used, existing metacognition instrument is the Metacognition Inventory by O'Neil and Abedi (1996). This instrument has also been validated in several experimental studies (Khabiri, 1994; Kosmicki, 1993; O'Neil, Sugrue, Abedi, Baker, & Golan, 1992), and comprises 20 items on which students report on their own thinking processes. There are four factors of five items each in the instrument (planning, monitoring, cognitive strategies and awareness). Results of validation studies have indicated that this inventory is valid for 12^{th} graders and older participants, but not recommended for 8^{th} graders or younger students. At lower grade levels, lower reliabilities have been recorded. This may again be due to the difficulty levels of the vocabulary used in the scale.

One metacognition inventory that has been used at lower grade levels is the Knowledge Monitoring Assessment (KMA) developed by Tobias, Everson and Laitusis (1999). The KMA evaluates how well students perform on a task by comparing their actual and predicted knowledge. Results with female students from grades 9 to 11 have indicated acceptable internal reliability and construct validity for this instrument. Despite this, the KMA is relatively difficult to implement, requiring that students predict the likelihood of their success on specific types of items. This kind of measure is not suitable for measuring more general metacognitive skills such as planning and evaluation.

Howard, McGee, Hong and Shia (2000) also developed the Inventory of Metacognitive Self-Regulation (IMSR) to assess intervention outcomes in class. This instrument includes 37 items, and represented a combination of two existing inventories related to metacognition and problem solving: The Junior Metacognitive Awareness Inventory (Dennison, Krawchuk, Howard, & Hill, 1996) and the How I Solve Problems scale (Fortunato, Hecht, Tittle, & Alvarez, 1991). Factor analysis and reliability analyses with participants from grades 6 through 12 indicated five major scale factors: knowledge of cognition, objectivity, problem representation, subtask monitoring, and evaluation. Although this scale is applicable to the middle and secondary school levels, a large component of the scale focuses on generic problem-solving, rather than metacognition per se.

Based on this review, few instruments have been made available to assess metacognitive skills at the middle and secondary levels. Of the measures available, these are either intended to be used with older students or adults, or assess metacognitive skills only in specific areas. Furthermore, while these measures have often been subjected to various validation methods (e.g., factor analysis, reliability checks), rarely has there been any attempt to confirm the convergent validity of these instruments with alternative measures.

It is possible that when students are asked to self-rate their strategy use, those less familiar with the strategies will give themselves higher ratings. This may not reflect any form of response bias, but may be a product of their unfamiliarity with the strategies. These students do not have clear reference points for their judgements – for example, when a student is asked whether he/she checked his/her work whilst completing a task, it is likely to be unclear as to how thorough this check should have been. As a result, there is reason to question whether the ratings obtained from self-completed questionnaires are likely to correlate with those obtained either from teachers or from more open-ended tasks.

The aims of this study were, therefore, to (i) develop a closed-ended, self-rating instrument for assessing metacognitive strategy use in the middle to upper secondary levels, and (ii) assess the criterion-related validity of this instrument by comparing scores obtained on the scale with teachers' ratings and responses to open-ended metacognitive planning, cognitive strategy use, monitoring, and evaluation tasks. Given that the latter tasks provide students with no prompts on which they can base their responses, these open-ended tasks provided a valid measure of students' actual metacognitive levels. Scores on these tasks were then compared with those in the closed-ended section of the instrument.

3.2. METHOD

Participants for the validation sample were drawn from two schools located in two suburbs in Western Australia. Based on the data from the 2001 population census (Australian Bureau of Statistic, 2003) these two schools were located in areas that fell within the upper 25th and upper 50th percentiles of socioeconomic advantage/disadvantage in Perth, Western Australia. Table 3.1 indicates median ages, grade levels, and number of males and females for the resulting sample of 323 students.

Table 3.1.

Profiles of participating students

Year level	Median age	Male *n*	Female *n*	Total
7	12	45	16	61
8	13	19	24	43
9	14	18	106	124
10	15	17	30	47
11	17	10	21	31
ESL	17	8	9	17
Totals	14	117	206	323

3.2.1. Instrument Development

The instrument constructed was based on a comprehensive review of previous literature on assessing students' self-regulated learning and metacognition (e.g. Bloom & Krathwohl, 1956; Chapman, 2000; O'Neil & Abedi, 1996). The instrument constructed comprised one close-ended, and one open-ended, section (see Appendix 1). The close-ended section drew largely from an instrument proposed by the Victorian Department of Education (see Chapman & Cuttance, 2000), and included 29 items related to four factors of metacognitive skills: Planning (7 items: e.g., "Before I start working, I ask myself: What is the best way to learn the topic?"), monitoring (5 items: e.g., "While I am researching my topic, I ask myself, did I understand what I just heard, read and saw?"), Evaluating (7 items: e.g., "When I am finished my work, I ask myself: "What would have helped me do that task better (more time, better organisation)?") and Cognitive strategy use (10 items: e.g., "When I am starting a new topic, I ask myself:

How do the ideas “fit in” with what I already know?). A three point scale (1 = never, 2 = sometimes, 3 = always) was used to assess students’ responses to the items.

The open-ended questions were developed to assess similar metacognition skills, and also drew heavily on the instrument proposed by the Victorian Department of Education (see Chapman & Cuttance, 2000). There were four open-ended questions in this section. Each question asked the respondent to indicate the advice they would give to another student when they were approaching a new learning topic. Students were asked to indicate what they would recommend other students do:

(i) Before they start working (Planning),

(ii) While are were working (Monitoring),

(iii) When they face problems in learning the topic (Cognitive strategy use), and

(iv) After they finish their work (Evaluating).

Given that the above questions provided students with no prompts on how to respond, this open-ended section of the instrument was included to provide a genuine test of students’ metacognitive knowledge and skills. This section was then used to validate students’ responses to the closed-ended section of the instrument.

3.2.2. Procedure

Once ethics approval for the project had been granted, the researcher contacted the school principals and discussed the possibility of conducting the survey at each school. The researcher then visited all the classrooms from Year 7 to 11. During the first visit, the researcher gave a brief introduction and explained the purpose of the survey to the students. The information sheet and the consent forms (Appendices 2A and 2B) were distributed to the students at the end of the first visit. The information sheet indicated that all information given would be confidential and that no individual students would be identified.

About 472 consent forms were distributed and 323 were returned (a return rate of around 68%). The moderate number of returned consent forms may be attributed to a few factors. First, the survey was conducted in the middle of Term IV, when most of the Year 11 students were away at home, studying and preparing for finishing exams. Second, on the data collection day, some students were involved in a sport carnival. The questionnaires were administered within each classroom during the researcher's second visit to the schools. The data were collected from five Year 7, five Year 8, nine Year 9, six Year 10, and three year 11 classes, with one English as a Second Language (ESL) class. The students completed the questionnaires in 15 to 20 minutes. The entire data collection process took around two and a half weeks.

3.3. RESULTS

3.3.1. Closed-Ended Questions

Once the data collection was completed, the data were entered into SPSS Version 13 and LISREL 8.71 for further analysis. The 29 close-ended items were analysed with Confirmatory Factor Analysis (CFA). CFA has been described as more sophisticated than Exploratory Factor Analysis (EFA) (Tabachinick & Fidell, 2001). In CFA, the hypothesised factor structures are specified before the analysis is performed. The factors are usually established from mainly on the researchers' knowledge of previous research or other experiences related to the topic (Foster, Barkus, & Yavorsky, 2006). On the other hand, EFA is applied when there is not enough evidence to form hypotheses on the factors represented by the data.

CFA goals are to test the probability that a hypothesized factor structure is supported or confirmed by the data and to investigate the construct validity of an instrument. CFA is part of Structural Equation Modelling (SEM) and used extensively in the economics, social sciences and other fields where a number of complex relationships must be examined efficiently (Foster et al., 2006).

In this study, three models were compared: A four-factor model (planning, monitoring, cognitive strategy use and evaluating), a three-factor model (in which planning and cognitive strategy use were combined), and a one-factor model (in which all 29 items were loaded on a single factor). Descriptive statistics and abbreviated labels for the items are presented in Table 3.2. Bivariate correlations are presented in Table 3.3.

Table 3.2

Descriptive statistics for Metacognition items

Item Number and Label (n = 323)	*M*	*SD*
When I am starting a new topic, I ask myself:		
q1. How the idea "fit in" with what I already know?	2.11	0.56
q2. What should I do if I do not understand?	2.35	0.62
q3. Can I think of relevant examples from my own experience?	2.21	0.61
q4. Can I find pictures or examples that help me understand?	2.20	0.69
q5. Which information is the most important to remember?	2.64	0.80
q6. Which information do I need to learn first?	2.46	0.63
q7. How the ideas "fit in" with what we are learning in other classes?	1.90	0.69
q8. What are the main ideas or key themes?	2.26	0.65
q9. Can I use concept maps to get an overall picture of the topic?	1.81	0.70
q10. How the different bits of the topic "fit in together"?	2.15	0.65
Before I start working, I ask myself:		
q11. What is the best way to learn the topic?	2.27	0.66
q12. What should I do first?	2.61	0.58
q13. How much time I have to complete the task?	2.57	0.60
q14. Do I know what do I need to know in order to get started?	2.44	0.63
q15. Do I know where to get the information that I need from?	2.46	0.60
q16. How much time will I need to learn this?	2.23	0.68
q17. What are some strategies and tactics that I can use to learn this?	2.10	0.66
While I am researching my topic, I ask myself:		
q18. Did I understand what I just heard, read and saw?	2.47	0.60
q19. Am I on the right track?	2.45	0.59
q20. Should I use different ways to complete the task?	2.16	0.66
q21. Should I go slower or faster on this task?	2.15	0.70
q22. Do I know what to do if I don't understand something?	2.41	0.65
When I am finished my work, I ask myself:		
q23. What would have helped me do that task better (more time, better organisation)?	2.29	0.67
q24. How well did I do?	2.69	0.51
q25. What could I have done differently?	2.23	0.67
q26. What have I learned from doing this task?	2.23	0.63
q27. How can I use what I have learned here in other situations?	2.12	0.64
q28. Should I use the same strategies in doing my next task?	2.26	1.79
q29. Did I do as well as I could have on that task?	2.49	0.57

Table 3.3

Bivariate correlations for Metacognition items

	q1	q2	q3	q4	q5	q6	q7	q8	q9	q10	q11	q12	q13	q14	q15	q16	q17	q18	q19	q20	q21	q22	q23	q24	q25	q26	q27	q28	q29
q1	--	.07	.20	.11	.17	.15	.24	.13	.20	.28	.13	.06	.00	.14	.13	.06	.17	.14	.02	.08	.11	.15	.17	-.09	.01	.14	.24	.08	.06
q2		--	.05	.10	.18	.09	.05	.04	.02	.11	.05	.16	.05	.04	.07	.00	.10	.13	.09	.05	-.02	.21	.15	.15	.15	.01	.09	.03	.05
q3			--	.28	.00	.04	.26	.10	.20	.15	.18	.08	.08	.18	.09	.04	.19	.13	.00	.11	.16	.14	.17	-.05	.07	.12	.15	.17	-.01
q4				--	.14	.05	.10	.07	.21	.07	.17	.13	-.01	.14	.07	-.04	.15	.09	.09	.06	.00	.10	.14	.03	.01	.07	.22	.13	.01
q5					--	.31	.14	.20	.04	.24	.11	.18	.06	.13	.15	.09	.12	.07	.22	.04	.01	.12	.04	.22	.06	.11	.11	.13	.15
q6						--	.16	.19	.02	.18	.21	.24	.03	.10	.05	.10	.16	.07	.12	.08	.08	.06	.21	.08	.10	.14	.13	.06	.14
q7							--	.12	.20	.16	.20	.02	-.01	.19	.14	.08	.13	.07	.01	.08	.16	.09	.16	.00	.12	.15	.23	.15	.02
q8								--	.19	.25	.13	.15	.20	.26	.10	.19	.25	.13	.18	.05	.02	.14	.14	.11	.10	.27	.17	.10	.13
q9									--	.15	.19	-.02	.09	.15	.04	.08	.14	-.01	-.01	.15	.19	.14	.10	-.04	.00	.15	.15	.14	-.02
q10										--	.17	.14	.19	.20	.05	.17	.17	.23	.09	.10	.15	.21	.06	.04	.10	.20	.15	.26	.11
q11											--	.21	-.03	.11	.13	.09	.29	.22	.13	.27	.13	.10	.24	.02	.11	.14	.26	.10	.06
q12												--	.26	.23	.23	.13	.10	.24	.22	.16	.05	.13	.16	.13	.16	.21	.06	.10	.15
q13													--	.31	.25	.32	.21	.14	.18	.01	.07	.24	.13	.14	.16	.16	.03	.19	.22
q14														--	.30	.32	.29	.20	.23	.16	.19	.20	.19	.12	.21	.29	.23	.13	.12
q15															--	.29	.28	.16	.19	.09	.07	.20	.11	.16	.20	.18	.18	.14	.11
q16																--	.30	.12	.25	.12	.06	.20	.14	.06	.19	.25	.14	.20	.07
q17																	--	.17	.18	.23	.16	.25	.18	.09	.15	.23	.36	.17	.12
q18																		--	.27	.16	.21	.15	.22	.10	.14	.16	.16	.00	.09
q19																			--	.20	.02	.21	.13	.28	.13	.15	.12	.07	.18
q20																				--	.15	.25	.14	-.01	.19	.23	.22	.11	.11
q21																					--	.15	.07	.01	.16	.09	.12	.14	.09
q22																						--	.18	.13	.26	.36	.15	.08	.14
q23																							--	.12	.24	.19	.17	.07	.19
q24																								--	.23	.12	-.04	.11	.22
q25																									--	.30	.15	.10	.24
q26																										--	.27	.23	.15
q27																											--	.22	.11
q28																												--	.12
q29																													--

Results for the three CFA models on the closed-ended items are summarized in Table 3.4. To measure which of the models fit the data best, several indices were used. Absolute fit indices assess how closely a model is able to replicate the actual covariance matrix (Foster et al., 2006, p. 109). Amongst the most commonly used indices are:

(i) Chi-square (χ^2) and chi-square/df ratio (χ^2/df) – Given that the chi-square statistic is influenced heavily by sample size (Bentler, 1990; Joreskog & Aish, 2006) it is not generally used as the sole measure of model fit. The (χ^2/df) is often used as an alternative to χ^2. Byrne (1998) suggests that χ^2/df values of less than 2 are acceptable.

(ii) Goodness of fit index (GFI), Comparative Fit Index (CFI), Non-Normed Fit Index (NNFI) - GFI indices ranges from 0 to 1, with values exceeding 0.9 indicating good fit (Kelloway, 1998). CFI ranges similarly from 0 to 1, with values above 0.9 indicating good fit (Hu & Bentler, 1999). NNFI is has range of 0 to 1, with values approaching 1 indicating a better fit (Foster et al., 2006).

(iii) Root Mean Squared Error of Approximation (RMSEA) - RMSEA is a measure of fit that "could be expected if the model were estimated from the entire population, not just the samples drawn for estimation (Zhang, 2001). If the lower bound of RMSEA is less than .05, this indicates that the model has close approximate fit in the population. It is the same for the upper bound, which shouldn't be more than the cut-off value selected as an indicator for poor fit (Kline, 2005). Loehlin (1998) indicated that values below 0.100 are considered to be indicative of good fit, while Bentler (1990) and Schumaker and Lomax (1996) suggest that the values less than 0.06 indicate good fit.

One aim of the socio-behavioural sciences is to find the model that has the fewest parameters. This will provide the simplest or most parsimonious explanation of the data (Cramer, 2003). Thus, to find the best model it is essential to compare nested models to identify the most parsimonious model that still has adequate fit.

As indicated in Table 3.4, all three of the models approximated adequate fit. However, significance tests indicated there were significant differences between all three models. Thus, the Four-Factor, which demonstrated the best fit, was eventually retained for the purposes of computing the subscale scores (see Figure 3.1).

Table 3.4

Goodness of fit measures

Model	χ^2	*df*	χ^2/df	*GFI*	*RMSEA*	*NNFI*	*CFI*
One-factor	739.43	377	1.96	.88	.05	.88	.86
Three-factor	725.09	374	1.93	.89	.05	.88	.89
Four-factor	664.49	371	1.79	.88	.05	.90	.91

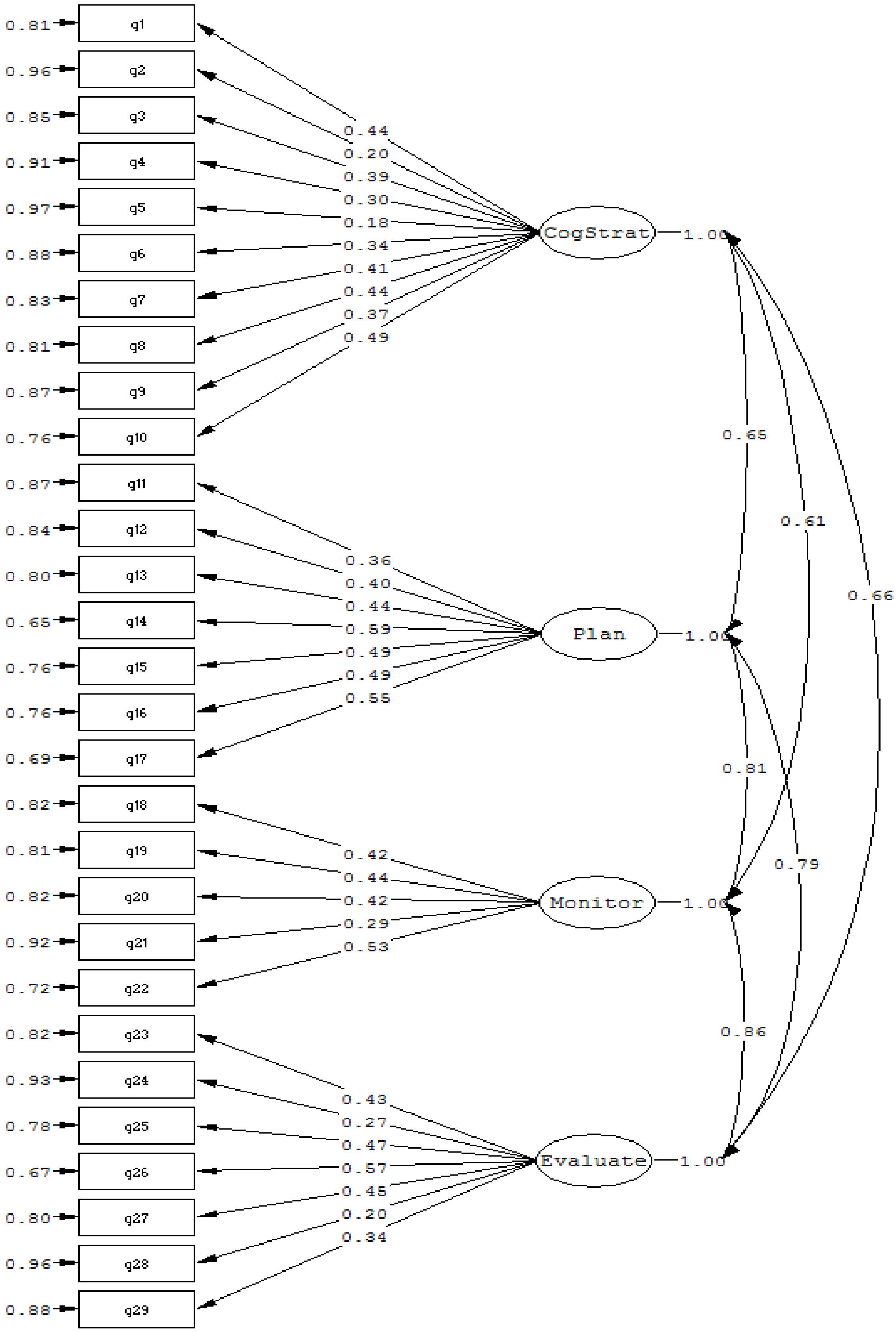

Figure 3.1 *Correlated Four-Factor model*

3.3.2. Open-Ended Questions

The open-ended questionnaires consisted of four related questions on students' planning, monitoring, cognitive strategy use and evaluating skills. Based on the students' responses in the open-ended section, a rubric was generated to assess the students' open-ended responses to the second section of the metacognitive skills inventory. Inter-rater reliability methods were then used to verify that the criteria could be applied reliably. Examples of responses that were credited under each of the categories in the questionnaire are listed in Figure 3.2.

<u>Responses given in the open-ended Metacognition skills:</u>

If you had to teach another student how to learn a new topic in class, what kinds of things would you tell them to do:

Before they start working ? (Planning skills)

1. Brainstorming
2. Skim through the task/browse through
3. Relates to past experiences – what they already know about the task, their prior knowledge.
4. Set a goal/aim on what they want to achieve at the end of the lesson.
5. Set a focus question.
6. Understand what the task is all about – what the task require you to do, what is the main idea.
7. Do the concept maps – how the information connected together.
8. Set your time plan.
9. Plan on your task.
10. General orientation about the task – e.g. the benefits of the task, the fun bit of the task, the application of the task outside the classroom.
11. Be prepared to learn new things – get organised, think positive and listen properly.

12. Do some additional research on the task thus you can have comprehensive picture about the task.
13. Follow guidelines if provided.
14. Clarifies any difficulties – get everything clears before proceeds.

While they were working? (monitoring skills)

1. Check their work based on the time plan.
2. Ask questions when they don't understand (ask for help).
3. Check whether they are on the right track.
4. Check if they got any problems.
5. Regularly check if they understand the task given.
6. Think about what they are writing for that particular task.
7. Have they got the information needed that can help them finish the task.
8. Use examples, clues or tools (e.g. picture, graphs, graphics) to help them understand better.
9. Do practical learning – do some experiments.
10. Use technology to find additional information that can help them understand (e.g. internet, computer supported collaborative learning).
11. Learn step by step (gradually).
12. Makes notes.
13. Concentrate/focus on the task and the key ideas.
14. Relate it to other things outside the classroom (application wise).
15. Discuss, share and compare ideas with other people such as learning in groups.
16. Check and compare their progress with the marking criteria – thus, they know where they are up to, their level.

When they came across a difficult problem?(Cognitive strategy used)

1. Ask for a help – either from teacher, friend or parent.
2. Look again at the task, try to understand the basic problem – figure out step by step on what they don't understand, breaking the problem down into a number of smaller problems.
3. Working backwards from the goal to the unsolved initial problem.
4. Refer back to their notes.

5. Try to look at the task from different perspectives/ explore other possibilities.
6. Look in details and thoroughly.
7. Try to use any clues available.
8. Give some example that assembles the real problems.
9. Discuss with peer.
10. Do the difficult one later when you have done the best, thus you can have more time to solve the difficult one.

How would they check their work after they finished? (evaluation strategy)

1. Run through it again
2. Give it to the teacher to check.
3. Exchange with friends/ peer assessment than compare your work.
4. Self-check with the answers given in the answer sheet or from the teacher.
5. Check if there is any error.
6. Do additional research to check on your work/outcomes.
7. Use other alternatives to check the answer – e.g. books/internet/ calculator
8. Read it aloud
9. Try to explain to another person and check whether they understand what you are saying.

Figure 3.2 *Open-ended responses*

The open-ended questionnaire was analysed using inter-rater reliability methods. Inter-rater reliability is the measurement of two or more raters who assess the same responses given (Wiersma & Jurs, 2005). This is to accomplish consistency on rating the subjective answers. In this case, 50% of the responses were analysed by more than one rater. The overall interrater reliability achieved on these questionnaires exceeded 80%, indicating that the reliability of the rubric was adequate.

3.3.3. Validity of the Questionnaire

3.3.3.1. Correlations between open-ended and closed -ended tasks

The open-ended and closed-ended questions were first correlated to assess the degree of relationship between the two sections of the inventory. The correlation matrix for the 323 students is shown in Table 3.5.

Table 3.5

Correlations between open-ended and closed-ended tasks

	Planning closed-ended	Monitoring closed-ended	Cognitive strategy closed-ended	Evaluating closed-ended	Total closed-ended
Planning open-ended	-.005	.092	-.029	.055	.047
Monitoring open-ended	-.008	.046	-.035	.278	.004
Cognitive Strategy open-ended	-.007	-.023	-.002	.323	-.015
Evaluating open-ended	-.018	.028	-.060	.034	.000
Total open-ended	-.012	.055	-.042	.616	.016

As indicated, all four metacognitive skills (Planning, Monitoring, Cognitive Strategy Use, Evaluating) indicated no correlation between the open-ended and the closed-ended questionnaire. These results suggest that the two components of the questionnaire were assessing different constructs. Given that the open-ended section did not provide prompts to students in their responses, this was the more stringent test of their metacognitive skills. As such, these results cast some doubt on the validity of the closed-ended questionnaire section.

3.3.3.2. Correlations between closed-ended task and teachers' ratings

Teachers in six selected classes were asked to rate, on a four-point scale (ranging from less likely to always), their own perceptions of selected students' metacognitive skills, under the headings of planning, monitoring, cognitive strategy use, and evaluation (Appendix 3). Teachers were not provided with any information on the responses given by the students on their own metacognitive skills assessment.

The teachers' ratings were then correlated with the students' scores on each of the four factors in the closed-ended questionnaire. The correlations are shown in Table 3.6. As indicated, many of the correlations were negative, indicating that students' ratings were actually in the opposite direction to those of teachers. Although it was not anticipated that the correlations with teachers' ratings would be high, it was anticipated that there would be some level of positive correlation between these. In light of the fact that students gave themselves ratings in the opposite direction to those given by teachers, this cast further doubt on the validity of the self-rating scores.

Table 3.6

Teachers' rating with the closed-ended tasks

Subtest	*Year 7*	*Year 8*	*Year 9*	*Year 10*	*Year 11*	*ESL*
Cognitive strategy use	-0.15	0.15	0.10	-0.08	-0.19	-.40*
Planning	-0.25	0.05	0.14	0.00	-0.50*	-.32
Monitoring	-0.06	0.08	0.13	0.03	-0.02	-.13
Evaluating	-0.10	0.26	-0.14	-0.17	-0.28	-.13
Total	-0.16	0.16	0.10	-0.06	-0.38	-.30

3.3.3.3. Correlations between open-ended task and teachers' ratings

The correlations for the open-ended task are shown in Table 3.7. As indicated, there were no and low correlation for most of the Metacognition skill. In this case, however, any significant correlation was in the positive direction.

Table 3.7

Teachers' rating with the open-ended tasks

Subscale	*Year 7*	*Year 8*	*Year 9*	*Year 10*	*Year 11*	*ESL*
Planning	0.09	-0.10	0.22	0.28	-0.25	0.12
Monitoring	0.11	-0.02	0.38*	0.33*	0.01	-0.32
Cognitive Strategy Use	0.19	-0.06	0.09	0.04	0.22	0.07
Evaluating	0.19	-0.05	0.20	0.19	0.12	-0.16
Total	0.23	-0.09	0.37*	0.30*	-0.03	-0.07

3.3.3.4. Age-related differences for the closed-ended task

A multivariate analysis of variance (MANOVA) was conducted to examine differences in the planning, monitoring, cognitive strategy use, and evaluation ratings across year levels. Descriptive statistics for the four components are shown in Table 3.8. The

MANOVA indicated no significant difference across age groups for these ratings, V = .040, $F(20,1268) < 1$. Given that metacognitive skills are supposed to increase with age, this provided a further piece of evidence against the validity of students' closed-ended ratings of their own metacognition levels.

Table 3.8

Descriptive statistics for closed-ended tasks

Dependent measure	*Year Level*	*M*	*SD*	*N*
Cognitive strategy use closed-ended	7	2.24	.31	61
	8	2.18	.40	43
	9	2.17	.31	124
	10	2.25	.34	47
	11	2.23	.20	31
	12	2.26	.24	17
	Total	2.21	.32	323
Planning closed-ended	7	2.41	.38	61
	8	2.36	.42	43
	9	2.37	.34	124
	10	2.36	.37	47
	11	2.41	.34	31
	12	2.41	.36	17
	Total	2.38	.36	323
Monitoring closed-ended	7	2.35	.33	61
	8	2.37	.41	43
	9	2.32	.37	124
	10	2.26	.40	47
	11	2.36	.38	31
	12	2.34	.39	17
	Total	2.33	.37	323
Evaluating closed-ended	7	2.34	.69	61
	8	2.27	.40	43
	9	2.36	.31	124
	10	2.30	.28	47
	11	2.38	.39	31
	12	2.23	.32	17
	Total	2.33	.42	323

3.3.3.5. Age-related differences for the open-ended task

A MANOVA was also conducted to examine the differences in planning, monitoring, cognitive strategy use, and evaluating in the open-ended responses. Descriptive statistics for the four components are shown in Table 3.10. Based on the Pillai-Bartlett criterion, the MANOVA indicated a statistically significant difference between groups on the composite dependent variable, $V = .24$, $F(20,1268) = 3.97$, $p < .01$.

Univariate ANOVAs for each individual subtest are shown in Table 3.10. Using a Bonferroni-adjusted alpha level of .012, the differences across groups were significant for all four subtests, Fs(5,317) > 3.91, ps < .012, partial $\eta^2 > .06$. From the means shown in Table 3.9, Year 7 students scored lowest levels across all four subtests. Thus, these results suggest that students in the lower grades obtained significantly lower scores than those in higher grades in the open-ended tasks.

Table 3.9

Descriptive statistics for the open-ended tasks

Dependent measure	*Year level*	*M*	*SD*	*N*
Planning open-ended	7	.97	.60	61
	8	1.02	.41	43
	9	1.64	.87	124
	10	1.51	.95	47
	11	1.52	1.34	31
	12	1.47	.80	17
	Total	1.39	.89	323
Monitoring open-ended	7	.77	.64	61
	8	.79	.51	43
	9	1.35	.69	124
	10	1.34	.79	47
	11	.94	.93	31
	12	1.12	.60	17
	Total	1.11	.74	323
Evaluating open-ended	7	1.05	.46	61
	8	1.14	.64	43
	9	1.38	.65	124
	10	1.02	.71	47
	11	1.10	.60	31
	12	1.29	.59	17
	Total	1.20	.63	323
Cognitive strategy use open-ended	7	.97	.48	61
	8	1.14	.51	43
	9	1.48	.69	124
	10	1.17	.56	47
	11	1.10	.75	31
	12	1.12	.86	17
	Total	1.24	.66	323

Table 3.10

Analyses of variance for the open-ended tasks

Source	*Measures*	*df*	*MS*	*F*	Partial η^2
Year level	Planning open-ended	5	5.14	7.12*	.10
	Monitoring open-ended	5	4.38	8.93*	.12
	Evaluating open-ended	5	1.50	3.91*	.06
	Cognitive strategy use open-ended	5	2.62	6.55*	.09
Error	Planning open-ended	317	0.72		
	Monitoring open-ended	317	0.49		
	Evaluating open-ended	317	0.38		
	Cognitive strategy use open-ended	317	0.40		

* Significant at $\alpha = .012$

3.4. SUMMARY

The present study examined the validity of two approaches to metacognitive skills assessment in middle and secondary school students. The primary objective of the study was to develop valid and reliable means to assess metacognitive skills in Study II. Results for the close-ended metacognitive items demonstrated good fit with the hypothesized four-component scale structure using CFA.

Despite this, correlations between the close-ended and open-ended sections of the instrument indicated that these two components were assessing different constructs. Further, evidence from correlations with teachers' perceptions and from age comparisons suggested that the validity of the closed-ended component was questionable. Based on these outcomes, Study II relied entirely on the open-ended section of the instrument to assess students' metacognitive skills.

Chapter 4

STUDY II: IMPACT OF A FIRST-TIME IMPLEMENTATION OF WKF IN SECONDARY SCIENCE

4.1. INTRODUCTION

As noted in Chapter 2, previous studies have shown that the use of WKF can have significant positive effects on students' achievement, higher-order thinking and metacognitive skills (Hurme & Jarvela, 2001; Lamon et al., 1993; Oshima, 2005). WKF has been used across various grades and age levels, including primary, secondary and university students (Cuthbert & Hoadley, 1998; Reeve & Lamon, 1998; Sherman, 1998; Tan et al., 2005). The impact of WKF on teachers' pedagogical approaches in the classroom have also been explored, with outcomes indicating that WKF can prompt the use of more diverse teaching strategies (Lamon et al., 2001; Lee, 1992; Winter & McGhie-Richmond, 2005).

A few studies have, however, indicated a mixture of positive and negative effects of WKF in comparison to traditional instructional methods and non-ICT-based collaborative learning (Korbak, 1997; Lin Hsio, 1998; Rahikainen, Jarvela, & Salovaara, 2000). Thus, the results of studies that have evaluated the impact of collaborating through WKF have been somewhat mixed. Studies on computer-supported collaborative learning have indicated several factors that can influence the effectiveness of programs like WKF (Harasim, 1990; Light & Maverech, 1992). Amongst these, the most prominent are the approaches used by teachers in integrating the programs into their everyday routines. Independently of ICTs, teachers' perspectives on classroom teaching have been associated significantly with students' achievement and motivation to learn (Bartz & Mathews, 2001; Neo & Neo, 2005). Different teaching methods can produce diverse effects on students' understanding and comprehension levels across different learning tasks. Furthermore, teachers' beliefs about teaching have been found to influence both school and classroom planning (Keranto, 2001).

Many programs described in the literature have been found under controlled conditions to produce positive effects in a range of key learning areas. In order to meet contextual constraints (e.g., on time or resources), however, teachers must adapt the approaches to their own circumstances. As all of these programs include a number of potentially active "treatment variables", discriminating between "optional" (i.e., safely alterable) and critical procedural components can be difficult. This can lead to unsystematic adaptations, reduced effects and, ultimately, loss of community or administrative support for the approach. Further, there is generally little empirical evidence on the kinds of design and implementation factors that moderate (i.e., alter the direction or magnitude of) such program effect within field settings.

Many of these programs can, furthermore, be very difficult to apply for first-time implementers. It is in this critical period that teachers will decide whether to persist with, or abandon, a particular learning tool. Regrettably, many teachers also find that they do not have sufficient training or time to integrate the use of these tools effectively in the early stages. Although standardized manuals are generally provided, these often do not provide the kind of hands-on training and support required. Again, the difficulties that these factors create can lead to reduced effects and then loss of support for the program. Against this backdrop, there is a need to establish stronger channels of professional communication amongst first-time implementers of complex programs.

Study II was designed as a first effort to open channels of communication between teachers who wish to make use of WKF in their own classrooms. This study was *not* designed as another evaluation of what WKF *can* do under idealized conditions. The goal of the study was to document, evaluate, and develop recommendations from the efforts made in one ICT-rich secondary school in which WKF was being implemented for the first time. It should be noted here that both the participating school and the participating teacher in the study were chosen because they were considered "exemplary" in terms of their track records in implementing ICT-based programs. The teacher was also provided with time to familiarize himself with WKF, and to develop the related curriculum tasks. Thus, the efforts documented in this study were intended to be representative of, if not more advanced than, the kinds of efforts that typical first-time users of WKF would make in the field.

In the study, the participating teacher implemented WKF in two phases, taking a form similar to an action research project. After Phase I was completed, the tasks used in WKF were modified based on reflection, and these modified tasks then implemented in Phase II. In each phase, a quasi-experimental design was used to evaluate the impact of the teacher's implementation on student learning outcomes. Both quantitative and qualitative data were used in this evaluation. Quantitative data were used to evaluate impact on students' achievement, attitudes toward science, preferences for collaborative learning, and preferences for ill-structured tasks. Qualitative data were collected through students' research summaries and then analysed quantitatively for evidence of higher- and lower-order thinking processes, as well as metacognitive skills. The two major research questions addressed in the study were:

1. What approaches did this teacher use to integrate WKF in his normal science teaching methods class in his initial WKF implementation, and what modifications did this teacher incorporate in his second attempt?
2. What were the effects of these two implementations on student learning outcomes and processes?

4.2. GENERAL METHOD

4.2.1. Participants

The initial sample comprised 79 female students from three Year 9 classes, with ages ranging from 14 to 15 years. Of these, seven students chose not to participate in the study, and a further two were subsequently excluded for having large quantities of missing data. The study took place in an all girls' school located in a relatively high socioeconomic area in Perth, Western Australia. Based on the data from the 2001 census, this suburb was ranked at the 90th percentile in terms of socioeconomic advantage (Australian Bureau of Statistic, 2003). The school was advanced in its technology infrastructure, with every classroom, library, and laboratory connected through a sophisticated school network system. The school had a full-time ICT co-ordinator, as well as a network supervisor, and all teachers in the school had attended at least five ICT-related professional development workshops over the past two years. All students in the year level for the study had portable notebook (laptop) computers which allowed them to access a range of online resources, educational software, and other network resources in every class.

The intervention was conducted with one Year 9 teacher, who had more than 10 years of experience in teaching Chemistry. This teacher had won several awards for science teaching, including ICT-based programs, at the time of the study. Again, this teacher was chosen because he had an "exemplary" track record at the time for implementing ICT-based programs within science. The implementation documented is thus likely to represent a relatively advanced first-time implementation of WKF within a well-resourced field setting.

4.2.2. Research Design

A quasi-experimental design with random assignment of classes to conditions was used to assess the effects of the WKF implementations on student outcomes. In the study, there were two intervention phases. Given that one goal of the study was to document one secondary level teacher's efforts to integrate WKF, he did not receive any curriculum-related advice from the researcher. The researcher's role in this process was to document the approaches taken by the teacher throughout the study, and to evaluate the impact of these approaches on students' learning outcomes and processes.

Phase I represented the teacher's first efforts to implement WKF within his science classroom. This phase, conducted in a topic called "Elements", extended over a four-week period. Two of the teacher's three classes were randomly assigned to participate in WKF for this unit, the other, the teacher's traditional approach. All students in the three classes were divided into groups of three to four members.

Phase II was designed as a documentation and evaluation of the teacher's second effort to implement WKF based on reflections from Phase I. This phase was conducted in a unit called "Compounds", and was conducted for a similar period of time. In Phase II, one class that had previously worked under WKF switched to the teacher's more traditional method, whilst the class who participated in the traditional method in Phase I became a WKF class. The third class, who had worked under WKF in Phase I, continued to use WKF, thus providing a basis for comparing the effects of both short- and longer-term implementations (see Figure 4.1).

Term III (Phase I)		**Term IV (Phase II)**
Class A (WKF A)	→	Class A (WKF A)
Class B (WKF B)	→	Class B (Traditional Class)
Class C (Traditional Class)	→	Class C (WKF B)

Figure 4.1 *Class assignments in Phases I and II*

4.2.3. General Apparatus

4.2.3.1. Computer equipment

All students within the study school had their own laptop computers. Students used these computers within their science classes each session. The school server provided a network infrastructure with online access and wireless technology within the school setting. Students therefore had permanent access to the intranet throughout the intervention.

4.2.3.2. Web Knowledge Forum

WKF Version 4.5, the most recent version at the time of the study, was used to provide the online network system for collaborative learning and inquiry. WKF is a cyber-meeting place that was designed to facilitate and encourage knowledge building processes. WKF is a networked learning environment that links classroom computers to a database that contains the students' work (Scardamalia et al. 1989). In WKF, students engage in discussions, share information and ideas, and construct knowledge together. In WKF, students work and communicate together by quoting their classmates' ideas, building knowledge from those ideas, and integrating, annotating and synthesizing them to create new information (Knowledge Forum, 2003). Students use notes to build and develop a knowledge base on the topics discussed. Notes can be recorded in sections that include problems, research plans, graphics to explain theories, summaries of the information and statements of inquiry (Knowledge Forum, 2003). The notes are attached in the database for other readers to comment on. These are accessible publicly on any computer connected to the local and wide area networks, as well as the internet.

WKF allows students to construct, collaborate and build knowledge progressively. WKF was designed to facilitate and support knowledge building communities. In constructing knowledge, participants are able to use several methods to represent knowledge (e.g., graphics, texts), as well as tools to link notes and construct knowledge. In this situation, WKF provides skills that imitate expert ways of thinking. To be engaged in a successful knowledge building process, WKF offers supportive tools to promote collaboration among participants. WKF also preserves every note in the database. Thus, everyone can view and discuss the topic at any time and anywhere. WKF includes six collaborative tools to promote this process.

The first tool, *build on*, allows ideas to be built on someone else. Each note is independent but connected to the notes built earlier. The build on notes chain can lead to deeper understandings and the generation of new ideas. The second tool, known as *quoting*, acknowledges other participants' work when a reference has been made. *Annotation* is the third collaborative tool that enables the participants to comment on, check, and evaluate other work. *Co-authoring* allows authors to share their rights to contribute to and edit certain notes. High quality notes can then be *published* upon agreement between all participants. Finally, *rise above* notes are generated from old notes, integrating old and existing ideas to create new information and theory. WKF encourages progressive inquiry by providing scaffolding activities that will lead to cognitive orientation. Figures 4.2 and 4.3 present snapshots of the WKF database and examples of the scaffolding provided.

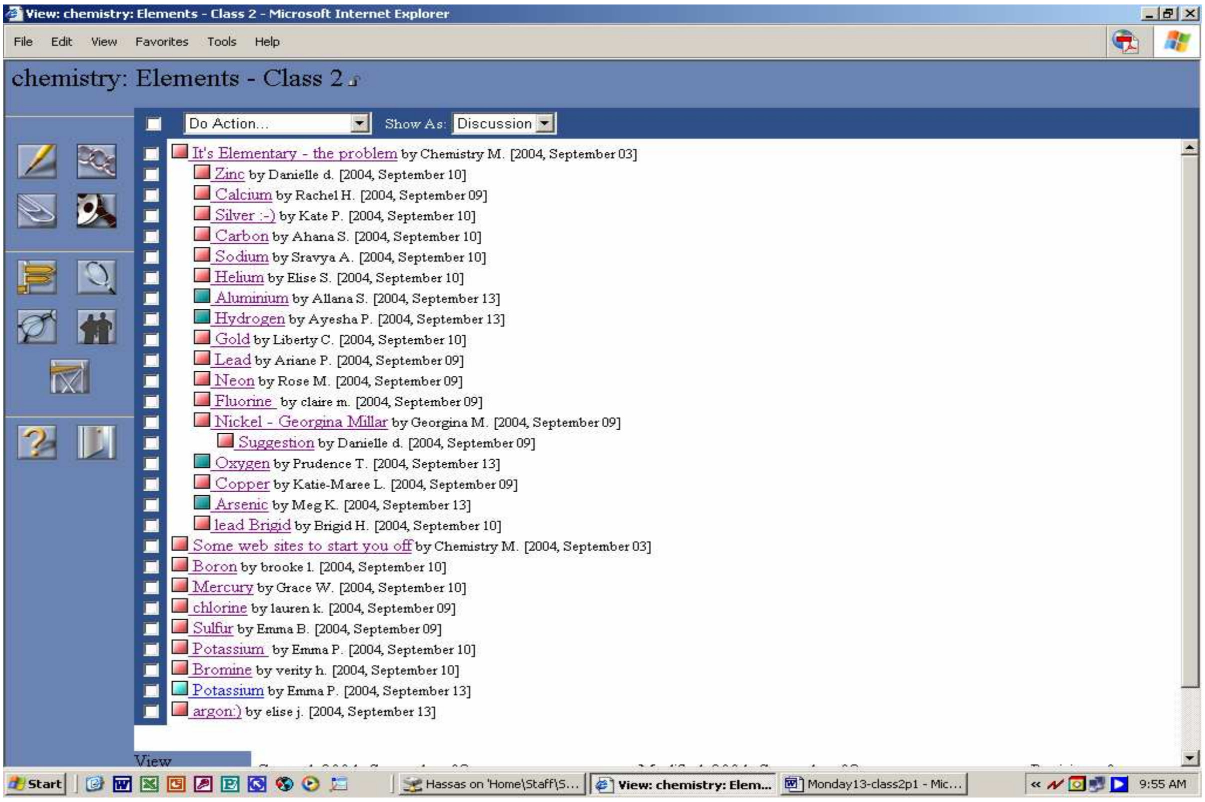

Figure 4.2 *Screenshot of a WKF online database*

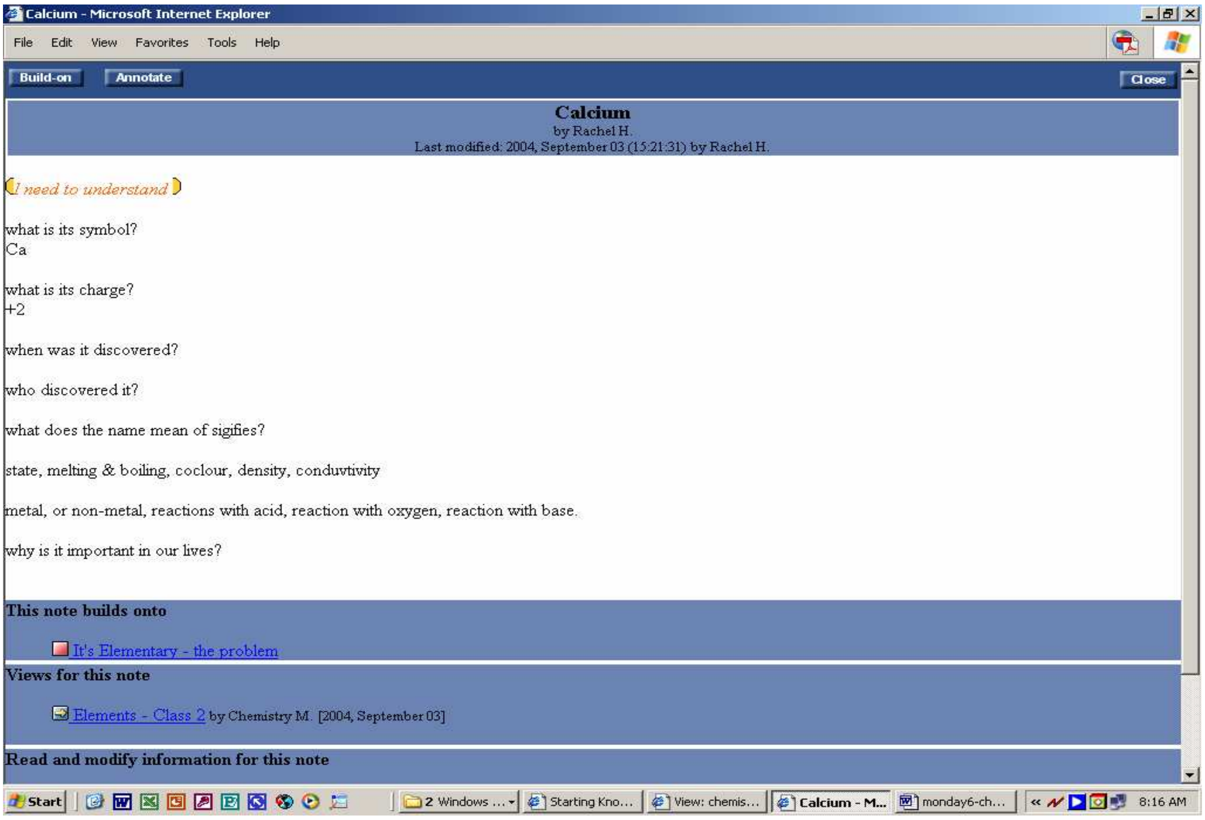

Figure 4.3 *An example of scaffolding in WKF*

4.2.4. General Procedures

A meeting was held at the end of Term II with the science coordinator and the science teacher who had agreed to participate in the study. A comprehensive introduction to the research project was presented in the meeting. The teacher then distributed 79 information sheets and consent forms (see Appendices 4A and 4B) to the students in the middle of Term III. The information sheet explained the purpose of the study and its potential contribution to the research field. Once the students had returned the consent forms, the researcher visited each classroom and gave a brief introduction to the study. Seven students decided not to participate in the study, and these students did not contribute data to any of the study analyses.

Each student who participated in this study, in both the WKF and traditional classes, used their own notebook computer to perform the internet research tasks assigned in lessons. Students in the WKF classes had their own user name and password to access the WKF database. They could ask questions, discuss, and comment on other students' work. The notes could be viewed by other WKF participant within the same class but only the author could edit the content and make modifications to her notes. The traditional class students saved their final work in a special folder in the school database. This folder could be viewed by other students, but it was not available for any discussion or comment.

4.3. PHASE I

Phase I represented the teacher's first efforts to implement WKF within his science classroom. This phase was implemented during a unit that focused on Elements, and was conducted in Term III for four weeks. As noted above, all three of the teacher's classes participated in this phase.

4.3.1. Method

4.3.1.1. Participant allocation

Of the three classes (72 students) who took part in the study, two classes were assigned at random to participate in WKF for the four-week period, and the third was assigned to participate in more traditional, non-WKF collaborative learning over the same period.

4.3.1.2. Instrumentation

Student Achievement. To assess student achievement, two tests were developed by the science teacher: a General Chemistry pretest, and an Elements posttest.

(i) ***General Chemistry Pretest***. A test of General Chemistry Knowledge was used as a pretest prior to the intervention. The General Chemistry Knowledge Test had three parts (A, B, and C) and is included in Appendix 5. In Part A, students were asked to draw a concept map of "chemistry-related" words given in the test paper. They then had to link the words to show the connections between them. Part B consisted of four open-ended questions on the use of chemistry in society. In Part C, there were nine chemistry-related statements and students had to decide on the "acceptability" of each statement. The General Chemistry pretest asked questions to elicit both lower- and higher-order thinking skills as described in the revised version of Bloom's Taxonomy of Educational Objectives. It took around 15-20 minutes to complete. The scores for Part A, B, and C were added up to produce the total pretest score.

(ii) ***Elements Achievement Posttest***. After the four week intervention, students were tested using the Elements Achievement posttest (refer to Appendix 6). This test included three categories, all with open-ended questions. In Part 1, students had to write down the name and history of two elements they had chosen. In Part 2, they were

required to respond to open-ended questions on the physical properties of the elements. In Part 3 they were asked about the element's chemical properties. The questions asked in this test required both lower-and higher-order thinking skills and it took roughly around 15-20 minutes to complete. The total scores for Parts 1, 2, 3 were again totalled to produce the overall posttest score (maximum score = 20).

Higher-and lower-order thinking. Students' higher-and lower-order thinking skills were assessed from students' research summaries posted in the WKF database and on the school's intranet (for the traditional class students). An example of a student research summary is presented in Figure 4.4.

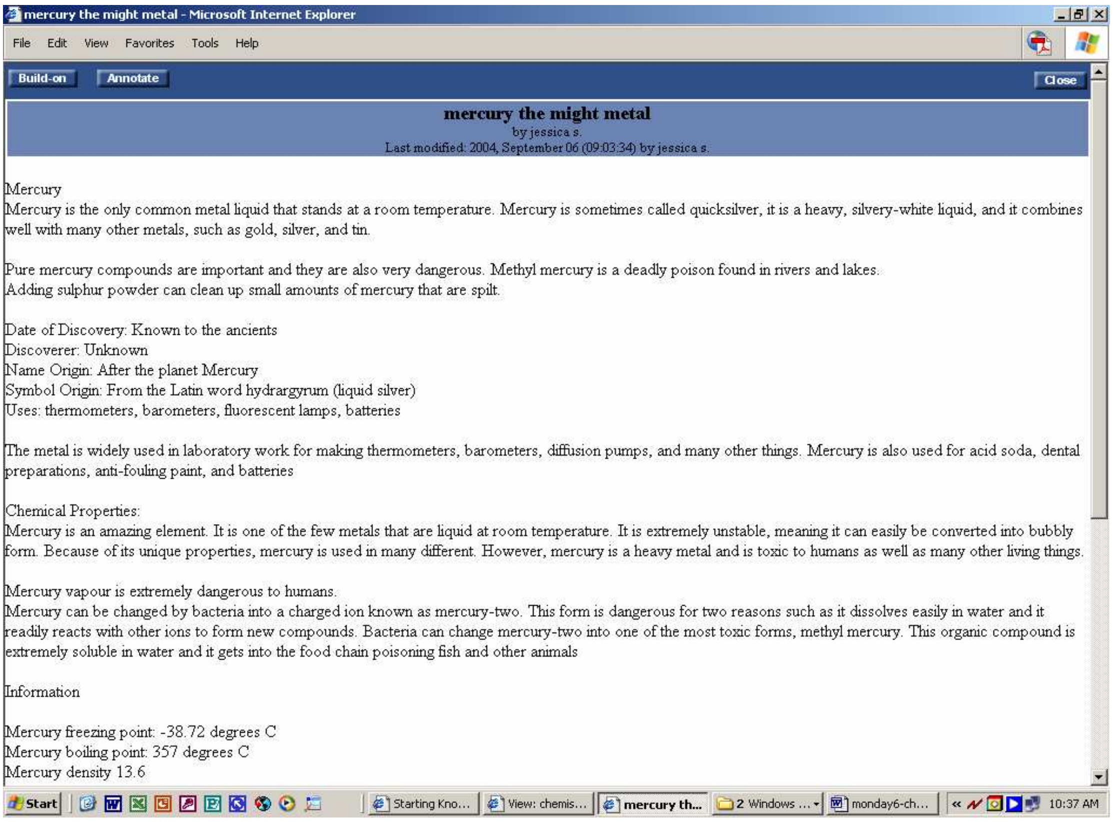

Figure 4.4 *An example of a student's research summary in two WKF database*

Students' research summaries were assessed using a rubric developed from Bloom's Taxanomy of Educational Objectives and other literature related to thinking processes (Arter & Salmon, 1987; Kearney & et al., 1986; Paul & Nosich, 1991). The rubric is presented in Appendix 7. The rubric was designed to evaluate students' thinking processes from the lower to the higher levels. Cognitive and thinking processes can be classified into five separate hierarchical categories (Anderson et al., 2001). Starting from the lowest thinking category, the skills are (i) Remember, (ii) Understand, (iii) Apply, (iv) Analyze, (v) Evaluate and (vi) Create. Herrington and Oliver (1997) differentiate between lower-order and higher-order cognitive skills, identifying lower-order processes as those that involve procedural operations, browsing functions, and information-seeking. Examples of lower-order thinking would include routine talk, reading aloud, and making comments that require no level of evaluation or judgement. Conversely, he classified higher-order skills as those that involve planning and strategy use, judgements of uncertainty, predicting outcomes, imposing meaning, taking multiple perspectives or engaging in coaching.

Attitudes towards science. Students' attitudes towards science were assessed using the Enjoyment subscale of a well-established instrument known as the Test of Science-Related Attitudes (TOSRA) (Fraser, 1981). This instrument has been found to demonstrate high internal consistency, test-retest reliability and discriminant validity (Fraser, et al). The TOSRA has also been used widely across Australia and the US for students in years 7-12 (Fraser & Butt, 1982; Lucas & Tulip, 1980; McRobbie & Fraser, 1993; Schibeci & McGaw, 1980). The modified version of the Enjoyment scale used in this study is shown in Appendix 8. There are seven items in the scale, and students respond to the items on a five-point Likert scale (Strongly Agree, Agree, Not sure, Disagree and Strongly Disagree). As previous studies (Man, 2005) have shown that this scale comprises two distinct sub-components (Enjoyment and Difficulty), these two components were also separated in the present study. The Enjoyment component of the instrument thus included four items, with the Difficulty component including three.

4.3.1.3. Specific Procedures

Prior to the intervention period, students completed the General Chemistry pretest and the science attitudes scale. The intervention period lasted four weeks, with three one-hour science sessions conducted in each week. Two classes were assigned to participate in WKF, while the third participated as the traditional class.

WKF Classes. In the two WKF classes, students worked in groups of three to four. These were their collaborative groups and they remained in the same groups over the entire four-week period. The students worked on their laptop computers the entire study period. Students were given a set of tasks to perform over the entire four-week period, which involved conducting research relating to one element they had chosen to research. During the implementation, the students sat together, and were encouraged to engage in face-to-face collaboration, as well as regularly posting their research summaries, inquiries and comments in the WKF database. These students thus had two avenues to collaboration throughout the study period: Face-to-face in their groups, and with the rest of the class through the WKF database. The guidelines for the face-to-face collaboration were not strict – students were encouraged merely to share any resources they had (e.g., key websites) and to discuss in each session what they had found with other students. For the WKF collaboration, students were told to record their ongoing work in the database, and to draw and comment regularly on the work of all other students in their class in completing their assigned tasks.

Traditional Class. In this class, students also sat together in groups of three to four members. During the sessions, they worked with their notebook computers and performed research on the same tasks that were assigned to the WKF classes. Traditional class students were encouraged to engage in face-to-face collaboration with their classmates during the sessions, but did not have access to the ongoing online collaboration offered by WKF. The guidelines for the face-to-face collaboration were again not strict, being identical to the instructions given to the WKF class for this component. Students in this class were not asked to draw upon, or comment on, their classmates' work regularly.

As indicated, the only difference between the WKF and traditional classes in the study was that the WKF students were able to engage in regular collaborative discussion with their entire class through by the WKF database, as well as having face-to-face collaboration within their groups during classes. Traditional class students engaged only in face-to-face collaboration within their groups, and did not engage in the ongoing online collaboration, monitoring, and peer review with the rest of the class provided by WKF. Thus, the comparison evaluated whether the collaborative opportunities available in WKF augmented traditional, face-to-face collaborative learning within small groups.

4.3.2. Results

4.3.2.1. Documentation of Approach

In Phase I, the teacher's implementation of WKF was evaluated in a task related to Elements. The teacher justified choosing this task because it required students to develop a deep understanding of the natural occurrence of an element. Recognising and identifying factual knowledge relating to elements, such as names, histories and symbols is necessary, but to integrate the theory and concepts, and apply the use of elements in the environment, requires a deeper understanding. The instructions given to all students in the WKF classes are presented in Figure 4.5, with instructions given to the traditional class presented in Figure 4.6.

IT'S ELEMENTARY (WKF GROUP)

1. Select an element and claim if for your own on the A3 table in the classroom
2. Use the internet resources listed to find out about that element, using the following headings to guide your research:
   - □ occurrence (abundance, found as element or compound)
   - □ history (when discovered, who discovered, what the names means and signifies)
   - □ physical properties (state, melting & boiling points, colour, density, conductivity)
   - □ Occurrence (Does it occur naturally or do we make it?)
   - □ chemical properties (metal or non-metal, reactions with acid, reaction with oxygen, reaction with base)
   - □ Uses (Why it's important in our lives)

RESOURCE LIST:

http://www.chemsoc.org/viselements/pages/pertable _fla.htm
http://www.webelements.com
http://www.ch.cam.ac.uk/misc/weii/table.html
http://www.ktf-split.hr/periodni/en/index.html

3. Your task

FIRST:

□ Make a (maximum) one-page summary of your key findings about this element; and

NEXT:

□ create a video (or combine a series of still pictures to make a video) showing the major findings of your research. This video should be between 30 seconds and 5 minutes in length; and

□ create a set of credits which references any material that is not your own work; and

NEXT:

□ create a narration for your video to explain the images or graphics.

4. In Knowledge Forum, you should

□ use the annotate button to post annotated notes about any really useful web sites that aren't already listed

□ use the "build on" button to submit the one-page summary of your work-copy and paste it into the "content window"

□ next to the "reference" heading, use the "attachment" drop-down menu to create a new attachment to your video

In Knowledge Forum, use the "view list" button to locate the questions you must answer, and then use the "search" button to find the (one or more) elements that meet the criteria given. Use the "build on" button to submit your written answers.

Figure 4.5 *Element instructions to the WKF class*

IT'S ELEMENTARY (TRADITIONAL CONDITION)

Select an element and claim if for your own on the A3 table in the classroom
Use the internet resources listed to find out about that element, using the following headings to guide your research:

- □ occurrence (abundance, found as element or compound)
  - □ history (when discovered, who discovered, what the names means and signifies)
  - □ physical properties (state, melting & boiling points, colour, density, conductivity)
  - □ Occurrence (Does it occur naturally or do we make it?)
  - □ chemical properties (metal or non-metal, reactions with acid, reaction with oxygen, reaction with base)
  - □ Uses (Why it's important in our lives)

RESOURCE LIST:

http://www.chemsoc.org/viselements/pages/pertable _fla.htm
http://www.webelements.com
http://www.ch.cam.ac.uk/misc/weii/table.html
http://www.ktf-split.hr/periodni/en/index.html

Your task
FIRST:

- □ Make a (maximum) one-page summary of your key findings about this element; and

NEXT:

- □ create a video (or combine a series of still pictures to make a video) showing the major findings of your research. This video should be between 30 seconds and 5 minutes in length; and
- □ create a set of credits which references any material that is not your own work; and

NEXT:

- □ create a narration for your video to explain the images or graphics.

Print out summary page. Have the summary and your video ready by the due date.

Figure 4.6 *Element instructions to traditional class*

In the WKF classes, students had to post their formative summaries into the WKF database on an ongoing basis, so that other students could see and comment on this work. In addressing their questions, the WKF groups therefore had access to the information available in the WKF database, as well as other resources such as the internet, library and their own experiments in other classes. Throughout the implementation, students were also required to evaluate any work that they drew upon and provide constructive, research-oriented comments on this work.

The traditional class addressed their tasks based only on the information available in a special database on the school server, and other resources such as the internet, the library and their own experiments in class. These students also posted their final answers in a special folder on the teacher's intranet account, but could not collaborate on these answers on an ongoing basis, or make ongoing evaluations of their classmates' work.

As indicated, the approach taken by this teacher used three main features of the WKF program: The "annotate" function, which students used to tell others about useful websites that were not already listed; the "build on" function, which students used to submit their research summaries; and the "attach" function, which the students used to link their work to related videos that they had created. The adaptations made to learning to the learning tasks for the WKF environment were therefore minimal, and did not incorporate elaborate instructions to guide students in their collaborations.

4.3.2.2. Impact on Student Achievement

A one-way between-groups analysis of covariance (ANCOVA) was first performed to compare the achievement of the two WKF classes with that of the traditional class at the end of the Elements task. In this analysis, the dependent variable was the score on the Elements posttest, with students' total scores on their General Chemistry pretest used as covariates. With this criterion, four students who did not complete the General Chemistry pretest were excluded, leaving a total sample of $n = 68$ for this analysis. A univariate analysis of variance (ANOVA) confirmed that there were no significant differences in scores on the General Chemistry pretest across the three classes, $F(2,65) = 2.07$, $p = .14$.

Descriptive statistics for the Elements achievement posttest are shown in Table 4.1. The ANCOVA indicated no significant difference between the three groups at posttest, $F(2,64) = 2.01$, $p = .14$. Thus, there was no evidence that the WKF intervention produced a significant favourable effect on chemistry achievement.

Table 4.1

Descriptive statistics for the Element Achievement Posttest

Group	*M*	$M_{ADJ.}$	*SD*	*N*
WKF A	4.74	4.62	0.82	21
WKF B	5.14	5.20	1.35	23
Traditional	5.06	5.11	0.84	24
Total	4.99	5.00	1.04	68

4.3.2.3. Impact on Student Attitude

For the 68 students who provided complete data in Phase I, a one-way between-groups multivariate analysis of covariance (MANCOVA) was performed to compare the scores of the three classes on the two subscales of the Science Attitudes Scale. The two dependent variables in this analysis were posttest scores for the Enjoyment and Difficulty subscales, with corresponding pretest scores.

An initial multivariate analysis of variance (MANOVA) indicated a significant difference in the pretest scores of the three groups in terms of attitudes, $V = .15$, $F(4,130) = 2.70$, $p = .03$, partial $\eta^2 = .08$. Univariate ANOVAs further indicated a significant difference on the Enjoyment, but not on the Difficulty, component, $F(2,65) = 4.77$, $p = .01$, partial $\eta^2 = .13$, $F(2,65) = 1.84$, $p = .17$ respectively. Thus, the outcomes of the MANCOVA for the Enjoyment component should be interpreted with some degree of caution.

Descriptive statistics for the Difficulty and Enjoyment subscales are shown in Table 4.2. Based on the Pillai-Bartlett criterion, the MANCOVA indicated no statistically significant difference between groups on the composite dependent variable, $V = .10$, $F(4,126) = 1.66$, $p = .16$. Thus, there was no evidence that WKF had a significant positive effect on students' attitudes towards science.

Table 4.2

Descriptive statistics for the Science Attitude subscales

Subscale	*Group*	*M*	$M_{ADJ.}$	*SD*	*N*
Enjoyment	WKF A	3.25	3.25	0.62	21
	WKF B	2.90	3.13	0.65	23
	Traditional	3.65	3.43	0.73	24
	Total	3.27	3.27	0.73	68
Difficulty	WKF A	2.84	2.92	0.85	21
	WKF B	3.14	3.00	0.62	23
	Traditional	2.58	2.65	0.57	24
	Total	2.85	2.86	0.71	68

4.3.2.4. Impact on lower- and higher-order thinking

A MANOVA was conducted to compare the scores of the three classes in terms of lower- and higher-order thinking processes. These scores were assigned on the basis of the research summaries. Associated descriptive statistics are shown in Table 4.3. The MANOVA indicated no significant difference between groups on the composite dependent variable, $V = .02$, $F(4,130) < 1$. Thus, there was no evidence that the WKF intervention significantly impacted either higher- or lower-order thinking processes.

Table 4.3

Descriptive statistics for lower- and higher- order thinking scores

Subscale	*Group*	*M*	*SD*	*N*
Lower-Order Thinking	WKF A	3.81	1.21	21
	WKF B	4.09	1.41	23
	Traditional	3.96	1.30	24
	Total	3.96	1.30	68
Higher-Order Thinking	WKF A	2.00	1.22	21
	WKF B	2.22	1.35	23
	Traditional	2.33	1.27	24
	Total	2.19	1.27	68

4.3.2.5. Discourse analysis

Students' WKF comments on the Elements task were then examined to provide some indication of how they were using the program during the intervention. This examination suggested that neither of the WKF classes showed a high level of task-oriented collaboration amongst students. There was very little active sharing of information. Figure 4.7 presents an example of such an exchange in WKF A.

As noted, the documentation of processes used in Phase I suggested that the modifications of the participating teacher for WKF were relatively minimal. The major difference between the WKF and traditional conditions was that students in the WKF classes had ongoing access to collaboration with their entire class, rather than just a small group, like the traditional class students.

Note building on Nickel in WKF A

1) I suggest that you split up the information into sub groups so it is easier to read (comment by G.M)

2) I think your movie was really enjoyable and you did a good job. It had lots of useful information and it helped me to understand your summary. I think it was also creative and I think you covered most aspects of the element. I think it was really good so well done. (comment by L.K)

3) hey georgie, I thought that your movie was the BEST nickel video !. it had relevant information and very enjoyable to watch. Not only you include useful facts but you also gave pictures as examples of what you where referring to. You observed your topic really well and I thought you did a great job. well done !. (comment by K.M)

Figure 4.7 *Exchange recorded in WKF A*

4.4. PHASE II

The second phase was conducted in a unit called Compounds for a similar period of time (four weeks). As noted previously, all three of the teacher's science classes also participated in this phase. To provide a more stringent test of the effects of WKF on learning outcomes, however, two of the classes reversed conditions. Thus, the class that worked under the traditional method in Phase I now became a WKF class, and one of the two WKF classes from Phase I (WKF B), now became the traditional class. This reversal was assigned to provide a test of robustness for any effects observed in Phase I. To examine whether there were differences between classes that had longer or relatively short-term exposure to WKF, one of the WKF classes from Phase I (WKF B) remained a WKF class in Phase II.

In Phase II, both WKF classes use a combined database, unlike in Phase I, where the two classes used separate databases. This was done to provide a larger pool of knowledge for the students to use as a reference. This was one of the two major differences in the procedures used across the two phases. The second major difference was that the tasks assigned to students were designed more carefully to elicit a range of higher-order thinking skills. This was done to ensure that the impact of WKF on these processes could be assessed in the posttest.

4.4.1. Method

4.4.1.1. Participant Allocation

In Phase II, one class that had previously worked under WKF switched to the teacher's more traditional method, whilst the class who participated in the traditional method became a WKF class. The third class, who had worked under WKF in Phase I, continued to use WKF.

4.4.1.2. Instrumentation

The three assessment tasks used in Phase I were also used in Phase II. The Compound Achievement Posttest was similar to that used in the Elements unit. This test included two sections of open-ended questions (Appendix 9). In Part 1, students had to write down compound names. In Part 2, they had to describe the chemical properties of three compounds and give evidence for these conclusions. Part 3 required the students to indicate possible solution issues associated with handling and storage of three compounds that they had chosen. The questions asked in this test were designed to elicit both lower- and higher-order thinking skills. The test took around 15-20 minutes to complete. To assess the students' achievement posttest, the three parts (1, 2 and 3) were totalled together to form a total mark out of 10.

In the analysis of the Compounds achievement posttest, scores on both the General Chemistry Pretest and on the Elements posttest were used as covariates. Three additional instruments were then used to assess the impact of WKF on students' learning and thinking processes:

(i) ***Metacognitive skills***: Metacognitive skills were assessed using the instrument developed in Study I. As indicated, it was determined in this study that the open-ended tasks had stronger validity for assessing such skills than did the closed-ended ratings. As a result, only the open-ended tasks were used in Study II. Four subscales were used: planning, monitoring, cognitive strategy use, and evaluating.

(ii) ***Students' preferences for collaborative learning:*** This researcher-developed instrument (see Appendix 10) consisted of six items which were designed to assess students' preferences for working in groups or individually. Students responded to the items on a four-point Likert scale (not at all like me, not much like me, a bit like me, a lot like me).

(iii) ***Students' preferences for ill-structured tasks***: This researcher-developed, three-item scale was used to assess students' preferences for working with ill-structured tasks. Similar to the preferences for collaborative learning scale, students' scores were based on a four-point Likert scale (not at all like me, not much like me, a bit like me, a lot like me) (see Appendix 10).

4.4.1.3. Specific Procedures

The intervention period for the Phase II started in the second week of Term IV. Prior to that, the pretests for the three additional measures were given. The intervention period was similar to the period of Phase I (four weeks). There were again three one hour science sessions in each week. Once the four-week intervention was over, students completed the posttests (achievement, attitudes, preferences for ill-structured tasks, preferences for collaborative learning, and metacognitive skills).

4.4.3. Results

4.4.3.1. Documentation of Approach

The Compounds task used in Phase II provided greater opportunity for students to demonstrate applications of the principles they had learned in everyday life. It thus provided further opportunity for the students to demonstrate some aspects of higher-order thinking. The instructions given to all students in the Compounds task are presented in Figure 4.8.

COMPOUND INTEREST

1. Select a common household substance and claim it for your own on the A3 table in the classroom

2. Use the internet resources listed to find out about that substance, using the following headings to guide your research:
   - □ Is it an element, compound or mixture? (which is it? How can you tell?)
   - □ Scientific name and formula (of the ingredients)
   - □ Diagram or photograph (of the substance and its packaging)
   - □ Occurrence (does it occur naturally or do we make it)
   - □ History (who discovered or invented it, and when, what the name means and signifies)
   - □ Physical properties (state at room temperature, melting & boiling points, colour)
   - □ Chemical reactions (with acid, with oxygen, with base etc- NR to show "no reaction")
   - □ uses (why it's important in our lives)
   - □ Safety (how to handle it, store it, what not to mix it with, what it can do to the human body)

RESOURCE LIST:

http://www.chemsoc.org/viselements/pages/pertable _fla.htm
http://www.webelements.com
http://www.ch.cam.ac.uk/misc/weii/table.html
http://www.ktf-split.hr/periodni/en/index.html

3. Your task

FIRST:

□ make a (maximum) one-page summary of your key findings about this compound; and
□ post it to Knowledge Forum as your contribution to the Encyclopaedia of Common Chemicals

NEXT:

□ choose three problems from the question bank; and
□ use the information posted in the Encyclopaedia of Common Chemicals (on Knowledge Forum) and sany other sources (internet, library, experiments) to answer those three problems
□ post your answers as annotated to the problems

Extension Questions

1. Explain how the properties of the compound relate to the ways that we use the compound.
2. Is the compound cheap, or expensive to buy? What might decide its price on the market?
3. Are they many brands or varieties of this compound available, or only a few? Imagine you are in charge of marketing the compound. What would you do to make your brand stand out from the rest? Explain.
4. Imagine you are the safety advisor to the government. What advice would you give about the best way to dispose of the compound – just throw it away, wash it down the sink ….or what? Explain your answer.
5. In your opinion, should we use more of this compound, or should we try to cut down on its use? Explain.

Figure 4.8 *Compounds instructions for students*

Both the WKF and the traditional class used the same instructions. The major difference between the conditions was that students in WKF classes had to post their summaries on an ongoing basis into the WKF database and make regular comments on other students' work across both classes, as well as having access the face-to-face collaboration in class in their groups. Traditional class students only had access to face-to-face collaboration with their own group members.

4.4.3.2. Impact on Student Achievement

A one way between-groups ANCOVA was performed to compare the achievement of the three Phase II classes on in the Compounds posttest. Students' total scores both on the General Chemistry pretest and on the Elements posttest were used as covariates in this analysis. Descriptive statistics are shown in Table 4.4. As indicated, the results indicated no significant differences across the groups, $F(2,63) = 1.44$, $p = .25$. Thus, again, there was no evidence that WKF had a significant positive effect on achievement in Phase II.

Table 4.4

Descriptive statistics for the Compounds Achievement Posttest

Group	*M*	$M_{ADJ.}$	*SD*	*N*
Traditional	2.23	2.17	0.73	21
WKF A	2.42	2.45	0.38	23
WKF B	2.38	2.40	0.52	24
Total	2.34	2.34	0.55	68

4.4.2.3. Impact on Student Attitude

A one-way between-groups MANCOVA was performed to compare the classes in terms of attitudes towards science. In this analysis, students' attitude scores, both before the entire intervention, and after the Elements task, were used as covariates. Descriptive statistics are shown in Table 4.5. The MANCOVA indicated no significant differences between groups on the composite dependent variable, $V = .04$, $F(4,130) < 1$. Thus, there was again no evidence that WKF had a significant positive effect on attitudes.

Table 4.5

Descriptive statistics for the Science Attitudes subscales

Subscale	*Group*	*M*	$M_{ADJ.}$	*SD*	*N*
Enjoyment	WKF A	3.22	3.24	0.89	24
	Traditional	3.22	3.43	0.50	23
	WKF B	3.71	3.49	0.72	25
	Total	3.39	3.39	0.75	72
Difficulty	WKF A	2.82	2.81	0.85	24
	Traditional	2.83	2.64	0.39	23
	WKF B	2.58	2.77	0.64	25
	Total	2.74	2.74	0.66	72

4.4.3.4. Impact on preferences for collaborative group learning

A one-way between groups ANCOVA was conducted to compare the three classes in terms of students' preferences for collaborative or individual learning. In this analysis, scores from the same scale, given just prior to Phase II, were used as covariates in the analysis. A univariate ANOVA indicated that there were no significant differences between groups on this measure at pretest, $F(2,69) < 1$.

Descriptive statistics for the Phase II posttest scores on the preferences for collaborative learning scale are shown in Table 4.6. The ANCOVA indicated no significant differences across groups on this measure, $F(2,69) = 0.27$, $p > .05$.

Table 4.6

Descriptive statistics for the Preferences for Collaborative Learning Scale

Group	*M*	$M_{ADJ.}$	*SD*	*N*
WKF A	3.10	3.060	0.49	24
Traditional	2.99	3.000	0.44	23
WKF B	3.03	3.051	0.63	25
Total	3.04	3.037	0.52	72

4.4.3.5. Impact on preferences for ill-structured tasks

A between- groups ANCOVA was also conducted to compare the three classes in their preferences for ill-structured tasks. Again, in this analysis, scores from the same scale, given just prior to Phase II, were used as covariates in the analysis. A preliminary ANOVA indicated that there were no significant differences between groups on this measure at pretest, $F(2,69) < 1$. Descriptive statistics for the Phase II posttest scores are shown in Table 4.7. The ANCOVA on these scores indicated a significant difference across groups, $F(2,68) = 6.68$, $p = .002$, partial $\eta^2 = .16$.

Post-hoc comparisons indicated that both WKF classes obtained significantly higher scores on this measure than did the traditional class. Thus, this result suggests that WKF increased students' preferences for ill-structured tasks. The pattern of means obtained across groups on this measure is shown in Figure 4.9.

Table 4.7

Descriptive statistics for the Preferences for Ill-Structured Scale scores

Group	*M*	$M_{ADJ.}$	*SD*	*N*
WKF A	2.88	2.88	0.49	24
Traditional	2.38	2.43	0.58	23
WKF B	2.92	2.88	0.62	25
Total	2.74	2.73	0.61	72

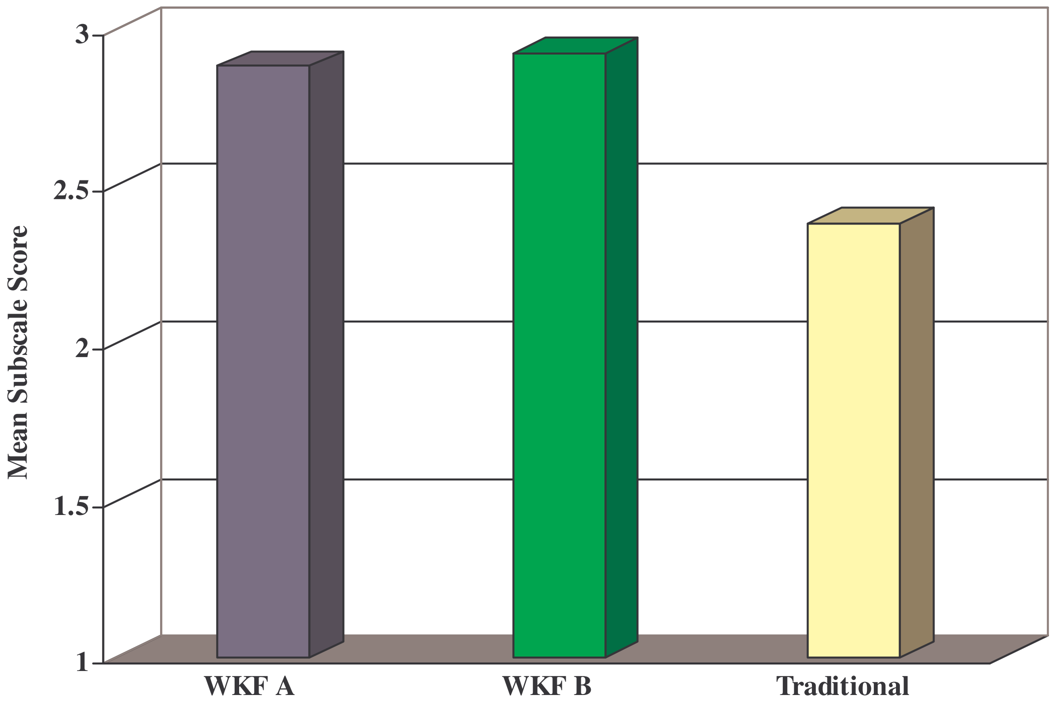

Figure 4.9 *Mean scores for preferences for the ill-structured tasks*

4.4.3.6. Impact on lower- and higher-order thinking

A one-way between-groups MANCOVA was then performed to compare the classes students' lower- and higher-order thinking skills. Descriptive statistics are shown in Table 4.8. The MANCOVA indicated a significant difference across groups, $V = .16$, $F(4,134) = 2.83$, $p = .03$.

Table 4.8

Descriptive statistics for lower- and higher-order thinking scores

Subscale	*Group*	*M*	$M_{ADJ.}$	*SD*	*N*
Lower-Order Thinking	WKF A	2.97	2.99	1.46	24
	Traditional	3.98	3.94	0.87	23
	WKF B	3.63	3.65	1.32	25
	Total	3.52	3.53	1.30	72
Higher-Order Thinking	WKF A	2.20	2.31	1.25	24
	Traditional	2.95	2.89	1.16	23
	WKF B	2.27	2.23	1.46	25
	Total	2.47	2.47	1.32	72

Based on a Bonferroni-adjusted alpha level of .025, univariate ANCOVAs indicated that there was a significant difference across groups on the lower-order subtest, $F(2,68) = 4.15$, $p = .02$, partial $\eta^2 = .11$, but not on the higher-order subtest, $F(2,68) = 2.62$, $p = .08$. Post-hoc comparisons indicated that the mean score for the traditional class on lower-order thinking skills was significantly higher than for WKF A. WKF B did not differ significantly from either of the other two classes. Thus, this result suggests that the traditional class students made significantly greater use of lower-order thinking skills than did students in the eight-week WKF class. The pattern of means obtained across groups is shown in Figure 4.10.

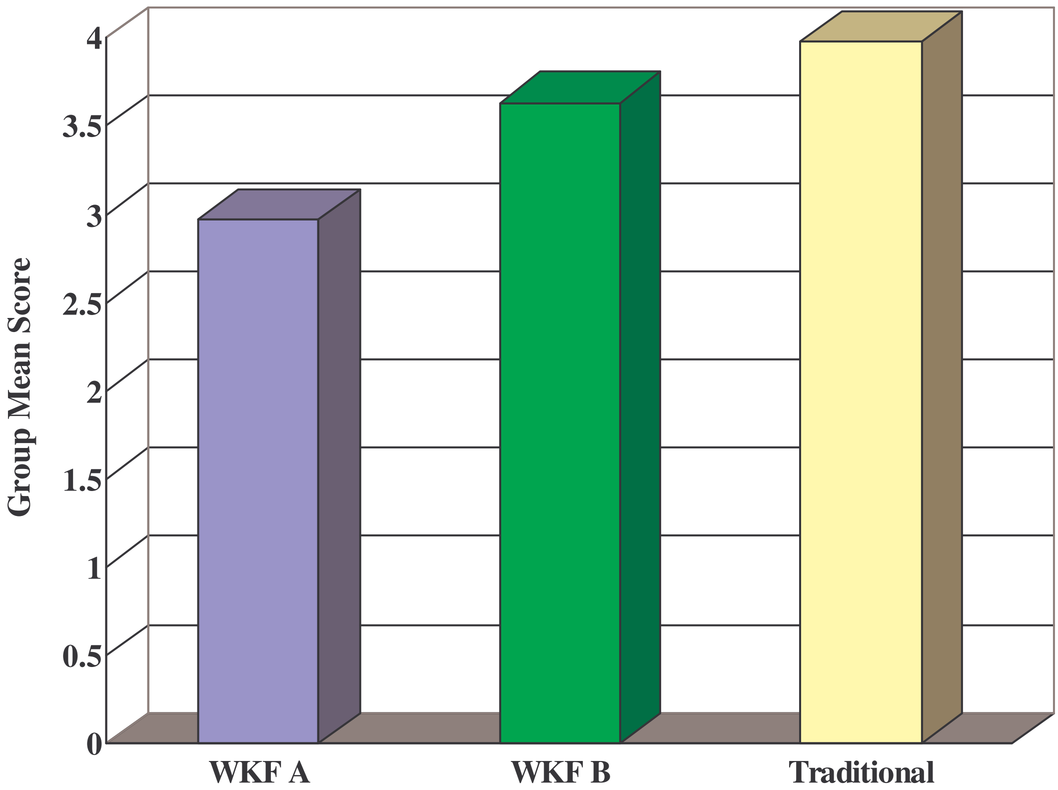

Figure 4.10 *Mean Lower- order thinking scores*

4.4.3.7. Impact on metacognitive skills

A one-way between-groups MANCOVA was performed to compare the classes in terms of students' metacognitive skills for the compounds task. Students' pretest scores on the same test were used as covariates in this analysis. Descriptive statistics for the four parts of the metacognitive scale are shown in Table 4.9. Based on the Pillai-Bartlett criterion, the MANCOVA confirmed a marginally significant difference between groups, $V = .21$, $F(8,132) = 1.84$, $p = .07$. As noted by Tabachnick and Fidell (1999), the use of MANCOVA can produce power reductions with certain variables combinations. Given also the relatively low power of the comparisons in this study due to small cell *n*s, univariate ANCOVAs were also performed to investigate this effect.

As indicated in Table 4, ANCOVAs using a Bonferroni-adjusted alpha level of .02 confirmed significant differences in students' cognitive strategy use, $F(2,68) = 4.20$, $p = .01$, partial $\eta^2 = .11$. Bryant-Paulson *q*s showed that WKF B significantly outperformed the traditional group, $q = 2.88$, $p < .02$. From this result, the WKF intervention appeared, at least in one class, to have encouraged students to develop their cognitive strategy use relative to the traditional class. The pattern of means obtained across groups is shown in Figure 4.11.

Table 4.9

Descriptive statistics for the Metacognitive skills test

Subscale	*Group*	*M*	$M_{ADJ.}$	*SD*	*N*
Planning	WKF A	1.75	1.799	0.68	24
	Traditional	1.43	1.395	0.72	23
	WKF B	1.83	1.814	0.80	25
	Total	1.68	1.669	0.74	72
Monitoring	WKF A	1.38	1.379	0.77	24
	Traditional	1.52	1.523	0.37	23
	WKF B	1.78	1.780	0.81	25
	Total	1.56	1.561	0.70	72
Cognitive Strategy Use	WKF A	1.21	1.275	0.59	24
	Traditional	1.11	1.060	0.52	23
	WKF B	1.52	1.506	0.49	25
	Total	1.29	1.280	0.55	72
Evaluating	WKF A	1.33	1.438	0.76	24
	Traditional	1.26	1.157	0.64	23
	WKF B	1.52	1.517	0.70	25
	Total	1.38	1.371	0.70	72

Table 4.10

Analyses of variance for the metacognitive skills test

Source	Measures	*df*	*MS*	*F*	Partial η^2
Pretest	Planning	1	1.44	2.75	.04
	Monitoring	1	0.21	0.45	.01
	Cognitive strategy use	1	0.66	2.35	.03
	Evaluation	1	2.65	5.76	.08
Groups	Planning	2	1.41	2.69	.07
	Monitoring	2	0.92	1.93	.05
	Cognitive strategy use	2	1.17	4.20*	.11
	Evaluation	2	0.64	1.39	.04
Error	Planning	68	0.53		
	Monitoring	68	0.48		
	Cognitive strategy use	68	0.28		
	Evaluation	68	0.46		

*Significant at $\alpha = .02$ level

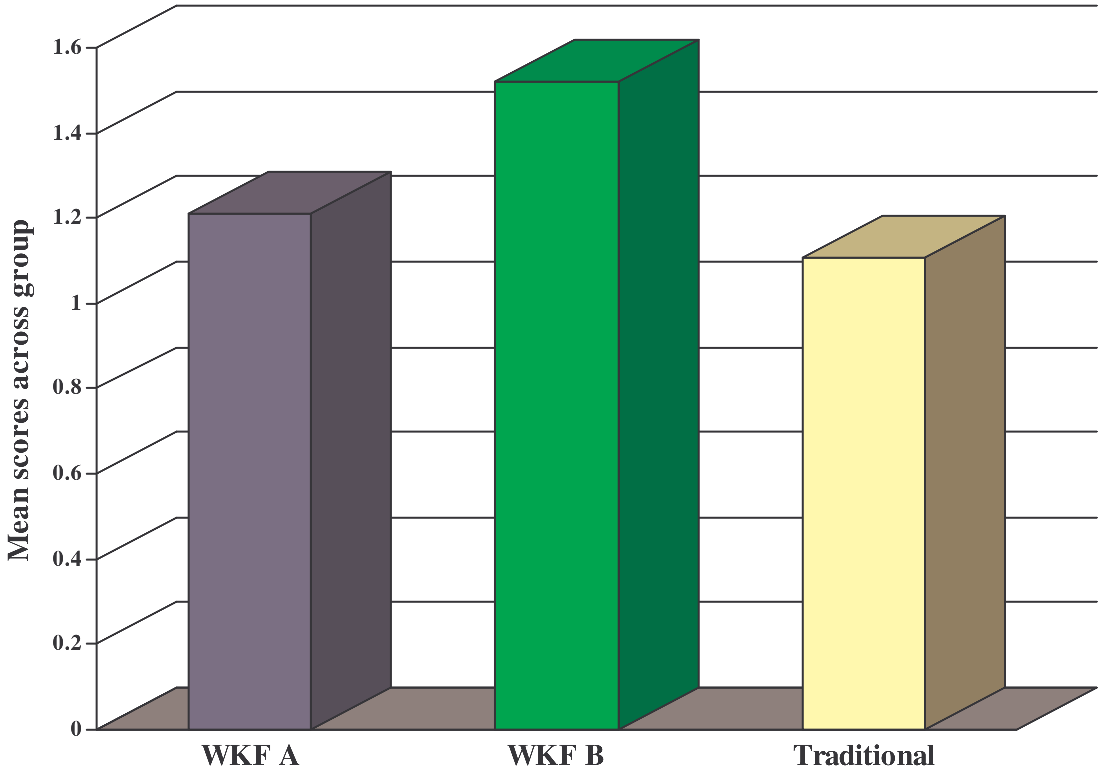

Figure 4.11 *Mean scores for the cognitive strategy use subtest*

4.4.3.8. Discourse analysis

Despite some of the promising results obtained for WKF in Phase II, students' WKF discourse sessions in this phase continued to indicate relatively low level use of the program's collaborative features. Their interactions tended to focus mainly on sharing and comparing information. Figure 4.12 provides one example of an illustrative exchange.

Annotation for Soap. 1) Wow goon! Nicely done! I see you have worked very hard and researched a lot. I have learnt a lot about soap I never knew. (comment by J. P) 2) Nice summary and research questions! Well Done. (comment by P. W.) 3) Goon ! now I know not to throw soap around otherwise you can hit some elses eye and not to use cheap stuff because then I can get skin infections. Nice work Goon !!. (comment by S. C.)

Figure 4.12 *Students' discourse in WKF*

4.5. SUMMARY

As noted, the documentation of processes used in Phase I suggested that the modifications used by the participating teacher for WKF were relatively minimal. The major difference between the WKF and traditional conditions was that students in the WKF classes had ongoing access to collaboration with their entire class, rather than just a small group, like the traditional class students.

The results for Phase I indicated that there were no significant differences between the conditions in terms of achievement, attitudes, or higher- and lower-order thinking processes. It is possible that these outcomes reflect the nature of the assessments used. First, both achievement and attitudes may not be the kinds of characteristics that are likely to improve immediately – these are more likely to be preceded by changes in certain types of learning processes, like metacognitive skill levels. Second, the tasks assigned in this phase did not lend themselves well to the demonstration of higher-order thinking processes. This may account for the lack of significant findings on this measure.

In order to ensure that these processes were assessed in Phase II, three further instruments were added to the assessment. The instructions given for the assignments, and thus also for the research summaries, were also crafted more carefully by the class teacher to encourage the use of higher-order thinking skills.

Results for Phase II indicated there were no significant differences between the WKF and traditional classes in terms of student achievement, attitudes or preferences for collaborative learning. There were, however, significant differences between classes in terms of their preferences for ill-structured tasks (WKF favouring more ill-structured tasks), cognitive strategy use (higher skill levels for WKF B over traditional class), and lower-order thinking skills (higher use of lower-order thinking in traditional class over WKF A). Thus, the outcomes of Phase II were somewhat more positive for the effects of WKF.

CHAPTER 5

STUDY III: BEGINNING TEACHERS' PERSPECTIVES ON WKF

5.1. INTRODUCTION

Previous studies have shown that the strategies teachers use to integrate ICTs within classrooms can influence significantly the efficacy of these tools (Driscoll, 2002; Lamon et al., 2001; Lee, 1992; Moreau, 2001; Winter & McGhie-Richmond, 2005). Not surprisingly, the results of Study II suggested similarly that using different approaches can impact the outcomes of using WKF in secondary classrooms. In Study III, three teachers from the school in which Study II was conducted were interviewed regarding their views on the benefits and limitations of WKF based on their initial experiences. One of these participants was the teacher involved in the implementation of Study II. The other two were teachers who implemented WKF independently in the following year as part of a whole-school program.

The goal of conducting Study III was to provide an analysis of WKF from beginning teachers' points of view. The semi-structured interviews used in this study focused specifically on addressing the following research questions:

1. Overall, what were teachers' views of WKF as a tool for enhancing student learning processes and outcomes?
2. What are the strategies and approaches that these teachers used to implement WKF in their classroom teaching?

3. What did teachers feel were the primary advantages of using WKF in their classrooms?
4. What were some of the problems that teachers encountered in their first implementations of WKF?
5. What are these teachers' recommendations for those who want to use WKF for the first time?

5.2 METHOD

5.2.1. Participants

Three teachers were interviewed who had used WKF, either as part of the current research program, or in the year that followed Study II. The teacher who participated in Study II was interviewed immediately after the intervention concluded. The first teacher (labelled T1) was a chemistry teacher; the second (labelled T2), a general science teacher; and the third (labelled, T3), a geology teacher. All three teachers were highly experienced as science teachers, and had used WKF for at least one school term.

5.2.2. Procedure

The data gathered in this study were based on semi-structured individual interviews. Semi-structured interviews were used because this method has been found to be effective in building rapport and clear understandings of informants' points of view (Minichiello, Aroni, Timewell, & Alexander, 1990). Minichiello et al. (1990) further elaborated that this method allocates a high status to the information given by the interviewee and emphasizes the importance of allowing the interviewee to use language that they are comfortable in using.

Initially, themes were generated on the basis of the first interview conducted with the teacher involved in Study II (T1). These themes were then integrated with existing literature reviews on the use of ICTs within secondary level classrooms. The integration of this information was then used as a basis for constructing the semi-structured interview questions for the next two teachers (T2 and T3). The list of the interview questions is attached in Appendix 11. On some occasions, the researcher asked some additional questions based on the responses given by the teachers in order to clarify the issues raised. Each interview took about 20 to 30 minutes, and each was conducted during the teacher's free period at the school.

All of the interviews were recorded with permission, then transcribed and analysed based on the Miles and Huberman (1994) framework. The approach involves three major stages: data reduction, data display, and drawing/verifying conclusions. These three steps are taken to provide a general basis for the analysis of open-ended responses.

5.3 RESULTS

The teachers' responses were analysed and grouped for similarities for each of the major research questions. Themes were then generated from these groupings.

5.3.1. What were teachers' general views of WKF?

Overall views of the efficacy of the program were very mixed among the three teachers interviewed. T2 and T3, the two teachers who used the program on an "ad hoc" basis, were relatively unfavourable in their views. When asked whether they intended to use the program again in the future, these teachers indicated that they probably would not:

> *We did it as a trial, and … it wouldn't be fair to say that we were not impressed, but it wasn't something that anybody thought was so good that we need to make sure we use it again next year. So nobody has suggested that we should use KF again this year. For what it allows us to do, I probably wouldn't use it again (T2).*

> *I am not really sure. I found it had its benefits for what we used it for. They put their assignments on there and they got other students to give feedback and stuff, but I found that too time consuming. I also found it very hard for me to go back and evaluate what the kids had said from the database, so probably not (T3).*

In contrast, T1, the teacher who was given the time and opportunity to trial the program and plans his implementation before using WKF in the classroom, was far more positive. When asked whether WKF was worth the input, and whether he intended to continue using the program in his classroom, this teacher commented:

> *Yes, definitely, in our situation, absolutely. Now that I have begun to understand the kinds of things that it can do better, and I have started to think more about what I can do with it. The more I do it, the more I understand, and the better equipped I am to use it in the future (T1).*

This teacher also indicated his intention to encourage other teachers to make use of WKF in their own lessons, though he indicated that this could take time:

> *Getting other teachers to use it will come a little bit down the track. First I think that we have to get a model that works so that we can show them this is fantastic ... Any kind of new way of doing stuff is always going to require*

someone to take it out early and start the ball rolling. Whether it continues to roll or not depends on what the people do with it, whether it's useful, and the kind of effort it requires … Certainly, there are a couple of other people in the department who have been thinking that they might be able to do it as well, so with any luck we'll have a couple more people next year (T1).

5.3.2. How did teachers choose to use WKF in their initial implementations?

All three teachers had used WKF primarily for research tasks when they were interviewed. Despite this, the three teachers interviewed had used very different methods and approaches to implement WKF in the classroom.

T2 introduced WKF to the students in a lecture class at the beginning of the lesson and later followed with a "try and play" session. Once the students were comfortable with WKF, they were encouraged to do their work independently:

I use a lecture-type situation to introduce them to WKF. So I told them how it worked and then we had a session where they had a play, so they just tried posting a comment, looking at other people's comments and adding link to these. Then when we thought they got the idea of how to use it, we introduced them to doing the research tasks. They worked pretty independently on that (T2).

T3 indicated that she used tasks with a "question and answer" structure in her approach, and had found WKF effective in facilitating this process. Students made use of the feedback they were given from their classmates to improve on their work:

We used it for students to get comments on how other students answered the assigned questions. To figure out what were the positive and negative aspects of that, we then went through it. I told them that when you give feedback, you need to point out both the good things and things that need to be improved, so I found that really good (T3).

T1 indicated that he had attempted to integrate the use of WKF to teach both about science method and science theory. He indicated planning to integrate WKF in both theoretical and practical classes in the future, because he saw WKF as a tool that would allow students to monitor their own performance and self-correcting skills. In his vision of practical classes with WKF, the students would post their experimental results in the discussion forum to allow other students to comment on them:

At the moment, we're doing theory part stuff with WKF and second half bit practical. I can't see any good reason why practical results shouldn't get shared also … that's maybe the next thing I will start to incorporate … That way if one student sees something that other students didn't notice, or didn't understand, it can act as a kind of self-correcting mechanism as well (T1).

5.3.3. Advantages of WKF

WKF has been cited previously as offering diverse benefits in terms of facilitating and enhancing teaching and learning processes. Four major themes emerged in teachers' responses to the question about advantages of WKF for classroom teaching.

Theme I: Access to Peer Feedback

One of the major benefits indicated by all three teachers was that WKF provides opportunities for students to give feedback and comments on other people's work. This in turn prompted students to improve their own work, and taught them to be more open-minded and receptive to comments as part of the learning process. In particular, teachers commented that:

> *Students can post up a question or response, and this can prompt other members of their group to post other questions or responses. Then you can expand on that – so that some time later, different groups can be invited to comment on the exchanges of that group. Eventually we can have three classes with different types of students all involved. Something like that can't happen normally, so this provides opportunities for feedback that normally aren't available (T1).*

> *We asked the students to evaluate the work of other groups and in terms of getting access to other work WKF was really good … WKF does allow you to see what other students have done, and it allows students to make comments and make links to what they already know about the topic (T2).*

> *I did really like the way that students can give others feedback and they did really enjoy that. They enjoyed having a look, you know, like having bits of tasks belong to you (T3).*

Theme II: Encouraging Collaboration

The possibilities for collaboration through WKF were seen as a major advantage. These were viewed as particularly relevant for middle school students, for whom promoting teamwork and social interaction skills is a priority in Australian schools. WKF was seen to broaden possibilities for collaborative learning in the classroom, and to encourage students to engage in extended dialogues with their classmates:

> *It is a great strength, because it allows students to interact with one another. It has the potential for collaboration, definitely, and to enhance the social aspects of working as a team. There are all sorts of benefits for the students in this program, and particularly within the 13-14 year old category, who like to work in social groups (T1).*

> *Yes, we like our girls to work collaboratively and that is a strong focus at the middle school level. So we promote dialogues in the classroom. It did a good job at that, because it makes the kids talk and communicate with each other through the software. So it helps us to achieve one of the aims of middle school which is to promote collaborative learning (T2).*

WKF was seen particularly to enhance collaboration amongst students who either were unused to collaborating, or would normally choose not to collaborate with certain other members of their classes:

> *Collaboration is something the students have to come to understand and get used to. Very few students just naturally like to talk in question and answer form. But using WKF, a student can try something, get a result, and tell their friends, and start to collaborate naturally and gradually (T1).*

> *If you have some kids who say didn't know a couple of members in their group, or perhaps didn't like a couple of members of their group, socially within the classroom, there may not be a lot going on. But when they communicate online, they can be a little bit more objective in terms of what they are doing, because the personality thing doesn't necessarily get in the way (T2).*

WKF was also thought to introduce new types of collaboration within the classroom, thus broadening the types of tasks on which collaboration could be used:

The big advantage is interactivity without needing to be face-to-face talking to students – so it's not limited to your time. One of the possibilities that WKF brings is that whether they are in this class or in their regular time slot, they can have access to other students' ideas (T1).

Well, it's a different type of collaboration. They don't necessarily work together the whole time, but they can work together by commenting from the other side of the room and commenting on each other's finished work and using those comments to improve their own work. So in a way it's collaborative, but they are not working directly together, so they can add to each other's work in a different format. The girls found that interesting (T3).

Theme III: Online accessibility

WKF's ability to make students' work accessible on the internet beyond school was seen as a major benefit for parents, students and teachers as well, for several reasons. First, this feature was seen to provide parents with a general view of what their children were actually learning in class. Through this means, they could monitor their children's progress by looking at their contributions and discussions in WKF:

That is fantastic because the parents can have a chance to look at it as well. If you think about what happens in school, very few parents really understand what goes on, or see what much of what the students are doing (T1).

Second, it was also seen that student who needed to be away overseas could participate without having to be in the class itself:

The advantage of WFK lies in the fact that students can access it from overseas and get access to the online learning without coming to class. They can even have discussions without being in the school (T1).

It was also noted that the accessibility afforded by WKF allowed experts and other members of the community to contribute to class discussions:

> *And other people from the community can join in the discussions. So we can get science professionals out there who wish to donate some of their time, to further enhance the students' learning experiences. They could even just be engaged to take a look for say five minutes each week to provide feedback on what the students have done (T1).*

Theme IV: Promoting Independent Inquiry Skills

WKF was also seen by one of the teachers to encourage students to pursue different online pathways to source answers to assigned questions:

> *WKF produces a similar kind of format to what you find in forums on the internet. These kids will come across different discussion groups in online environments, and they have to learn how to follow the threads that run through discussion groups. This is a good way for them to understand how the websites work and to understand how they can follow a thread and actually find out the answers to what they want to know. Because often on the internet, you wind up on a forum of some sort and you have to read all of the comments. To find the answers to your questions, you need to learn how to drill down and follow the links to find answers to the questions that you want. To do this, they have to understand how to use a forum. I thought that this was a big plus for using WKF (T2).*

5.3.4. Problems encountered in WKF

All three teachers faced a number of problems when they applied WKF in their classrooms. Four major themes arose in teachers' responses to this question.

Theme I: Assessment

Two of the teachers noted problems in assessing the work of students who had used WKF to complete an assigned task. These were associated primarily with difficulties in assigning individual grades to members of each group:

> *When we did it in groups, it was almost impossible to access individual contributions because they are working collaboratively online and in the classroom as well. We can't really be sure that the students who do the most of work or their group really did collaboratively work well on that. That was little tricky (T2).*

> *When the students are doing group work, there must be an individual component as well. I think it is important to have a follow-up individual thing because it is hard to assess a group (T3).*

Theme II: Maintaining Students' Engagement

Both T2 and T3 noted difficulties in maintaining students' interest levels while they were using WKF. Both felt that students enjoyed learning with WKF in the beginning, but that this interest was not sustained. This was partly ascribed to the limited visual capabilities of the program:

> *I found that it wasn't an experience that the kids thought was so fantastic that they just wanted to keep doing it, doing it, doing it again and again (T2).*

Well, initially they thought it was quite cool because they could comment on each other's work, but I found that after a while, they wanted to do something more visual. It would be nice if it was more visual (T3).

T3 mentioned further that the program might be more engaging if students contributed to work simultaneously rather than following strings of messages:

With WKF the links are linear. You have to look at this kid's work and what they have done on their own, then make a link to your comments and your work. What I wanted was a bigger body of work that all students could contribute to, instead of having to follow the thread - you know what I mean (T2).

To overcome these problems, T3 suggested breaking up the implementation of WKF so that students had a more mixed exposure to the program:

They certainly need a break from it every now and then, like having a few lessons on and a few lessons off. They will get a little bit bored with using the same sort of things and reading and commenting and that type of stuff so it needs to be broken up (T3).

Theme III: Time and Funding Constraints

One of the major problems the teachers encountered in their efforts to implement WKF was time. This factor was considered likely to influence the efficacy of WKF dramatically. Even the teacher engaged in Study II felt that he did not have time to plan proper lessons and tasks to be conducted with WKF, or to analyse the real benefits offered by WKF, during his implementation:

I haven't spent a great time looking at the students' work. I am too busy doing other stuff to do lots of monitoring, so the capabilities are there, but I am not sufficiently confident and I don't have enough time that I can dedicate to it, to

> *actually sit down and analyse the tasks and stuff like planning and all that … I have to make it a priority to make that happen (T1).*

T1 noted that learning WKF required a significant time investment, particularly on the part of the teachers. It was less of a problem for students, because most of them are comfortable with computers already. He further mentioned that one of the problems that most teachers face in schools is lack of financial support for professional training:

> *For most students it's not that hard, it just different from anything they have used before so they have to work through it. But most students of this age are quite happy with computers. They learn fast and like anything else, the more they do it, the less threatening it is … But I don't think many schools are willing to fund teacher time to develop this stuff (T1).*

Theme IV: Plagiarism

As with many online programs, plagiarism was a common problem experienced by the teachers in this school. It was, however, not seen as a problem peculiar to WKF, but one that presents in all uses of internet-based learning tasks:

> *You always come across plagiarism issues when you use the internet and I don't think its any worse in WKF than it would be anywhere else (T3).*

T2 also indicated that issues like plagiarism were not unique in creating problems of assessing ownership of work. In particular, she noted problems of parental involvement in work in the same light:

> *Problems like plagiarism are not separate from distribution of work - like we have parents doing assignments as well, which make assessment equally meaningless for some of them (T2).*

To overcome these and related issues, T2 routinely did follow-up assessments on an individual basis, to give more accurate evidence on what the students actually gained from the learning tasks:

> *We tend to do follow-up research-based tasks with some form of written test that kids do in isolation, to obtain more reliable data (T2).*

5.3.5. Recommendations for beginning WKF users

The three teachers interviewed were enthusiastic about providing recommendations to other teachers who wished to use WKF for the first time. They focused particularly on ways that collaborative learning tasks should be designed around the use of WKF. Their suggestions centered upon five major themes.

Theme I: Start Small

The teachers recommended starting with small projects, because the students could then familiarize themselves with the software while concentrating on reading, analysing, and commenting on the information gathered properly. The major concern was that if teachers conducted their first attempt with WKF on an ambitious task, students would not cope with the large amount of information that needed to be processed and understood:

> *Start small with little things you want to do so that the students get used to it, the teacher gets used to it, and then work up to a fair size project slowly. You don't need to start projects slowly, but you should start in stages (T1).*

Certainly the important thing is that, whatever the research task is, it should be small. Then the kids can put up their comments carefully and other kids can actually read and comment on those entries properly. I think it's important to make sure that their comments are valid … So keep the task short and simple (T3).

Theme II: Run a Trial and Plan Sessions in Advance

T1 suggested that all beginning WKF users should conduct a trial before actually implementing the program within the classroom. This would allow the teacher to work out the strengths and weaknesses of their lesson plans beforehand:

I am glad at that I had a trial run with staff who were connected with the project before I tried to use it. That showed what the problems might be and it didn't take up project time. If you don't know what to do, and I would recommend for anyone who wants to use this, don't jump straight in, trial everything with other staff or on your own first (T1).

T1 also suggested that working out how to structure tasks around the use of WKF was a major challenge that required significant pre-planning:

The next biggest problem is to work out the structural stuff – such as questions and answers that are going to work, or how should we do this, should we have this resource when we do this, should we separate the students into groups based on interest or some other factor … these are the things that you need to work out in advance (T1).

Theme III: Consider Carefully Factors Like Group Size and Composition

Several comments were also made about how to structure groupwork in WKF. T2, for example, mentioned that while WKF is capable of hosting large group discussions, in the initial stages, he would favour smaller groups:

> *I am still experimenting with online collaborative work practices and don't know yet whether it is good to have large number of kids working together or whether it is better to have smaller groups. My gut feeling is that it would be more efficient to work with smaller number of kids in WKF, probably somewhere between 3 and 6. I suspect that would suit the way that the girls like to learn. So if I were going to use it again, I probably would put them into smaller working groups (T2).*

Two of the teachers commented on group composition issues, and held quite different views on whether the groups should be of mixed or similar ability levels. T2 believed that students of similar abilities should be grouped together:

> *I dislike having the situation where the smart kids have to help the low ability students. My personal opinion is that if you are able to do it, kids should be in similar ability groups, because for the very able kids, they will pick up how the software works very quickly. If you have to stop the class because some people are having problems with this, you will be wasting their time. The low ability kids need constant help, more specific tuition, and smaller chunks of information. So keeping them separate is more efficient. I would be wasting the time of the smart kids otherwise. So I am not a big fan of mixed ability groups with WKF (T2).*

T3 had a more mixed attitude towards group composition factors. She suggested that if students of similar ability were grouped together, they would produce similar answers. For the lower-ability students, this could be problematic:

> *It can make things quite difficult sometimes if you have similar ability groups. You can get similar sorts of responses from students and they can all be incorrect (T3).*

She also cautioned, however, that what comes of mixed-ability group efforts rarely reflects what all of the students have actually learned or understood:

> *If you have both high and low ability students in a group, sometimes the comments that come of that do not really reflect what the students have done. That can be difficult (T3).*

The teachers agreed that WKF is effective in promoting group cohesiveness, particularly with students who are not used to working together. The second teacher initially let students choose their own groups, but felt it would ultimately be better if they could work together with new students:

> *We tend to allow them to do that [choose their own groups] but you do get to the point where you think, these kids need to work with new people. Sometimes it is good for students to work with people they have never worked with before. So, you can do that quite effectively with WKF. As the body of work is developing, the girls don't have to let it be seen that they are working with somebody that they don't normally like, because it can get very complicated with that kind of relationship (T2).*

The third teacher actually used random number allocation strategies to group the students together. She believed that working with new people helps to create energetic, vibrant, and dynamic learning environments:

> *I normally do this by random number allocation. Because there is a certain group dynamic, I like them to try working with different students rather with than their friends all the time (T3).*

Theme IV: Consider using Scaffolding and Mixed-Mode Tasks

T2 noted that the scaffolding features in WKF can facilitate collaboration, helping students to work independently of the teacher's support:

> *I think I like the sort of scaffolding that WKF provided. I remember those things and this is good, the kids will be able to function quite well without needing a huge amount of assistance in the intervention. Scaffolding really helps with the collaborative structure (T2).*

T3 suggested combining structured and unstructured collaborative approaches in working with WKF. She considered that it is essential to ask the students to give their views on how tasks should be structured:

> *I think you should use a combination of the two really. Sometimes I have more structured collaboration, sometimes a little more on the unstructured side. I then let the kids say which they prefer to work with. I think it's important to have both, particularly starting with the structured approach and then starting to remove those structures as you move through your task (T3).*

All three teachers pointed out that they would prefer to use mixed modes in the implementation of WKF, because students tend to lose interest after using one method for an extended time period:

> *Sometimes you get to the point where, when the kids are working independently, they get a little bit bored and I need to get some kind of interaction with my whole class. So we need to pause and I need to reconnect with the class as a whole (T2).*

> *I think you have to have face-to-face discussion as well, because students get bored on the computer all the time, and they need face-to-face interaction, or a more visual concrete sort of exam or interaction as well (T3).*

T2 suggested that WKF could be conducted continuously for two weeks, followed by a short break, in which the class returned to the traditional teaching format. During the break session, they could then discuss what they had learned in the WKF sessions:

> *I feel that every couple of periods, I need to stop and we need to change the way we work so it might involve me bringing them back together as group and discussing the experience for the last two periods or discussing what we found out or being reflective about using WKF (T2).*

5.4. SUMMARY

The findings of this study highlighted the views of three teachers on WKF after implementing the program for the first time. Based on these outcomes, teachers highlighted a number of issues that they encountered with the use of the software, and made several recommendations for future first-time implementers of the program at the secondary level.

The three teachers' views of WKF as a tool for enhancing student learning processes varied considerably. Regardless of the advantages cited for the WKF program, two teachers indicated that they would be unlikely to use the program again in future. T1, who was also the participating teacher for Study II, was far more positive. He indicated that he would definitely be continuing his use of WKF in upcoming classes. It is possible that this result reflects the extra time that this teacher was given to prepare his lesson plans to incorporate the WKF activities.

The strategies and approaches that these teachers used to implement WKF also varied considerably. While T1 appeared to adopt something of a trial-and-error approach, T2 used a lecture-type introduction to each session followed by a practical session with tasks in a question-and-answer format. Clearly, therefore, teachers are likely to incorporate the use of the software in very different ways, which will moderate the impact that use of the program has on student learning outcomes and processes.

In terms of advantages of using WKF, the collaborative facilities provided by the program were seen as the major benefit. The database or forum that the students contribute to provides an extensive knowledge pool. This also introduces the possibility of having students from different classes (and even content experts) contribute to discussions by posting their comments in the database. Teachers appeared also to appreciate the program's facilities for peer assessment and faceless interaction, which can increase objectivity of students' comments on the work of others.

Teachers encountered several problems, however, in their first implementations of WKF. One major drawback was the sheer bulk of information available for assessment.

Teachers felt that this would be too much for them to handle on a regular basis. Time factors were also considered to be a significant factor in determining whether a WKF intervention would work. Other, more minor concerns focused on issues to do with maintaining students' engagement over extended periods when WKF is used as a single learning mode.

All three teachers made a number of recommendations for other teachers who wanted to use WKF for the first time. These included recommendations associated with starting with small projects or tasks and trialling the program before using it in the classroom. In general, however, teachers felt that having greater access to collaborative support from colleagues and/or experts would be essential to ensure success in first implementation of WKF.

CHAPTER 6

ENHANCING WKF EFFECTS IN SECONDARY CLASSROOMS: KEY RECOMMENDATIONS

6.1. INTRODUCTION

This chapter integrates the outcomes of the three studies conducted in this research program. WKF has been reported previously to improve students' thinking and learning processes within classrooms, particularly in terms of higher-order processes (Lamon et al., 2001; Oshima, 1998). Several studies have also explored different approaches that teachers can use to integrate WKF within the classroom (Hewitt, 1996; Moreau, 2001; Reeve, 2001). Rarely, however, have these effects been investigated concurrently. Furthermore, no research has been identified which examines teachers' initial experiences with using WKF.

The aim of this research was, therefore, to examine the effects of WKF on secondary students' learning processes and outcomes in a first-time implementation. Three studies were conducted to address this goal. In Study I, a self-report metacognitive skills test was developed. Study II documented one teacher's approach to using WKF and examined the effects of these interventions on students' achievement, attitudes, preferences for collaborative work, attitudes toward ill-structured tasks, metacognition, and higher- and lower-order thinking. Study III explored the teachers' perspectives on their own experiences of implementing WKF for the first time.

The ultimate goal of the research was to provide a set of guidelines on how to apply WKF effectively for first-time users. More often than not, teachers who wish to use WKF must develop their own models based on their personal teaching experiences, which can lead to the application of unstructured practices and procedures (e.g., promoting teamwork but setting tasks that establish an individualistic or even competitive goal structure). This can, in turn, attenuate positive effects and encourage teachers to abandon use of the approach prematurely. The recommendations provided here are based on previous literature on the effective integration of collaborative learning and ICTs, together with the findings of the three studies conducted.

6.2. SUMMARY OF FINDINGS

6.2.1. Study I

Study I was a preliminary study conducted to establish a valid means by which to assess metacognition in the main study. Four metacognitive skills (Planning, Monitoring, Cognitive strategy use, and Evaluation) were assessed in both closed- and open-ended format. This was done to allow a comparison of the two tasks, with the open-ended section used as a verification of students' skills in this area. Although confirmatory factor analyses supported the structure of the close-ended section, correlations between the closed- and open-ended tasks were very low. This outcome suggests that the two types of task assess different constructs. Given that the open-ended tasks were considered to provide a more stringent test of students' skills, only this section was retained in the major study.

There are several reasons why ill-structured (i.e., open-ended) tasks may be a more suitable means to assess metacognitive skills than more traditional, closed-ended questions. Open-ended tasks have been found to encourage students to think more actively than they do in closed-ended tasks. Initially, Gestalt psychologists employed this method to assess the insight levels of human beings (Dunker, 1939; Maier, 1931; Wertheimer, 1996). More recent research in cognitive science also suggests that, because open-ended tasks require “conscious attention” rather than “automatic processes”, students must have formed a more in-depth understanding of the topic to deliver appropriate responses (Just & Carpenter, 1987). Closed-ended tasks, in contrast, are more likely to elicit automatic responses, because students are not required to be actively involved in constructing new responses or answers.

As noted by Dirkes (1985), metacognition involves selecting learning strategies by relating new information to previous knowledge, actively selecting effective thinking strategies, and planning, monitoring and evaluating ongoing thinking processes. Given that open-ended tasks have no absolute answers, these kinds of tasks require similar processes. Close-ended tasks do not require these processes, because predicted responses are provided. The latter kinds of tasks, therefore, tend to be superior for assessing factual knowledge with an emphasis on information recall and recognition.

Further evidence to support the superior validity of the open-ended tasks was provided by other correlations obtained in Study I. First, previous research has indicated that several factors may affect metacognitive skill levels (Dufresne & Kobasigawa, 1989). In particular, metacognition has been found to increase significantly with age. Children are able to understand better what is needed to solve problems as their age and experience increase (Flavell, 1979; Paris & Parecki, 1993). In Study I, it was found that lower grade students performed significantly more poorly than higher-grade students on the open-ended, but not on the closed-ended, tasks. Given that this finding is well-aligned with previous research on metacognition and age, this provided support for the validity of the open- over the closed-ended tasks.

Second, the closed-ended tasks typically demonstrated a negative correlation with teachers' overall ratings of students' metacognitive levels. While it was not anticipated that the correlations with teacher ratings would be high for either section, some positive association was expected. The outcome obtained appears to suggest that students who estimated their own metacognitive levels to be high on the closed-ended tasks received lower scores from teachers. It is possible that this is due to the fact that some students were not even aware sufficiently of the strategies referred to in the instrument to provide an accurate evaluation in this section. Although few of the correlations for the open-ended tasks were significant, of those that were, all were positive.

Overall, outcomes of this study cast doubt on the validity of using any form of self-report instrument to assess metacognitive levels.

6.2.2. Study II

The findings of Study II were somewhat mixed. In Phase I, the use of WKF had no significant impact on any of the dependent measures used. In Phase II, there were some significant effects recorded, all of which related to "intermediate" or "formative" learning processes. Specifically, the results of Phase II indicated that in the WKF classes, students:

- were inclined to provide answers that included fewer lower-order responses;
- demonstrated a preference for ill-structured task formats, and
- demonstrated higher levels of cognitive strategy use.

The above findings could be seen as a "stepping stone" to more significant results for a longer-term intervention. As noted previously, many previous studies on WKF have assessed its benefits over a period of one school year or more (Messina, 2001; Elliot & Pillay, 2001; Caswell & Lamon, 1998). Many that have been conducted over short time periods like the present study have reported no significant differences between WKF and more traditional teaching and learning approaches. It is possible, therefore, that the present results reveal only the immediate consequences of the study procedures. A longer study might have shown a broader range of WKF outcomes.

Of the outcomes that were obtained, in Phase II, traditional group students made significantly greater use of lower-order thinking skills in their research summaries. Because these students were not able to contribute to discussions with their peers on an ongoing basis, their summaries did not reflect the input of peer criticism. As a result, these tended to included minimal explanation of the concepts. The superiority of WKF was evident, however, in only one of the two classes. Thus, this result suggests that the impact of the WKF implementation was not consistent across all students.

Also in Phase II, there was some evidence that students in both WKF classes had begun to develop stronger preferences for ill-structured tasks than the traditional class students. This possibly reflects the fact that these kinds of tasks lend themselves more readily to knowledge building activities than do more structured tasks. In ill-structured tasks, students have the freedom to pursue questions of their own, and can operate with little guidance in terms of finding related information. Students must, therefore, demonstrate stronger tendencies towards active and constructivist learning in these tasks.

On the metacognitive skills test, one of the WKF classes also significantly outperformed the traditional class in terms of cognitive strategy use. This suggests that students in this WKF class had started to develop stronger skills in this area after only four weeks of exposure to WKF. Ge (2001) asserted that the scaffolding support provided by WKF facilitates metacognitive processes of this kind. Scaffolding is one of the main features of WKF. In this program, scaffolds provide students with direct guidance on how to reflect on their own thinking processes (Oshima & Oshima, 1999). Again, however, these outcomes were found in only one of the two WKF classes, suggesting that the effects of the implementation were not consistent.

From the documentation of the approach taken by the teacher, two further factors (other than the short time period of the study) might also help to explain the relatively minimal effects of these first implementations on students' learning outcomes and processes. First, very little guidance was provided to students in terms of how they should collaborate together. Although these students were well acquainted with collaborative learning at the time of the study, it is possible that when a new tool is introduced to the learning setting, a higher level of structure is required to ensure that students are not distracted by the tool itself. This proposition is supported by the analyses of data from the WKF database, which suggested that many students did not engage in the high-level collaborative processes intended.

Second, in Phase I, the tasks assigned to students in both classes did not emphasize higher-order thinking processes. As a result, students in the WKF classes did not have the same level of opportunity to make use of the collaborative features of the program, because much of what they were researching was fact-based material. The task was changed slightly in Phase II to incorporate a stronger emphasis on these types of skills. It is possible that this modification was responsible for the effects observed in Phase II on students' learning processes (e.g., cognitive strategy use), at least in one of the two WKF classes.

6.2.3. Study III

The findings from the interview study conducted with three teachers who had used WKF suggested a mixed reaction to the program. All teachers seemed to take the view that WKF had significant potential for promoting collaboration amongst students, and were favourable about the range of options afforded by WKF for students to gain peer feedback. These views are consistent with previous literature on the main advantages of WKF. All three teachers did, however, note a number of problems that they encountered in using the program for the first time, and these issues, together with the findings of Study II, were used to derive the recommendations presented in the next section.

6.3. RECOMMENDATIONS FOR PRACTICE

As noted, across Studies II and III, a number of potential issues for first-time users of WKF were identified in this research program. The goal of this section is to draw from those results and from well-controlled previous research to provide some key recommendations to teachers who wish to make use of WKF in the future. Three major groups of issues were identified from the results of Studies II and III: infrastructural requirements for WKF, pedagogical strategies suitable for WKF, and assessment strategies suitable for WKF.

6.3.1. Infrastructural Requirements

6.3.1.1. Technical support and budget for implementation

Stegall (1998) argued that unless schools prioritize ICT use within classrooms, teachers are unlikely to make efforts to integrate these tools in their everyday practices. A considerable body of research has suggested that using "cutting-edge" forms of ICT in classrooms will, in many cases, be an intimidating and daunting experience for teachers, which could in turn produce reluctance to experiment with these methods (Hauge, 2006; Shedletsky, 1996).

As indicated, Studies II and III of this program were conducted in a well-resourced, ICT-rich context. As a result, although teachers indicated that they had all experienced some technical issues in their implementations, these were relatively minor. Generally, however, schools will not necessarily have sufficient levels of pre-existing hardware and networking facilities to support the effective use of WKF across multiple classes.

In this school, dedicated technical support staffs were involved initially in installing the WKF software and ensuring that it was functioning properly. Problems were experienced initially due to failures in the host server. This, in turn, meant that even though all students had their own laptop computers to access to the school intranet, on some occasions this was not possible. Thus reliability of the hardware and access to technical support is crucial, particularly in the early stages of implementation.

The budget to implement WKF will vary with schools' needs. The price ranges from one WKF database ($ 400) to three WKF databases ($1050). Additional databases cost $300 each. WKF can be bought as a site license as well, which costs around $4990 if the school has its own server. The site license allows WKF to be installed on a number of servers for users within the same location, and it can be copied for distribution within authorized areas (http://www.knowledgeforum.com).

6.3.1.2. Professional development and training

It was clear that even though the teacher involved in Study II was given free time to develop his implementations, these were relatively minimal. Although he had access to the relevant manuals for WKF, he received no formal training in the use of the tools. This situation would not be atypical in classroom settings. Despite this, it was evident that the teacher used a "trial and error" approach in his implementation, and was not comfortable enough with the software initially to embark on ambitious applications.

All three of the teachers in Study III made comment on the need for some training in the use of ICT-related tools. To attain relevant skills, teachers can attend conferences, seminars, and workshops. This, however, often meets with resistance from the school administration owing to resource constraints. One solution to this problem is to send only selected members of staff to these functions, and then rely on mentoring within the school to disseminate the information acquired more broadly. This is, in fact, the approach that was subsequently taken in the Study II/III school. WKF can facilitate these processes further through its online forum for teachers. This function allows teachers to interact with other WKF teachers, experts and researchers to share their experiences on dealing with problems related to its application.

6.3.1.3. Time allocation

In Study III, all three teachers noted lack of preparation time as a key obstacle to making full use of the WKF functions. This was the case even though one of the three teachers was given some six weeks to prepare his lesson plans for the WKF implementation. Time has also been cited as a potential barrier in previous studies of ICT integration factors. These previous studies have also indicated that teachers typically have difficulties in finding time to learn and apply new ICT tools (Manke, 1994; Norton & Wilburg, 2003). Thus, it is critical that, when considering the possibility of using WKF for the first time, teachers choose a period during which they have more time to make the relevant adaptations to lesson plans etc.

6.3.2. Pedagogical Strategies

6.3.2.1. Structuring Collaboration

Peer interaction is critical in WKF environments, because it is necessary for students to engage in these processes to create and build new knowledge. Effective collaborative learning offers a number of benefits to students. Slavin (1991), for example, argued that students can expand their strategy use and knowledge when they work together actively with other students. In this collective process, students integrate their contributions to construct new concepts and knowledge. At the same time, the effects of cooperative and collaborative learning can vary significantly depending on the specific approach taken in the classroom (see Slavin, 1991). From the results of this research, two major types of factors were identified that may impact the efficacy of the collaboration that takes place in WKF environments.

General Considerations. Previous studies on collaborative learning have indicated that group size may influence the outcomes of collaborative exercises for students. This point was also made in Study III by the teachers interviewed. The number of students in each group may vary with the type of task that is assigned to a group. Pragmatically, typical practices put four or five members in each group. If the collaboration is to take place on a strict time limit, it is generally best to do this with smaller groups (Cooper, 1990). Davis (1993) argued that using large groups can lead to a reduced sense of community amongst the members.

For more extended tasks, however, Orlich, Harder, Callahan, Trevisan and Brown (2004) recommended that discussion groups comprise around six to eight to ensure that there are many different perspectives available in the group. Indeed, in the present study, it was found that in Phase II, when the WKF database was expanded to include both participating WKF classes, results improved rather than declined. Thus, it is possible that the use of WKF makes considerations about maintaining small group sizes irrelevant.

There were also some differences of opinion about whether groups should include mixed or similar ability levels. Working in mixed-ability groups can provide opportunities for less able students to solve problems in collaboration with more competent peers. In this situation, less able students can receive help through explanations and demonstrations offered by more skilful students, whilst the students who give help can increase their understanding through the process of explaining, evaluating and synthesizing tasks. Jones and Carter (1994) further found that low-achieving fifth-graders who were grouped with other low-achievers demonstrated less effective problem solving strategies and more off-task behaviours than mixed-pair dyads.

Further studies have indicated, however, that differences between group members should not be too large since this will prevent the development of common understanding between them (Tudge & Rogoff, 1989). Koivusaari (1999) further indicated that for some tasks, homogeneous pairs are more likely to generate ideas compare to heterogeneous pairs, because both parties are more likely to engage actively in the collaborative process.

Specific models of cooperative/collaborative learning suitable for WKF. One of the issues encountered in this research was that students did not have firm guidelines for structuring their collaborative exchanges. This section will therefore highlight some of the established collaborative and cooperative learning models that would be suitable for use in a WKF environment.

- ***Jigsaw:*** One of the most popular approaches to cooperative learning that includes an integral collaborative component is the Jigsaw method developed by Elliot Aronson and colleagues (Aronson, Stephen, Sikes, Blaney, & Snapp, 1978). In Jigsaw, students are assigned to six-member teams that are heterogeneous in terms of ability levels, sex, and ethnicity. Individual members of Jigsaw groups receive unique subsections of an overall topic to study, and members of different groups with the same subsection meet in "expert" groups to gather information on their assigned subtopics. Students then return to their "home" groups and share this information with other group members. At the end of the session, all students complete individual tests on the topic as a whole.

- ***Group Investigation:*** Group Investigation was developed by Shlomo and Yael Sharan in University of Tel Aviv, Israel (Sharan & Sharan, 1976). Group Investigation focusses on developing students' higher-order cognitive skills through cooperative inquiry, group discussion, and cooperative learning activities (Sharan & Sharan, 1976). A second goal of this approach is to provide students with democratic decision-making and problem-solving experiences. There are six hierarchical steps involved in this approach (Sharan, 1980). Initially, an overall class task is broken into subtopics, and cooperative groups are formed according to students' interests. Next, each group plans how to investigate their assigned subtopic (e.g., dividing the tasks among members) and plan the use of any resources available. Each member in the group then conducts his/her research and presents their findings to other group members. Later each group presents their integrated outcomes to the whole class. The class teacher and other groups then evaluate the quality of each group's presentation. Sharan et al. (1984) indicated that each stage of this process provides students with training on different aspects of collaborative problem-solving.

- ***Circles of learning:*** Circles of learning, previously known as Learning Together, was developed by David and Roger Johnson at the University of Minnesota (see Johnson & Johnson, 1975). In this approach, students work together in a small and mixed-ability groups to complete an overall group task. This method emphasizes the sharing of ideas amongst group members so that each member of the group becomes competent to complete the task as a whole. The final outcomes represent the total of group members' contributions, and evaluations are based on the quality of the overall group product.

- ***Reciprocal teaching:*** Palinscar and others (1988) developed the Reciprocal Teaching model to improve the reading comprehension of students with learning disabilities by applying metacognitively-based question and answer procedures. Reciprocal Teaching engages the teacher and students in discussions on particular parts of the text. Four strategies are applied in these discussions: (i) summarising, (ii) question generating, (iii) clarifying, and (iv) predicting. Initially, the teachers demonstrate the application of these procedures to the students, later, they ask them to work with their partner using the same strategies. Students then practice the strategies independently within their dyads.

- ***Controversy Groups:*** According to Johnson, Johnson, Pierson and Lyons (1985), an advanced form of cooperative learning results from engaging students in structured academic controversies within a cooperative context. The combination of cooperative learning and controversy leads to higher achievement, more complex reasoning, creative problem solving and high quality thinking than alternative group work approaches (Johnson & Johnson, 1979). Johnson et al. (2000) stated that in order to structure the academic controversies approach, initially, the instructors choose a topic on which two well-documented positions ("pro" and "con") can be prepared. Students are assigned to groups with members of even numbers (e.g., six). The groups are then divided into two, with each subgroup given the assignment of proposing and developing the best arguments possible on either the "pro" or the "con" side. As the pairs research the topic, they engage in constructing persuasive arguments for each position and rejecting the opposing position. At the end, students integrate all at the information by synthesizing both positions and producing their best reasoned judgment. This is the stage at which knowledge is considered to be active, socially constructed, and optimally learned.

6.3.2.2. Structuring Tasks

Another major issue encountered in the present study concerned the design of the learning tasks assigned to students in the WKF class. As noted previously, in Phase I, these tasks did not lend themselves well to the application of higher-order thinking skills, nor were they particularly conducive to collaboration or the application of active self-regulation strategies. The incorporation of these features is likely to enhance significantly the impact of first-time WKF implementations. Based on these principles, WKF learning tasks should:

- ***Elicit higher-order thinking processes:*** Tasks that rely heavily on factual knowledge (i.e., who discovered this element?) and lower-order thinking skills (e.g., recognising and recalling) will prompt students to engage in more shallow knowledge creation activities. This will tend to undermine the purpose of the collaboration afforded by WKF. Tasks that require higher-order thinking processes (i.e., analysing, evaluating and synthesizing) will be better suited to the WKF environment.

- ***Be conducive to collaborative discussion and exchange:*** Lower-level tasks are also more likely to be achievable on an individual basis. These tasks, therefore, are less conducive to group interaction than are higher-level tasks. For example, in chemistry, locating lists of substances is a task that students can more efficiently solve individually than by working together in groups. On the other hand, tasks that require higher-order thinking (i.e., analysing, evaluating and synthesizing) may encourage more active discussion and groupwork. For example, a task on the causes of gravity may generate multiple perspectives from group members, and it is likely that the group members will have to engage in some discussion to arrive at a single or unified answer to the problem. It is through these processes that the students are compelled to build knowledge and construct new models.

- ***Provide scaffolds for collaborative discussion and inquiry processes:*** Ross and Cousins (1995) indicated that collaborative discussion in groups and pairs can be enhanced through the provision of clear structures or guidelines. This framework provides students with appropriate language through which they can express thoughts and ideas effectively. King (1993) similarly proposed the use of "guided cooperative questioning procedures" to facilitate the impact of groupwork on cognitive processes. This procedure encourages students to create their own questions on topics assigned by applying higher-order thinking processes (e.g., what can I predict or infer from this statement?). This approach would be particularly well-suited to the WKF environment, because students have opportunities to think about their questions carefully before posting them.

- ***Provide room for creativity and self-regulation through the use of ill-structured tasks:*** Studies have indicated that self-regulated participation in open-ended research promotes the free exchange of ideas between students (Jarvela & Hakkinen, 2002). Thus, although the processes of collaboration in WKF can be well-structured, the actual boundaries of the learning tasks can remain relatively ill-structured. This process is likely to encourage students to regulate actively their own thinking processes by selecting, analysing and generating the best solution or responses to the problems. Good and Brophy (2003) make a number of further recommendations for "good" and "poor" questions in terms of engaging students' self-regulation levels.

- ***Consider using mixed modes of learning over extended periods:*** Findings of this research indicated that reductions in student engagement may result from the constant use of WKF over extended periods. When students are first beginning with WKF, therefore, it may be best to use this program as only one of several learning tools available to students.

6.3.2.3. Dealing with Plagiarism

Like all kinds of online learning environments, the use of WKF increases the probability of encountering problems with students applying "cut and paste" strategies in their learning tasks. Plagiarism has been reported to be far more frequent in high school settings, because students are less aware of related issues than are those at higher levels (McCabe, 2001). Scanlon and Neumann (2002) further asserted that with the vast information afforded on the internet, new generations of students may consider the information they gather to be public, and intended for "sharing". Misunderstandings of this kind can increase the prevalence of online plagiarism in WKF environments.

Minkel (2002) provides a list of recommendations for addressing plagiarism issues in online and other learning environments. Six suggestions are presented in this report:

(1) initially, increase the students' awareness of cheating and plagiarism,
(2) provide a clear definition of cheating, plagiarism and academic integrity to students,
(3) educate teachers on how to identify plagiarism and how to construct assignments that discourage plagiarism (e.g., novel or original tasks),
(4) distribute notes and materials on plagiarism and cheating to parents and the broader community,
(5) encourage "instant ideas" to test for understanding independent of plagiarism, and
(6) advocate to the relevant school boards incorporating academic integrity in their curriculum plans.

Teachers are also advised to break up large assignments into smaller parts, so that they can regularly check on students' progress in each assignment. This approach encourages the students not to leave work till the end, which is likely to encourage them to plagiarize (Sterngold, 2004). Findings from Study III also suggested that teachers could conduct follow-up assessments on an individual basis to check on what students actually gained from completing the learning tasks.

6.3.3. Assessment Strategies

Teachers can perform assessment both on-paper and online. Given the issues raised above, online plagiarism can also be prevalent in assessment among the "cut-and-paste" generation (Larkham & Manns, 2002; McCabe, 2001). It is therefore essential for the teacher to impose mechanisms for preventing and detecting plagiarism. If teachers decide to use online assessment, it is suggested that they should also apply networked monitoring tools such as eBlastor (http://www.spectorsoft.com) or Turnitin.com (http://www.turnitin.com) to detect incidents of plagiarism (Tse, 2005).

Peer assessment is another approach that can be used effectively in WKF environments. Given that WKF is accessible online, students can make their contributions to the work of other students and access these comments easily. Teachers can then develop rubrics both for themselves and for students to use in determining how the assessment should be conducted.

As noted in Study III, teachers often find it difficult to assess individual work when students have worked together in collaborative groups. To overcome this, it has been suggested that a follow-up assessment on individual work is necessary. Teachers are also advised to conduct "spot quizzes" individually and ask each member to present their group's work individually (Johnson, Johnson, & Smith, 1991) as a further check on individual understanding.

Further to these procedures, WKF provides facilities for teachers to examine the individual contributions made by students within the database. Provided that teachers have the time to check on these processes, students can then be given marks also for their contributions to the WKF discussions. This would serve two purposes: (i) to check for individual understanding in group tasks, and (ii) to provide motivation to students to participate actively in their ongoing WKF discussions.

6.4. DIRECTIONS FOR FUTURE RESEARCH

In this chapter, a number of recommendations have been made for ways in which initial WKF implementations can be structured to optimize effects on student learning outcomes and processes. As yet, however, the practicality and impact of these modifications have yet to be evaluated. Thus, future research could explore whether these adaptations (e.g., the incorporation of explicit questioning guidelines, the use of established models of cooperative/collaborative learning) contribute significantly to the efficacy of WKF within secondary level classrooms. Longer-term evaluations of these effects would also contribute significantly to knowledge within the field, given that these implementations are generally anticipated to extend over much longer time periods (e.g., one school year).

While WKF is viewed to hold considerable promise for improving student outcomes in the areas of strategy use and higher-order thinking skills (Bereiter & Scardamalia, 1996; Bereiter, Scardamalia, Cassells, Hewitt, 1997), relatively few evaluations of its effects within these areas have been conducted. Several questions about the efficacy of WKF for improving student learning outcomes still remain. Thus, future research could extend further on the work reported here to assess impact over a broad range of possible learning outcomes and processes. The studies that have been conducted thus far have also examined the effects of WKF in a limited range of subject areas, most of which have been within the physical science and mathematics areas. Thus, future research could also explore the effects of WKF in a broader range of subject areas.

Amongst the studies that have appeared on WKF, the vast majority have been based on case study methods (Scardamalia et al. 1992; Lamon et al. 1999; Lamon et al. 2001; Hakkarainen et al. 1998; van Aalst, 1999; Tumblin, 2001; Lipponen et al. 2001; Rahikainen et al. 2000) and survey questionnaires (Koivusaari, 1999). Rarely have the effects of WKF been compared to alternative approaches using controlled experimental design methods. Thus, future research could also explore using more rigorous evaluations that compare the effects of WKF with alternative approaches.

As argued by Light et al. (1992), further studies are also needed to establish whether tools like WKF make a *unique* contribution to effective collaborative learning. That is, it is necessary to isolate the components of WKF that are responsible for any positive effects observed. If the same effects can be obtained solely thorough the use of traditional, non-computer assisted collaborative learning approaches, this would diminish the rationale for using WKF as part of the process. Future research could also focus on identifying the specific components of WKF that are responsible for any positive effects observed within classrooms.

In conclusion, while various studies have demonstrated the potential of WKF to enhance teaching and learning outcomes within schools under relatively controlled conditions, these effects are likely to vary considerably across field settings. Teachers must frequently adapt programs to suit various constraints imposed upon them within specific settings. In the use of WKF, which is a relatively sophisticated program, issues encountered in early efforts to integrate the tool may lead to loss of support for the use of the tool itself. Various strategies can be used to enhance the effects of WKF environments in beginning implementations. Further research is needed to evaluate the specific effects of these modifications on a broad range of student learning outcomes and processes. With such findings, teachers will be better placed to make informed judgements on how they should integrate the use of this promising tool within their own classroom practices.

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APPENDICES

Appendix 1: Metacognition instrument (open and closed-ended task).

Name: Group:

When I am starting a new topic, I ask myself:	Never	Sometimes	Always
How do the ideas "fit in" with what I already know ?	☐	☐	☐
What should I do if I do not understand ?	☐	☐	☐
Can I think of relevant examples from my own experience ?	☐	☐	☐
Can I find pictures or examples that help me understand ?	☐	☐	☐
Which information is most important to remember ?	☐	☐	☐
Which information do I need to learn first ?	☐	☐	☐
How the ideas "fit in" with what we are learning in other classes ?	☐	☐	☐
What are the main ideas or key themes ?	☐	☐	☐
Can I use concept maps to get an overall picture of the topic ?	☐	☐	☐
How the different bits of the topic "fit in together" ?	☐	☐	☐
Before I start working, I ask myself:			
What is the best way to learn the topic ?	☐	☐	☐
What should I do first ?	☐	☐	☐
How much time I have to complete the task ?	☐	☐	☐
Do I know what do I need to know in order to get started ?	☐	☐	☐
Do I know where to get the information that I need from ?	☐	☐	☐
How much time will I need to learn this ?	☐	☐	☐
What are some strategies and tactics that I can use to learn this ?	☐	☐	☐
While I am researching my topic, I ask myself:			
Did I understand what I just heard, read or saw ?	☐	☐	☐
Am I on the right track ?	☐	☐	☐
Should I use different ways to complete the task ?	☐	☐	☐
Should I go slower or faster on this task ?	☐	☐	☐
Do I know what to do if I don't understand something ?	☐	☐	☐

When I am finished my work, I ask myself:	Never	Sometimes	Always
What would have helped me do that task better (eg. more time, better organisation) ?	☐	☐	☐
How well did I do ?	☐	☐	☐
What could I have done differently ?	☐	☐	☐
What have I learned from doing this task ?	☐	☐	☐
How can I use what I have learned here in other situations ?	☐	☐	☐
Should I use the same strategies in doing my next task ?	☐	☐	☐
Did I do as well as I could have on that task ?	☐	☐	☐

If you had to teach another student how to learn a new topic in class, what kinds of things would you tell them to do:

Before they started working?

____
____
____

While they were working?

____
____
____

When they came across a difficult problem?

____
____
____

How would they check their work after they finished?

____
____
____

-End-

APPENDIX 2A

THE UNIVERSITY OF WESTERN AUSTRALIA

Dr. Elaine Chapman
Graduate School of Education
35 Stirling Highway
Crawley, Western Australia 6009
Fax: (08) 9380 1052
Telephone: (08) 6488 2388

PARENT INFORMATION SHEET

We are conducting a survey in Term 4 of this year in your child's classroom to examine their metacognition skills.

Metacognition refers to one's knowledge and active control over, one's thinking or cognitive processes. It is a form of Higher Order Thinking which involves strategies such as planning, evaluating and analysing. These skills are essential in knowledge gathering and learning activities. Learning how to adapt metacognitive skills can enhance a deeper understanding of the subject matter and knowledge required.

The aim of this survey is to examine a new metacognition test developed specifically for school children. To date, few metacognition tests are available and used within school settings. Further, most of the questions in those tests are vague and the terms are not well defined for the school level. This survey is expected to contribute a better framework for designing more robust and solid metacognition tests for school children.

The survey will be conducted in the classroom in term 4 this year. Students will be given a paper consisting of questions about their learning strategies. This survey will take about five to ten minutes. It will be administered at the end of the class session.

The confidentiality of all data collected will be ensured through the use of student-selected ID numbers. The data and the information are for research purposes only and will not be published in such a way that any student can be identified.

Participation is entirely voluntary. If you give your consent at this time, you will remain free to withdraw your child from the survey at any time during the data collection.

If you have any concerns about the survey, please contact:

Dr. Elaine Chapman
Tel: (08) 6488 2384
E-mail: elaine.chapman@uwa.edu.au

Sharinaz Abu Hassan
Tel: (08) 6488 7055
E-mail: lnazack@cyllene.uwa.edu.au

If you would like your child to participate in this survey, please sign the consent form attached.

APPENDIX 2B

THE UNIVERSITY OF
WESTERN AUSTRALIA

Dr. Elaine Chapman
Faculty of Education
35 Stirling Highway
Crawley, Western Australia 6009
Fax: (08) 9380 1052
Telephone: (08) 6488 2388

CONSENT FORM

I (parent) have read the information above and agree to allow my child/ children to participate in the study.

I understand that all the information provided is treated as strictly confidential and will not be released by the researchers unless required to do so by law.

I agree that research data gathered for the study may be published provided that the student name is not used.

___________________________ _____________________
Parent (Name & Signature) Date

Researcher: Sharinaz Abu Hassan
E-mail: lnazack@cyllene.uwa.edu.au

The committee for Human Rights at the University of Western Australia requires that all participants are informed that, if they have any complaint regarding the manner in which a research project is conducted, it may be given to the researcher or alternatively to the Secretary, Committee for Human Rights, Registrar’s office, University of Western Australia, Crawley, WA 6009 (telephone number 6488 2388). All participants will be provided with a copy of information sheet and consent form for their personal records.

Appendix 3: Teachers' perception on students' metacognitive skills

Thinking Assessment

Student name:

Please rate from 1 to 4, which indicates 1= less likely, 2 = more likely, 3 = moderate and 4 = always.

From the teacher observation in class,

The student...	1	2	3	4
1. Monitor his/her own progress				
2. Try to understand what the task required/ goals before attempt to answer				
3. Corrected his/her errors				
4. Attempted to find out the main ideas in the task				
5. Uses different ways/strategies in solving the problems/ tasks				
6. Checks about his/her works before submitting it to the teacher				
7. Plans his/her works, e.g draft frameworks or concept maps.				
8. Checks on how much time left before he/she has to submit their work				
9. Selects and organized relevant information to complete the task				
10. Uses prior knowledge to understand the task				

Appendix 4A

THE UNIVERSITY OF WESTERN AUSTRALIA

Dr. Elaine Chapman
Faculty of Education
35 Stirling Highway
Crawley, Western Australia 6009
Tel : (08) 6488 2384
E-mail: Elaine.Chapman@uwa.edu.au

Dear Parent/Guardian,

For the remainder of this term, Penrhos College will be working in partnership with the University of Western Australia (Graduate School of Education) to evaluate the effects of a new software package (Web Knowledge Forum, or WKF) on students' learning and attitudes towards technology in science education. Knowledge Forum is a network learning system in which students use a communal database to collaborate with other students and teachers on curriculum and ideas. This system was developed in 1986 by Marlene Scardamalia and Carl Bereiter at the Ontario Institute for Studies in Education (OISE), and is well documented for its ability to provide support for thinking and understanding.

The specific goal of the project is to evaluate how effective the WKF is for facilitating group work in science lessons. For the purposes of the evaluation, all students will complete pre- and posttests on the material they have covered under the WKF. These will include an achievement test and an Attitudes Towards Science survey. Video cameras and tape recorders will be used to record the group work activities during some sessions. Any children for whom consent has not been given will sit in locations in the classroom that are out of camera view.

The confidentiality of all data collected will be ensured through the use of student selected ID numbers. The video footage and the information gathered are for research purposes only and will not be published in such a way that any student can be identified.

Participation is entirely voluntary. If you give your consent at this time, you will remain free to withdraw your child from the project at any time. If you choose not to participate, your child may continue to participate in the class activities, but will not contribute data to the research project.

If you have any concerns about the project, please contact:

Dr. Elaine Chapman
Tel : (08) 6488 2384
E-mail: Elaine.Chapman@uwa.edu.au

If you would like your child to participate in this project, please sign the consent form attached.

Appendix 4B

THE UNIVERSITY OF WESTERN AUSTRALIA

Dr. Elaine Chapman
Faculty of Education
35 Stirling Highway
Crawley, Western Australia 6009
Fax: (08) 6488 1052
Telephone: (08) 6488 2384

CONSENT FORM

I (parent) have read the information above and agree to allow my child/ children to participate in the study.

I understand that all the information provided is treated will be as strictly confidential and will not be released by the researchers unless required to do so by law.

I agree that the research data gathered for the study may be published provided that the student names or video footage are not used.

__________________________ __________________________

Pupil's name | Parent's name

__________________________ ____________________

Parent/Guardian Signature | Date

The committee for Human Rights at the University of Western Australia requires that all participants are informed that, if they have any complaint regarding the manner in which a research project is conducted, it may be given to the researcher or alternatively to the Secretary, Committee for Human Rights, Registrar's office, University of Western Australia, Crawley, WA 6009 (telephone number 9380 2388). All participants will be provided with a copy the information sheet and consent form for their personal records.

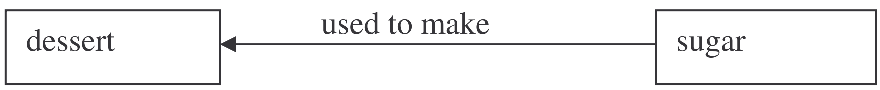
Appendix 5: General Chemistry Knowledge

CHEMISTRY AROUND YOU SURVEY

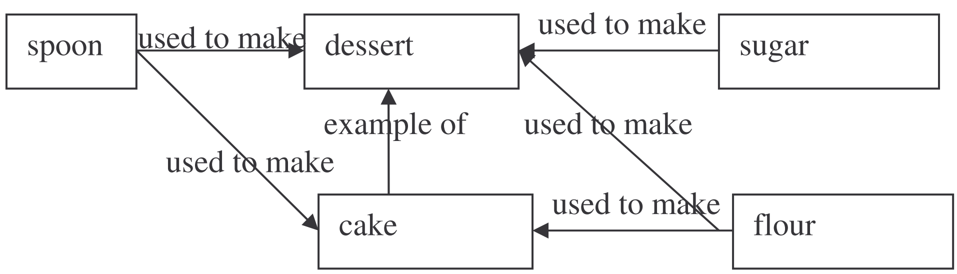
The purpose of this survey is to find out what you know about chemistry in the world around you. It is not a test and your answers will treated confidentially. The results of this survey will be used to help design teaching materials in this area.

Part A of the pretest involves you drawing a concept map. Please have a look at the example below before turning over and starting Part A.

An example of a concept map about the words sugar and dessert might be



A more complicated example using the words sugar, dessert, cake, flour and spoon might be



PART A

Your task:

1. **Chemistry** uses many words that are familiar to most people. Some of these words are listed below. Draw a concept map showing how these key concepts link together. Leave out anything that you don't know or understand.

Concept list:

atom	molecule	element	compound	metal
nonmetal	acid	base	salt	gas
mixture	fuel	oxidant	corrosive	iron
vinegar	ammonia	natural gas	peroxide	chlorine

Please go on to Part B

PART B

1. Acids, bases, oxidants and fuels are terms often associated with chemistry. List as many examples as you can where **acids** are **currently** used in our society.

2. List as many examples as you can where **bases** are **currently** used in our society.

3. List as many examples as you can where **oxidants** are **currently** used in our society.

4. List as many examples as you can where **fuels** are **currently** used in our society.

Please go on to Part C

PART C

Read each of the statements below.
For each statement, decide whether the statement is acceptable or not. Place a tick in the selected column. Give a reason for your choice in the last column.

Statement	Acceptable	Unacceptable	Reason
Zelda stores methylated spirits in an open jug next to the gas heater.			
Zelda uses a lead-based glaze to make a dinner plate in her pottery class.			
Zelda cleans her aluminium cookware with oven cleaner.			
Zelda removes rust with battery acid.			
Zelda brushes her teeth with bleach to get them sparkling white.			
Zelda cleans her priceless collection of eggshells with vinegar.			
Zelda cleans a valuable coin with cloudy ammonia.			
Zelda uses methylated spirits to remove an ink stain from her school shirt.			
Zelda stores Epsom salts next to some pool chlorine.			

APPENDIX 6: ELEMENT ACHIEVEMENT POSTTEST

IT'S ELEMENTARY POST-TEST

Name ________________________ Group ______________________

Select TWO elements. One must be the element that you researched this term, and the other should be one that you found out about from the research work that someone else did this term.

1. Which elements are you going to use in your answer?

My element is called	The other element is called
________________________________	________________________________

What is the history behind each element's name?

My element	The other element
________________________________	________________________________
________________________________	________________________________
________________________________	________________________________
________________________________	________________________________
________________________________	________________________________
________________________________	________________________________
________________________________	________________________________
________________________________	________________________________

2. **Using these two elements only**, briefly answer the following about their physical properties:

(a) Which one has the higher melting temperature?

(b) What colour is the element?

My element's colour is	The other element's colour is
________________________________	________________________________

(c) Comment on each element's density:

My element	The other element
________________________________	________________________________
________________________________	________________________________

(d) Comment on each element's ability to conduct electricity:

My element	The other element
______________________	______________________
______________________	______________________
______________________	______________________
______________________	______________________

Please turn over for the rest of the post-test questions

3. **Using these two elements only**, briefly answer the following about their chemical properties:

(a) Does the element occur in a compound, as the uncombined element, or both?

My element occurs as ______________________	The other element occurs as ______________________

(b) Does either one (or both) react with oxygen, or does either one burn in air?

____

____

____

____

(c) Does either one (or both) react with acid?

____

____

____

____

(d) Does either one (or both) react with base?

____

____

____

____

(e) How do we use these elements, or why are they important to us?

My element	The other element
______________________	______________________
______________________	______________________
______________________	______________________
______________________	______________________
______________________	______________________
______________________	______________________
______________________	______________________

APPENDIX 7: LOWER AND HIGHER ORDER THINKING RUBRIC

Cognitive processes	Level one	Level two	Level three
Remember: the learner is able to recall, restate and remember learned info. 1.1 Recognising: locating knowledge in memory that is consistent with presented material - identifying - naming - listing - describing - finding - locating 1.2 Recalling - retrieving relevant knowledge from long term memory	Limited number of information is recognised and recalled, answer is incomplete	Sufficient amount of facts are recognised and recalled; answer is complete and acceptable	Numerous facts and details are recognised and recalled; answer is thorough
Understand: Based on current and previous memory, learners are able/ unable to come out with their own understanding in the present context. - Determining the meaning of instructional messages, including oral, written, and graphic communication	Brief explanation of content; little or no evidence to support	Overall understanding of content; implied content/issues not addressed.	An interrelated, holistic interpretation of literal and implied content given; uses examples and illustrations to support.
1. Copying: cut, paste and cite from the original documents, ideas of others without citation.	Copy words for words and translate without adding any new	Adjust and elaborate selected words, structure of sentences	Modify the whole ideas using different words and sentence

Cyber-Plagiarism: copying or downloading in part, or in their entirely, articles or research papers found on the internet or copying ideas found in the web and not giving proper attribution. 2.interpreting – changing from one form of representation to another, paraphrasing, translating, representing, clarifying 3.exemplifying- finding a specific example or illustration of a concept or principle, instantiating, illustrating 4. classifying – determining that something belongs to a category (e.g. concept or principle). Categorising, subsuming 5.Summarizing – drawing a logical conclusion from presented information, abstracting, generalising 6.Inferring – Abstracting a general theme or major point, extrapolating, interpolating, predicting, concluding	info/ sentences.		structure, but still maintain the same content.

7. Comparing – detecting correspondences between two ideas, objects, etc. Contrasting..Matching.. mapping 8. Explaining – Constructing a cause-and-effect model of a system.			
Apply: Carrying out or using a procedure in a given situation 1. executing 2. implementing	Solution has none or a limited number of elements to support; solution is not workable	Workable solution is supported by an adequate number of generalizations and principles.	Solution has a "new slant"; supports solution with an abundant amount of facts and details.
Analyze: Breaking materials into its constituent parts and detecting how the parts relate to an overall structure or purpose 1. Differentiating 2. Organising 3. attributing 4. comparing 5. deconstructing 6. outlining 7. finding 8. structuring 9. integrating	Solution show minimal classification of elements; no relation between elements and their relation and structure to each other	Solution demonstrates the relation and structure between elements; recognizes patterns; rationally supported	Solutions classifies elements, their relationship to each other while identifying the arrangement and structure connecting them in a rational and persuasive way
Evaluate: Making judgements based on criteria and standards 1. checking 2. critiquing 3. hypothesising 4. experimenting 5. judging 6. testing 7. detecting 8. monitoring	Judgements have little or no support	Judgements are on both cognitive and effective levels; based on given criteria or selected remembered criteria.	Judgements are based on a variety of facets at both the cognitive and effective levels
Create: Putting elements together to form a	Solution lacks self expression; some important	Workable solution/ information is	Workable solution/ information

novel, coherent whole or make an original product. 1. generating 2. planning 3. producing 4. designing 5. constructing 6. inventing 7. devising 8. making	elements excluded; solution not workable; not clearly created/presented	new and includes essential elements; adequately communicated solution to appropriate audience; demonstrates self expression	which is new and includes all parts; demonstrates unique self expression; communication is directed to a specific audience in a unique and highly effective manner.

Appendix 8

About Science...

Student's Name:

	Strongly Disagree	Disagree	Not sure	Agree	Strongly Aggre
I look forward to science classes.	☐	☐	☐	☐	☐
I feel confused during science classes.	☐	☐	☐	☐	☐
Science classes are a waste of time.	☐	☐	☐	☐	☐
Science classes are among the most interesting at this school.	☐	☐	☐	☐	☐
The work is hard in science classes.	☐	☐	☐	☐	☐
The thought of science classes makes me tense.	☐	☐	☐	☐	☐
I enjoy science classes.	☐	☐	☐	☐	☐

Appendix 9

COMPOUND INTEREST POST-TEST

Name ________________________________ Group ______________

Select THREE compounds. One must be the compound that you researched this term, and the other two should be ones that you *only know about from the research work that someone else did* this term.

Red and Blue Groups: you may use Knowledge Forum. Green Group: use the files on the S drive.

1. Which compounds are you going to use in your answer?

My compound is called ______________	Second compound is called ____________	Third compound is called ____________

2. Is the compound an acid, a base, a fuel, an oxidant, or some combination of these? What is the evidence?

My compound ____________________	Second compound ________________	Third compound _________________
______________________________	______________________________	______________________________
______________________________	______________________________	______________________________
______________________________	______________________________	______________________________
______________________________	______________________________	______________________________

3. Is the compound safe to handle or store? What is the evidence?

My compound ____________________	Second compound ________________	Third compound _________________
______________________________	______________________________	______________________________
______________________________	______________________________	______________________________
______________________________	______________________________	______________________________
______________________________	______________________________	______________________________

APPENDIX 10: PREFERENCES FOR COLLABORATIVE LEARNING AND ILL-STRUCTURED TASKS

In this class.......	Not at all like me	Not much like me	A bit like me	A lot like me
I work better when I can talk over my ideas with other students	☐	☐	☐	☐
I like assignments that make me consider many different points of view	☐	☐	☐	☐
I like doing projects where I have the freedom try out my own ideas	☐	☐	☐	☐
When I work in a group, I'm usually unhappy with what we produce	☐	☐	☐	☐
I find projects more interesting when I'm working in a group	☐	☐	☐	☐
I find working in groups harder than working by myself	☐	☐	☐	☐
I like doing assignments where I have to think up lots of my own ideas	☐	☐	☐	☐
I do my best work when I am in a project group	☐	☐	☐	☐
If I have a choice, I usually prefer to work on my own	☐	☐	☐	☐

APPENDIX 11: LIST OF QUESTIONS FOR TEACHERS' INTERVIEW

Interview questions with the first teacher

1. What are some of the problems have you encountered while using WKF?
2. What are the recommendations you want to make to somebody who apply WKF for the first time?
3. What are some of the major benefits that WKF has for
   - students
   - teachers
4. Does WKF have the potential to improve collaboration between students?
5. Are there any particular topic areas that are well-suited to use in WKF environments?
6. Overall do you feel using WKF is worth the input?

Follow-up interview session

1. How long have you been using WKF in as part of your teaching method? How much have you used it in that time? Do you plan to continue using WKF in the future?

2. In general, what techniques have you found to be effective in adopting WKF?

3. What do you think are the major benefits that WKF has for teachers (e.g., reducing workload)

4. What do you think are the major benefits that WKF has for students? For example, do you think WKF can help to promote:
- higher-order thinking processes (e.g., problem-solving, creativity), self-regulation/metacognition?
- engagement/motivation (e.g., if WKF can be accessed from home, do you think students are willing to contribute)?
- positive classroom behaviours?

5. Do you think WKF has the potential to improve collaboration between students? If so, do you think that collaboration needs to be structured in a certain way to ensure that WKF is effective? For example:
- group size - number of students in each group?
- group composition - mixtures of high and low ability students?
- group cohesiveness - should we allow students to choose their own groups?
- structured vs. unstructured - any specific collaboration approach
- pure versus mixed modes – e.g., combine WKF practices and face to face discussion

6. Are there specific subject areas that are particularly well-suited to use in WKF environments?

7. Are there particular kinds of tasks (e.g., research tasks, topic-related debates) that are best suited to use in WKF? If so, what are they?

8. How do you assess your students' work in WKF? For example, should teachers:
- use specific incentive structures? (e.g., extra marks for asking good questions)
- assess students for their individual, rather than just their group's, contribution?

9. What are some of the problems you encountered while using WKF? How did you overcome these problems? For example:
- Technical problems
- Maintaining student engagement
- Classroom management
- Plagiarism

10. Have you used any educational software that offered similar advantages to WKF?
- what are the main differences between them?
- which one do you think is the most effective and why?

11. Overall, do you think WKF is worth the input?

12. Are there any general recommendations you would make to somebody who was planning to use WKF for the first time?