THE ROLE OF INSTRUCTIONAL FEEDBACK ON STUDYING, ACHIEVEMENT AND CALIBRATION

by

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ABSTRACT

This study examined the effects of instructional feedback on studying, achievement and calibration. Eighty-eight undergraduate students studied a chapter embedded in a customised computer environment that recorded traces of students' studying behaviour. Then, students proceeded to answer a paper-based short-answer achievement test. In a second study session, three groups were provided with one of three types of feedback (corrective, process, or process-plus-corrective) while the control group was not. Depending on the condition group, various self- report questions were completed by the participants indicating ratings of perceived use of studying tactics, studying effort, test effort, feedback effects on studying and test-taking and open-ended explanations for all of the ratings.

Results suggest process-plus-corrective feedback influenced high-order study tactic use and achievement in the second session. Although feedback effects were not observed, students reported that feedback had a moderate effect on their studying or test-taking. Moderate calibration was observed between participants' actual and recalled use of both low- and high-order study tactics. Statistically significant differences in calibration of high-order study tactics in session 2 were also found between corrective feedback recipients and the other two groups. Furthermore, students were moderately calibrated between their actual and recalled achievement, however no differences were found between treatment groups. There was a general tendency for students to overestimate their use of study tactic use and achievement. Effort was also examined and found to be predictive of subsequent effort. However, feedback did not have any effect on subsequent effort.

Findings for some specific hypotheses were consistent with the literature, however others were unexpected. This may have been due to several reasons such as cognitive overload, the timing and specificity of information supplied by the feedback, and the time frame for the study.

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CHAPTER 1

Rationale

Introduction

In all our daily interactions with others and even within our selves, we receive information about our actions. In educational settings, teachers provide feedback to help students prepare for future tasks, improve performance and correct erroneous actions. Furthermore, students may generate their own internal feedback through their learning activities. Feedback is vital to any effective learning environment (Azevedo & Bernard, 1995) if it addresses specific goals or outcomes and affords opportunity for learners to change. This information provides criteria for reflection that may consequently guide future behaviour.

Usually, studying is a precursor to performing a task that indicates a student's level of understanding of the material. Teachers assess students' knowledge and understanding through activities such as assignments or tests. Then, feedback is generated by the teacher and given to the student. The most common feedback students receive is feedback on performance. In research where students are provided feedback from an external source, three types of feedback have been distinguished: outcome, corrective and process feedback.

Though other forms of feedback exist, much research has focused merely on outcome feedback (Early, et al., 1990; Kluger & DeNisi, 1996). *Outcome feedback*, often called *knowledge of results*, is information provided after task engagement is over about qualities of products created; for example, a grade (Butler & Winne, 1995; Early, et al., 1990). Outcome feedback is not necessarily effective if it is the only feedback (Korsgaard & Diddams, 1996) and it may hinder learning in complex tasks (Kluger & DeNisi, 1996) because it provides little information about how students might adapt studying.

Corrective feedback supplements knowledge of results by adding the full text of the correct response to outcome feedback (Merrill, 1987). Corrective feedback affords students insight about the information they missed in their answers and the links they failed to make between pieces of information. Furthermore, it alerts students to how much of the material they actually understood. Presumably, the feedback provides students a second chance to learn what they have not yet and a possibly stronger cue about how to adapt studying tactics.

Process feedback is information about how students carry out studying tactics (Early, Northcraft, Lee, & Lituchy, 1990). It implicitly addresses the accuracy of content and directly provides a basis for adapting studying tactics so that they may be more effective. Based on the literature, it seems that students receive little if any *process feedback* informing them of the manner in which they study (Early, Northcraft, Lee, & Lituchy, 1990). This is surprising since studying is an important activity in learning.

A fundamental activity in schooling, especially at the higher levels is studying. When students study, they theoretically take an active role in four primary phases: defining what the activity is, setting goals to direct learning and creating plans to advance toward those goals, engaging tactics to study, and possibly adapting their overall approach to studying as a function of the fit between outcomes and goals (Winne & Hadwin, 1998). At each stage, students can generate their own feedback. Study tactics (for example, note-taking, highlighting, generating questions) and strategic articulations among tactics are the topic of plans for studying and the operations students use to approach goals. As students study, they may naturally produce or be coaxed to create observable traces (Winne, 1992), such as highlighting or notes, that reveal features of their "online" cognition.

As students put plans into action while studying, they generate feedback about the extent to which studying tactics and strategies are serving their goals (Butler & Winne, 1995; Pressley & Ghatala, 1990). Feedback on the act of studying affects knowledge construction (Butler & Winne, 1995) and feedback may produce on-the-spot adaptations to studying or longer-term alterations to any of the four phases of studying. This feedback may assist students in self-regulating and gaining a better understanding of their studying behaviours, which in turn, may influence future performance.

Ongoing assessment of one's understanding is called monitoring. To monitor, students need information on which to judge their plans, actions and changes. This can exist in the form of internal or self-generated feedback as described above or in the form of external feedback supplied by teachers. Left to their own accord to develop inferences about the value of strategies and tactics, students' long-term monitoring results in decisions about when and why they will use strategies (Pressley & Ghatala, 1990). Students in higher grade levels were found to use more strategies and tactics (Annis & Annis, 1982) but studies could not be found on how students initially learn about implementing study strategies and tactics or the type(s) of feedback teachers give students about study strategies and tactics.

External feedback provided by teachers consists of three types. Outcome feedback, such as a grade provides a means for which to compare one's achievement against others or a standard of mastery. An external source such as a teacher is also necessary for providing corrective feedback. The feedback not only affords students information about expectations for the activity, but also the opportunity to generate internal feedback. Teachers may also offer students process feedback — information about tactics use while performing the activity (for example, students' test-taking strategies). This may directly affect students' future behaviour in a similar activity or indirectly prompt them to consider and alter their preparation (e.g. studying) for the activity. Furthermore, although process feedback does not seem to be common, teachers could also provide it to students concerning their use of studying tactics, which could then affect any of the four stages of studying and subsequently alter future achievement.

Tests are one type of assessment activity that afford students not only external feedback, but an opportunity to generate feedback about how well goals were met as they respond to test items. Indirectly, tests also afford a chance for students to generate feedback about the utility of studying tactics. Schraw, Potenza, and Nebelsick-Gullet (1993) found that taking a test subsequently enabled students to detect deficiencies in their understanding and better predict performance in future tests similar in format or content.

To profit from self-generated feedback, students logically need to have accurate recall about two matters: what they did while studying and how well goals were met. Research is relatively consistent in showing that students succeed in the latter judgement, called calibration of performance (Glenberg, Saroki, Epstein & Morris, 1987; Hunter-Blanks, Ghatala, Pressley, & Levin, 1998; Pressley & Ghatala, 1990). Calibration is knowing when and what one knows or does not know. Regardless how well students perform accurate calibration exists when students' predictions or postdictions of performance correspond to actual performance, whereas poor calibration occurs when predictions do not correspond to performance (Glenberg & Epstein, 1985).

Although there is much interest in the studying behaviours of students, there is little evidence on how well students are calibrated when they describe how they studied. One study (Winne, Hadwin, Stockley, & Nesbit, 1999) suggests calibration about study activities is poor, at best. Furthermore, students' judgements can be influenced by self-generated feedback resulting from testing experiences. Specifically, encountering a test provides students with information about how they applied their knowledge and provides them with feedback to monitor their strategy and tactic use in future studying.

The Present Study

The present study examined the effects of instructional feedback on studying, achievement, and calibration. In a first session, students studied a chapter using a computer-based studying environment and were tested on the chapter. Students were then asked to assign themselves a grade for each question and to recall their use of specific study strategies and tactics. At the beginning of a second session, some students were given feedback on their test performance, while others were informed of how various study strategies and tactics could be used. A third group received both types of feedback and a control group received no feedback.

Feedback was predicted to increase calibration, enhance self-regulation, and improve test achievement on a similarly structured second study session. The study would not only add to current literature on the effects of feedback on achievement, but also to meagre literature on the effects of feedback on strategy and study tactic use. Reasons for why and how the feedback influenced achievement were also investigated.

Furthermore, the study examined whether different types of feedback differentially affected students' calibration of knowledge and studying tactics. Little research exists on student's recall of their use of study tactics compared to their actual use. This is most likely due to limitations in obtaining traces of studying behaviour. Using a specially designed computer environment that records traces of study behaviour, this study addressed these limitations and provided data to examine students' reported use and their actual use of study tactics. Lastly, the study endeavours to replicate the general findings in the literature of moderate calibration of achievement by students.

CHAPTER 2

Review of the Literature

Overview of the Literature Review

The literature review is presented in six sections. The first section introduces the process of studying and differentiates strategies and tactics. The second section explains self-regulation and monitoring processes and their role in activities such as studying. How students use study strategies and tactics and a rationale for their use are described in the third section. The fourth section concerns feedback and its effects on studying and achievement. Calibration studies and two areas of research concerning predictions and postdictions are covered in the fifth section. In the final section, the current study will be presented.

The Process of Studying

Studying is an extensive part of formal education, particularly from the secondary levels onwards. As students move through the educational system, more responsibility is placed on them for their own learning. This requires awareness of others' expectations and self-direction. Studying can be modelled as an active process comprised of four stages: (a) task definition, (b) goal setting and planning, (c) enactment, and (d) adaptation (Winne & Hadwin, 1998). In the first stage, students determine what they believe is the purpose of the activity and(or) the instructor's goals. Goals are standards by which the activity will be evaluated. In the second stage, students may alter the goals determined in the first stage if personal standards and perceived task standards differ. Thus, before participating in any learning activity, learners decide on personal goals to direct their learning. Students can set either simple or complex goals. These goals exist prior to studying and constitute the criteria by which learners monitor their studying (Winne, 1995b). Then, a plan with various tactics is created to advance toward the goals. As planned tactics and strategies are deployed in the third stage, the products of these operations spawn self-evaluations (internal feedback) which may, in turn, lead the student to alter the original studying plan. The final stage of studying may or may not occur depending on the learner. If it takes place, it consists of adaptive decision-making where students consider how their actions worked in all stages of studying and the adjustments that were made to facilitate their understanding. This stage also enables decisions about tactics and strategies in future studying.

Many theorists use the terms strategies and tactics synonymously (Zimmerman, 1995). However, strategies may be differentiated from tactics. Strategies encompass individual tactics. Specifically, strategies are organised sets of alternative tactics that function as plans for regulating the deployment of individual tactics as conditions change during learning (Winne, 1995a, 1996). In response to internal or external feedback, learners may change or adapt tactics to reach goals (Winne, 1996). The effectiveness of study tactics and strategies depends on certain task conditions. Task conditions are the environment or instructions provided to students outlining the nature and expectations of the learning activity (Winne & Marx, 1989). Learners must then determine which strategy or tactic is most useful under these circumstances.

Winne (1995a) noted three stages of strategic knowledge that enable students to determine which strategies are applicable to specific learning situations. First, is the development of conditional knowledge, "ifs" in an "if-then" rule that distinguish conditions for deploying a specific study tactic. Second, action knowledge consists of "then(s)" in the "if-then" rule. These are operations, or study tactics that are carried out depending on whether "ifs" are satisfied. These parts, condition and action, form an executable skill, called a procedure. Procedures can become automated due to recurrent deployment so that the entire process becomes one unit that is carried out quickly and without much thought about the actual steps involved.

Self-Regulation and Monitoring

At the most basic level, self-regulation occurs when students adapt to their changing environment (Zimmerman, 1995). Self-regulation can be a deliberate act or it may be automatic and not deliberate. The latter occurs when students automate procedural knowledge (Winne, 1995b). Since procedural knowledge is foundational to self-regulated learning and tends to build and change, self-regulation will build and change as well. Monitoring one's behaviour enables successful self-regulation. Adjustment of one's behaviour can be helpful in all stages of learning (Winne, 1995b; Zimmerman, 1998). As a result of ongoing evaluation of whether current cognitive actions support progress toward one's goals, monitoring, a controlled and laboured executive process of self-regulation, activates and deactivates other processes (Pressley & Ghatala, 1990).

Steps involved in self-regulation are based on a plan to achieve a goal. Self-regulated learners look for information in the domain of their task and monitor their engagement by comparing the products of actions to their goals. If sufficient progress is achieved (internal feedback) relative to standard and effort involved, the student will probably continue with the current plan. However, if progress is deemed inadequate, the current plan may be altered or abandoned in favour of another procedure, or the initial goal may be adjusted or rejected (Pressley & Ghatala, 1990; Winne, 1995a). Winne (1996) noted that judgements of learning (JOL) where students consider their learning after task engagement may be important in metacognitive monitoring for determining whether a strategy or tactic will be enacted to correct discontinuities in learning.

Successful self-monitoring students are alert to the productiveness and appropriate use of learning strategies (Lan, 1996, Zimmerman, 1998) based on internal feedback that is created through the monitoring process (Butler & Winne, 1995). Interestingly, monitoring, even by skilled adults, frequently is far from optimal and is more likely to occur during a test than during study (Pressley & Ghatala, 1990).

Zimmerman (1995) cautioned that though students may possess metacognitive knowledge and skill, they may not partake in self-regulating activities such as monitoring. Knowledge about cognition and metacognition are not sufficient in promoting student achievement. Motivation to use strategies and to regulate cognition, and effort are also needed (Pintrich & De Groot, 1990). In addition, perceptions of competence and self-efficacy have been found to predict self-regulated learning practices (Zimmerman, 1995). The use of metacognitive knowledge and skill is regulated by a sense of personal agency, motivational, social, and environmental sources. Students who have the ability to self-regulate may not because of a lack of interest in the topic, fatigue, and distractions in the environment. Instead, students may be cognitively overwhelmed rather than motivationally stimulated, resulting in decreased self-regulation (Alexander, 1995) and diminished performance. However, students who view failure as a result of inadequate effort tend to have positive performance expectations and to engage behaviours oriented towards success (Ames, 1984). Self-regulation is multifaceted with metacognitive motivational, and behavioural components, making it a complex, recursive, and interactive process (Winne & Hadwin, 1998).

Study Strategies and Tactic Use

Observable traces of cognitive processing while studying are frequently formed as notes, outlines, summaries, questions, diagrams, highlighting or underlining and indications of struggles to resolve difficulties. These studying activities are a consequence of focusing attention on the content, and may help learners to review and actively process pertinent information in the text (Wade & Trathen, 1989). The observable traces can also be perceived as externally stored products available for use during review (Di Vesta & Gray, 1972, as cited in Wade & Trathen, 1989).

In a semester-long study, Lan (1996) investigated the effects of self-monitoring on course performance, use of learning strategies, attitude, self-judgement ability, and knowledge representation. Self-monitoring was chosen as the independent variable and manipulated for an entire semester by asking graduate students to document the frequency and intensity and their learning activities using a self-monitoring protocol. In two conditions, instructor-monitoring and control, students were not asked to monitor their learning activities. Lan hypothesised that the self-monitoring group would have better achievement and develop better knowledge representation and more interest in the course.

Lan found that his first supposition was supported. The finding that self-monitoring students performed better than the non-self-monitoring groups on each examination illustrate that self-regulated learning strategies are important to course work. The self-monitoring group showed greater ability to organise course content, thus supporting the notion of better knowledge representation. The self-monitoring group used self-evaluation and environmental structuring strategies more than the other two groups, and rehearsal, memorisation, and reviewing previous assignments and tests more frequently than the control group. Generally, students who self-monitored used more study strategies than non-self-monitoring students. Students' interest in the course did not differ as a function of treatment, possibly due to the fact that student interest in course content is intense at the graduate level, and this may have overridden self-monitoring effects. The positive effect of self-monitoring on academic performance is consistent with previous research and denotes the importance of self-monitoring in learning (Lan, 1996).

Nolen and Haladyna (1990) proposed that another factor that may influence the use of strategies is a belief in how the strategy will assist in attaining one's goal. The objective of their study was to distinguish factors that influence high-school science students' beliefs in strategies' value. In their research, they examined two types of strategies: elaboration and monitoring.

Elaboration strategies integrate new knowledge to what is already known, augmenting learning and recall by assisting students to develop meaningful relationships among related concepts. *Monitoring* strategies entail assessing one's understanding and can trigger appropriate use of elaboration strategies. When monitoring, learners ask themselves questions as they are reading to ensure comprehension, and to stop and consider what they have just read (Nolen & Haladyna, 1990).

Questionnaire data were collected from students at the start and end of the school year concerning their values of the two deep-processing strategies described above. The model proposed that interactions between task orientation and perceptions of teachers' goals would influence ensuing task orientation and beliefs about the value of strategies. Results suggested that individual differences in the starting level of students' task orientation had a strong effect on subsequent motivation and beliefs about the value of strategies. Students' task orientation and beliefs in the value of the strategies seemed to be positively influenced by their perceptions that the teacher wanted them to think independently and master the material. Individual differences were found in students that influenced their goal orientations and what they thought were their teacher's goals. However, regardless of individual differences, teachers were found to influence how students approach a task and students' beliefs about the value of strategies. Therefore, teachers who emphasise understanding as an important goal rather than performance may encourage students to study strategically (Nolen & Haladyna, 1990).

Nolen (1988) hypothesised that orientations influenced beliefs about the value of strategies and the use of strategies. Students' motivational orientations were presumed to influence their beliefs about the value of strategies and their choice of strategies. In addition, a positive correlation between task orientation and valuing of deep-processing strategies was expected. A second set of hypotheses pertained to the roles of perceived strategy value, motivational orientation, ability, and self-perceptions of ability in predicting students' impromptu use of study strategies. A critical constituent of strategy use is knowledge of the value of effective learning strategies (Nolen, 1988). However, this knowledge does not always lead to strategy use. Nolen cited a previous study (Nolen, Meece, & Blumenfeld, 1986) where elementary school students understood that deep-processing strategies were more useful than surface-level strategies and would promote learning, but did not inevitably choose to use them. They concluded that students need to be interested in understanding, otherwise knowledge of the benefits of deep-processing strategies is not enough to promote their use.

Given the two hypotheses above, eighth graders completed several scales on general motivational orientation, strategy value, and perceived ability. At the start of the session, students were told that the researcher was interested in how students think and feel about science, how they studied their science texts, and their opinions. Before the second study session several weeks later, students were reminded that the researcher was interested in learning different ways students learn from what they read. Students studied a science article that interested them until they felt they could paraphrase it for someone else. As students studied, the researcher recorded their overt studying behaviours. After completing a series of task-specific scales, students returned the next day to complete recalls of the passages.

Results indicated that deep-processing and not surface-level strategy use was related to general and task-specific task orientation. That this relationship was sustained over several weeks, attested to the significance of individual differences in motivational orientation. Interestingly, perceived strategy value did not strongly predict strategy use. This supported the findings in other research (e.g. Lan, 1996, Pintrich & De Groot, 1990) that knowledge about the value of deep-processing strategies is not sufficient for implementing their use if interest in understanding is absent. A third finding was that students who felt that the purpose of learning is to perform well did not use or value deep-processing strategies. This suggested that an emphasis on strategy use to gain high performance scores may not be effective. This study implied that students need to be encouraged to value learning rather than performance and only then, will effective learning strategies be put to use.

Lastly, it seems that the use of study strategies by students differs depending on age. In a study with junior high, senior high, and college students, a questionnaire regarding study techniques was distributed to determine differences in strategy usage (Annis & Annis, 1982). Findings indicated that grade level was positively related to increased use of study techniques. Students at higher-levels of schooling reported using more strategies and tactics. This suggested that as students' studying-load increases and becomes more difficult, more study techniques were employed. A second finding was that the "read only" technique decreased in usage with increasing grade level and was replaced by underlining or note taking. Again this suggested that increased study-load and difficulty in higher grade levels incorporated more active engagement and encoding and thus, techniques such as note taking were employed for those purposes.

Feedback

Generally, feedback refers to, "evaluative information that is provided on the functioning of a system that is intended to correct variations from a productive pathway...and [it] is an important ingredient to any effective learning environment" (Azevedo & Bernard, 1995, p. 111). Effective feedback concentrates on specific goals (Zimmerman, 1995). In the absence of goals for performing the task, feedback may cue and induce learners to set goals and strategies (Johnson, Perlow, & Pieper, 1993). In the presence of goals, feedback can consequently alter goals or chosen paths to goals. Pittman and Heller (1987), as noted by Winne and Marx (1989), concluded that many people behave consistently with their goals only until they are overcome by incongruous information (feedback) which drives them to depart from their selected course. However, not all people react in this way. Change is moderated by beliefs of self-efficacy, hence individuals may react differently to feedback. Some learners may develop better strategies and increase effort while others may lower their standards or even become despondent. To understand individual differences in response to feedback, Zimmerman (1995) maintained that knowledge about the learner's sense of self-efficacy is necessary. Beliefs of self-efficacy regulate numerous self-regulatory processes which, in turn, direct performance, cognition, motivation, choice and affect. Feedback external to the learner has taken many forms in the literature but the outcome, corrective and process feedback are identified for purposes of this study.

Feedback and Studying Behaviour

Interestingly, although a considerable variety of theories have been posited concerning students' self-regulation, monitoring of cognitive processes and learning, and strategy and tactic use, little feedback tends to be given to students concerning their studying behaviour. Generally, students frequently are left on their own to infer the value of strategies as they use them and monitor their use of strategies and levels of performance. This information may be used to construct long-term knowledge about the strength of a strategy. The long-term knowledge may then be used in future decisions on the use of the strategy (Pressley & Ghatala, 1990). Thus, students may learn to make use of incorrect strategies or not fully understand the conditions appropriate to enacting a tactic, leading to incorrect or poor deployment of strategies. Executing a study strategy and accurate monitoring of its implementation are often difficult for novices. Thus, they often need social feedback and guidance (Zimmerman, 1998).

Studying is a precursor to and vital to achievement performance. For example, Zimmerman and Kitsantas (1998) found that the amount of time students spent on studying was predictive of their academic achievement (as cited in Zimmerman, 1998). Pintrich and De Groot (1990) examined motivational and self-regulated components of classroom academic performance of seventh graders. Results support the importance of feedback pertaining to studying. Their findings suggested that self-efficacy is less directly linked to performance than is cognitive engagement. Improvement on actual performance of classroom activities such as test taking may take place if students are taught about different cognitive and self-regulatory strategies.

Feedback and Achievement

Achievement acquired through activities such as tests or assignments is viewed as an indicator of learning and knowledge gained. The most common feedback received by students is feedback on performance. Much research has focused solely on outcome feedback even though other forms of feedback exist (Early, Northcraft, Lee, & Lituchy, 1990; Kluger & DeNisi, 1996). *Outcome feedback* or *knowledge of results (KR)* provides information related to the products of a task (Butler & Winne, 1995). In general, relevant literature suggests that although outcome feedback is an important element for learning and improving performance, this type of feedback alone is not always effective (Korsgaard & Diddams, 1996). Outcome feedback informs learners of a need to change but does not supply specific information on how to change their behaviour (Early, et al., 1990). The lack of information on how to correct current behaviour makes improvement difficult for students who do not know how to redirect their effort or improve their performance. Furthermore, outcome feedback does not address specific goals or strategies and thus, may not indicate discrepancies between specific aspects of expected and actual behaviours. Not perceiving a need to change, students will refrain from modifying their behaviours. In some cases, outcome feedback has been suggested to impede learning in complex tasks (Kluger & DeNisi, 1996). A meta-analysis by Bangert-Downes, Kulik, Kulik, and Morgan (1991) indicated that supplying additional information was more effective than simply informing students of the correctness of their responses.

Corrective feedback supplements outcome feedback by informing learners of the correctness or incorrectness of their responses, and for each incorrect answer supplies all the information required in a correct response (Merrill, 1987). Feedback containing specific information on process and performance can in turn be used in future monitoring while studying and performing an activity (Winne & Marx, 1989).

Process feedback provides information about the manner in which a learner executes a strategy or tactic (Early, et al., 1990). This type of feedback presents specific information on task cues and past actions that outcome feedback lacked. This additional information is then hypothesised to facilitate and focus areas for change, by prompting students to consider modifications in future actions.

Schraw (1997) contended that effective achievement performance depends on two important skills, (a) selecting correct responses to questions and (b) accurate monitoring of one's performance. Accurate monitoring is the use of general metacognitive knowledge where test takers evaluate their performance using metacognitive processes independent from the domain, examine their comprehension of test questions, sufficiently designate resources and review not only the content, but their behaviour. These types of skills, Schraw asserted, are not domain-specific and therefore, may be presumed to transfer across knowledge domains.

Pressley, Snyder, Levin, Murray, and Ghatala (1987) examined how well university students self-monitored as they prepared for a post-test. All students studied a chapter from a text, were informed about the tests' format and level of difficulty, and then responded to the test without the opportunity for review. Depending on experimental condition, students were asked to predict their performance, (a) before reading, (b) after reading, or (c) after testing. Performance predictions were found to be more accurate after testing, and a test effect was found. Findings were consistent with other research where metacognitive information gained by monitoring during studying was not sufficient to maximise self-regulated restudy and use of reading strategies. In later research, similar findings prompted Pressley and Ghatala (1990) to suspect that tests may play an important role in regulating behaviour. This suggested that tests may provide information for monitoring the use of strategies in study behaviour.

In a similar study, Hunter-Blanks, Ghatala, Pressley, and Levin (1998) examined adults' ability to monitor their learning and memory of sentences. The researchers requested university students to study sets of precisely and imprecisely elaborated sentences. Three conditions existed in this study. In the first condition, subjects estimated their performance on the types of sentences before studying, presumably to tap into pre-experimental knowledge. In the second condition, students estimated their performance after studying. The purpose was to see if after-studying estimations differed from pre-studying estimations. Monitoring would account for differences between the two estimations. In the third condition, students estimated performance after being tested under an assumption being that, if after-testing estimates were more accurate than after-study estimates, then monitoring of what they remembered about the sentences occurred during testing.

Results indicated that f[illegible] students had prior knowledge about the two types of sentences, although some reported trying to make sentences more memorable (e.g. repetitive reading, adding to sentences). These students self-monitored during studying and adjusted their behaviour in response to their perceptions. Subjects who were asked to estimate after-study performance seemed to monitor their studying activity, but tended to be inaccurate. The strategies and efforts they used during studying were not enough to overcome differences in learning the sentences. Subjects who estimated after the test most accurately perceived their recall of the sentences. The researchers also noted a testing effect and concluded, in accordance with previous observations (e.g., Pressley, Snyder, Levin, Murray, & Ghatala, 1987), that testing was a meta-cognitive experience for their participants. An implication from this study is that practice tests may be useful for advancing more effective studying.

Calibration

The concept of monitoring one's behaviour is directly tied to the notion of calibration. Calibration involves self-assessment of one's state of knowledge, specifically, knowing when and what one knows or does not know. Accurate calibration occurs when predictions of performance correspond to actual performance regardless of whether performance was correct or not. Poor calibration refers either to overconfidence when knowledge is absent or underconfidence when knowledge can be retrieved (Glenberg & Epstein, 1985). The literature has presented two lines of calibration. In one, learners were asked to make predictions of their knowledge, or rate their confidence in their knowledge, before testing. These judgements concern subsequent responding (Nelson & Narens, 1990) and include studies on calibration of comprehension (e.g. Glenberg & Epstein, 1985, 1987) and pre-test confidence judgements (e.g. Glenberg, Saroki, Epstein & Morris, 1987). The second body of research focused on learners' predictions about their behaviour or learning after test taking such as in studies on feeling-of-knowing

(FOK) (e.g. Nelson & Narens, 1990), probability calibration (e.g. Lichtenstein, Fischhoff, & Phillips, 1982), and performance calibration (e.g. Schraw, 1997). These types of predictions are otherwise known as postdictions (Glenberg & Epstein, 1987). A brief synopsis of the first body of research follows since it is a minimal basis for one aspect of this study. Subsequently, the second body of research regarding postdictions will be discussed more fully.

Predictions

The first body of research concerning predictions has generally found poor calibration (see Glenberg & Epstein, 1985, 1987, 1995, 1997; Glenberg, et. al, 1987; Weaver 1990). Students were unable to discern what they understood from what they did not. Glenberg and Epstein (1985) coined the term, "illusion of knowing" to describe why subjects may believe that they have attained knowledge, but failed to respond to questions correctly and did not actually gain knowledge. This ineffectual monitoring is surprising especially under conditions where it would not be expected to occur, such as when competent readers processed text (Weaver, 1990). Poor calibration of comprehension has been attributed to students' assessments of familiarity based on prior familiarity of the domain rather than knowledge gained from the text and a lack of feedback upon which to base judgements and monitoring (Glenberg, et al, 1987).

Studies on confidence judgements (e.g. Glenberg, et al., 1987) also reported low relationships between confidence judgements and test performance although these relationships were statistically significant. These results support an interpretation that domain-specific knowledge provided a foundation upon which to make confidence judgements. Glenberg and Epstein (1987) reported that domain-specific expertise resulted in overconfidence and overestimation of learners' abilities to perform and their understanding prior to being tested, in addition to weak correlations between predicted and actual performance. Nelson and Dunlosky (1991) encountered inaccurate estimations of FOK that had negative implications on metacognition and motivation (cited in Zimmerman, 1995). However, Zimmerman proposed that though estimations were inaccurate, overestimation suggested higher self-efficacy belief and in the long run, optimistic self-beliefs may facilitate persistence with what learners are doing. Over time, continued effort may lead to success.

Some interesting findings have transpired in studies on the calibration of comprehension. A few studies investigated postdiction judgements that occurred after pre-test performance. For example, Glenberg and Epstein (1985) cited poor calibration as a result of (a) deficiencies in processing text, (b) inappropriate construction of knowledge where students may learn isolated facts but not consider relations among them, and (c) a lack of skill in assessing and applying procedural knowledge, even though they may be able to do so for declarative knowledge. Thus, in their third of a series of experiments, Glenberg and Epstein (1985) examined the use of probes for each passage. First, undergraduate students stated their confidence in answering inference questions. Second, they answered an inference question for each text. Third, subjects rated their confidence in the correctness of their answer. Fourth, they rated their confidence in their ability to respond to items in an upcoming test, and fifth, answered questions on a second test.

The confidence rating of their "correctness of answer" was correlated with performance and was significantly greater than zero. This judgement about the correctness of already answered questions was labelled "calibration of performance". The second pre-question rating was correlated with performance on the second test. This recalibration was significantly greater than zero and significantly greater than the value for the initial calibration. The researchers proposed that encountering the first inference test provided students with information (feedback) about how they applied their knowledge. This is in accordance with other studies reporting a test effect (e.g. Pressley & Ghatala, 1990; Hunter-Blanks, et. al., 1998). Assessment of this information about their application of knowledge enabled students to detect deficiencies in their understanding and better predict performance in the second test. Judgements concerning the correctness of responses after taking the test resulted in moderate correlations with actual correctness of responses, and were significantly greater than zero.

The researchers found calibration of performance to be statistically significant and modestly accurate, thus surmising that self-generated feedback from the pre-test was used by the subjects to predict their performance on a forthcoming criterion test. Glenberg et al. (1987) suggested that instructing students to appraise aspects of knowledge more closely associated with test performance rather than domain familiarity may improve calibration. They noted, however, that calibration of comprehension could be enhanced only when processes and knowledge invoked in the pre-test are similar to those in the criterion test.

In several studies, Glenberg and Epstein (1997, 1995, 1987, & 1985) and Glenberg et al. (1987) found little evidence to support calibration of comprehension. Predictions made before a test and the feedback gained during and after test taking was too late to be used for accurate predictions. However, there was support for the general sentiment that subjects can accurately report their performance. Only when learners take a test do they seem to become aware of the amount and parts of text they learned, and this feedback can be applied to future testing and postdiction judgements concerning the correctness of responses to test questions. Nevertheless, this heightening of calibration due to test taking is limited to incidences where the knowledge and processes invoked by the pre-test are similar to those necessary for the next test. As a result of the pre-test experience, subjects use feedback to predict their performance on the next test.

Postdictions

In the second body of research, subjects wrote a pre-test or test and then were asked to make postdictions or predictions. One domain where relationships between predictions and performance were strong was in the calibration of probabilities (e.g. Lichenstein, Fischoff. & Phillips, 1982). Subjects answered general knowledge questions, then judged the probability that answers were correct. Self-generated feedback may have been derived from the processes used to answer a general knowledge question. This feedback could then be used to make accurate judgements. Again, overconfidence occurred, but sizeable relationships between accuracy and judgement probabilities were found (Glenberg, et al., 1987).

Another area where strong relationships have been reported is in judgement of knowing (JOK) research. King, Zechmeister, and Shaughnessy (1980) provide an example of this work. In their study, they examined memory-monitoring performance to ascertain whether previous test-trial experience influenced judgements of knowing. College students learned pair-associate lists. Two of four groups were asked to predict the probability that they would recall the terms on a test trial. One of these two groups only had study trials before predicting, while the other alternated between study and test trials. The two remaining groups were control groups and were not asked to predict recall. Next, all four groups learned a third list without test trials and made judgements of knowing. It was expected that if subjects were influenced by test trials, their predictions would not be as accurate in the absence of test trials for the third list. Results showed that higher prediction accuracy occurred for subjects who received test trials. As expected, in the absence of test trials, accuracy decreased on the third list. King et al. proposed that knowing about previous test-trial performance provides a basis for decisions about encoding strategies on ensuing study trials. Therefore, not only should various techniques for attaining information be taught, but also manners in which the effectiveness of these techniques can be evaluated.

Strong relationships have also been reported in studies of feeling-of-knowing (FOK) where people are asked to make "predictions about subsequent memory performance on previously nonrecalled items" (Nelson, Gerler & Narens, 1984). FOK accuracy is assessed by comparing the FOK predictions against criterion performance (Nelson, 1984). Learners were asked to think about items that they failed to recall. This resulted in students' self-generating feedback and self-monitoring, and lead to better predictions on subsequent performance.

Calibration of performance is defined as, "how accurately learners assess their performance on a test of previously studied material" (Schraw, Potenza, & Nebelsick-Gullet, 1993, p. 455). Related to research on postdictions, calibration of performance is important because learners partake in comprehensive monitoring within a test or while studying. Schraw et al. asserted that well calibrated learners adapt to test demands and consequently "use this information to plan effectively for future tests that are similar in format or content, or to review previously studied material" (p. 455).

The purpose of their study was to investigate the individual and interactive effects of feedback and incentives on test performance and calibration of performance. Undergraduate students answered reading comprehension and math multiple-choice questions and then rated the accuracy of their responses. Instructions for the feedback group indicated that they would be told about how accurate their responses were at the end of each block of questions. For the incentive group, instructions informed students of the possibility of extra benefits such as extra credit for scores above the mean of the control group and for improved calibration. The control group did not receive any specific instructions.

Correlations, and mean bias and accuracy scores were used in their analyses. Correlations indicated the relationship between postdictions and actual performance, while mean bias assessed the direction of judgement error; mean accuracy assessed the magnitude of error judgement. Results indicated that incentives resulted in significant effects. Schraw et al. (1993) posited that providing incentives can enhance the degree to which students successfully monitor their performance. In addition, the findings to a limited extent imply that monitoring is flexible and controllable by learners. Interestingly, feedback did not have an effect on performance, bias or accuracy. This led the researchers to suggest that the experimenter-provided feedback was of little value to the students and to consider that perhaps the self-generated feedback obtained during the test was sufficient. The researchers also considered the effectiveness of outcome feedback, where specific information about performance is supplied. Citing Lhyle and Kulhavy (1987), the researchers proposed that outcome feedback may have little effect on correct responses and subsequent testing. A final implication of the findings is that stressing accurate calibration may do more to improve performance than rewarding improved performance. This finding suggests that improved performance may be a result of focusing on why and when performance occurs rather than on its success.

For example, Schraw (1997) investigated the effect of generalised metacognitive knowledge on test performance and confidence judgements. Schraw predicted that confidence judgements would be related to performance in both domain-specific and domain-general tests. The purpose of his study was to test the domain-specific and the domain-general hypotheses. The former proposes that performance-monitoring skills are developed through the procurement of domain-specific knowledge, whereas the latter states that monitoring of performance occurs by applying general metacognitive knowledge. Undergraduate students completed four different multiple choice tests and rated how much confidence they had in response to each test item. Schraw posited that if the domain-specific hypothesis was correct, correlations between performance and confidence within each domain would be high and correlations between performance and confidence judgements on different tests would be low. If the domain-general hypothesis was correct, the opposite was expected. The findings were consistent with the domain-general hypothesis. The findings implied that test takers rely on two fairly different sources of knowledge: domain-specific content and domain-specific knowledge. The use of the two types of knowledge leads to better performance when students are tested on content-knowledge and domain-general metacognitive knowledge which, in turn, directs performance assessments and confidence judgements.

Calibration for Studying

Literature on calibration has focused on calibration of performance. Little research seems to be available on how well students recall their use of study tactics. This is most likely due to a lack of available traces of study tactic use with which to compare recalled use. However, one study provided the means of logging the traces. Winne, Hadwin, Stockley, and Nesbit (1999) asked undergraduate students to report how frequently they used seven study tactics. Students were assigned two photocopied chapters to study. After retrieving the chapters, traces of study tactics were counted. Winne et al. then examined self-reports about study tactic use and matched recollections with traces of tactics produced while studying. The researchers found that calibration between actual and postdicted tactic use was poor at best.

The Present Study

The present study investigates the effects of feedback about study tactics and ideal response feedback on studying and achievement performance. To produce feedback, students will study a chapter using a custom-built software tool, respond to short answer test questions and make postdictions of their performance. Feedback will be created from students' studying activities and achievement performance. In a second session, students will receive one of three types of feedback or no feedback (to be discussed in the methods chapter). Students will then study a chapter that is similar in structure to the one they studied in the first session. Following the study period, students will respond to questions similar in structure to those on the test they wrote in the first session. The data obtained will be examined for changes in students' performance and calibrations between postdictions and achievement.

One set of hypotheses examined in this study was that various types of feedback—outcome, process, and corrective feedback—supply different information about performance and have different effects on studying processes and on achievement. Offering these types of feedback to students is posited to enhance subsequent study and increase achievement because this combination of feedback informs students not only of their results, but also about the manner in which they executed strategies to create responses and answers.

The second set of hypotheses concerned students' calibration: (a) their accuracy in predicting and postdicting achievement compared to actual achievement, and (b) the level of accuracy of their perceptions about how they study compared to their actual studying behaviours. If students are poorly calibrated about knowledge and/or their studying, they are in a weak position to self-regulate learning. Therefore, by providing specific feedback and directing students to think about their performance (studying or achievement), monitoring may improve.

It was proposed that process feedback will prompt students to focus more on their studying because they now had external feedback as well as self-generated generated feedback, leading to refined monitoring and improved calibration between predicted and actual achievement. Similarly, students receiving corrective feedback were directed to focus on aspects of their achievement. Giving students information about components of correct responses may lead to increased monitoring during test-taking and result in improved calibration between predicted and actual achievement. The group that received the corrective plus process feedback was anticipated to increase monitoring in both studying and achievement and, therefore to be better calibrated between reported and actual study activities and between reported and actual achievement.

Four Research Facets and Related Hypotheses

This study investigates four facets and specific hypotheses (see Table 1).

Table 1

Research Facets and Related Hypotheses.

Facet		Hypotheses
1. Effect of feedback on subsequent studying	i.	Process feedback will increase study tactic use.
	ii.	Process-plus-corrective feedback will improve students' use of studying tactics.
2. Effect of feedback on subsequent achievement	i.	Corrective feedback will improve achievement.
	ii.	The proposed increase in study tactic use by the process feedback group will result in improved achievement.
	iii.	The proposed increase in study tactic use in the second study session will result in improved achievement for the process-plus-corrective feedback group.
3. Calibration for studying activities	i.	Students will have poor calibration between reported and actual use of studying tactics independent of feedback.
	ii.	Process feedback will improve calibration between reported and actual use of study tactics.
	iii.	Process-plus-corrective feedback will improve calibration between reported and actual use of study tactics.
4. Calibration for achievement	i.	Students will have moderate calibration between reported and actual performance independent of feedback.
	ii.	The proposed improvement in calibration for studying activities due to process feedback will then improve calibration between reported and actual achievement.
	iii.	Corrective feedback will improve calibration between reported and actual achievement.
	iv.	Process-plus-corrective feedback will improve calibration between reported and actual achievement.

CHAPTER 3

Method

Participants

Eighty-eight undergraduate university students (64 women and 24 men, mean age=21.68 years, *SD*=4.84) volunteered to participate in the study for financial remuneration after completing both sessions. Predominately in their first year at the university (n=71), participants came from various disciplines. All student data were referenced by a number code to preserve anonymity.

Materials

PrepMate Practice, Lightning and Pumps Chapters

Three text passages were designed for students to study using custom-built software called PrepMate. The first passage was used in the Practice module and introduced participants to the computer software features. The two other chapters formed the studying materials. To cue students to important information, supplemental facts, descriptions, and text markers were added by Jamieson (1999). For example, "The result of…is that…" indicated a cause-effect relationship.

PrepMate Chapter: Practice Session

In the introductory PrepMate Practice module, a 627-word passage instructed students how to use PrepMate's features. Students could highlight, copy and paste text, create notes, examine figures, view figure explanations, and review notes. A hyperlink embedded in the chapter introduced students to viewing sequential figures and related explanations. See Appendix A for the full text and Appendix B for an example of illustrations and explanations.

Lightning Chapter: Studying Session 1

The chapter on the process of how lightning is created contained 915 words within seven paragraphs (see Appendix C). Embedded hyperlinks in the chapter linked to five illustrations and explanations, and corresponded to significant events in the development of lightning (see Appendix D). To provide more contextual information for the achievement test questions, Jamieson (1999) extended Mayer et al.'s (1996) text using information about meteorology from Wallace and Hobbs (1977) and Roth (1981).

Pumps Chapter: Studying Session 2

The chapter on pumps contained 1019 words within eight paragraphs and introduced pump systems (see Appendix E). The chapter presented two major kinds of pumps and four subcategories. Hyperlinks embedded in the chapter text linked to illustrations of the four subtypes of pumps and to the steps involved in operating each type of pump (See Appendices F and G). Jamieson (1999) supplemented the text produced by Mayer and Gallini (1990) using information found in Jones and Schubert (1963) and Scharf (1971).

PrepMate Software

The following section was written in collaboration with Jamieson (1999). PrepMate is a Macintosh computer tool used by participants to study a chapter in preparation for an achievement test. In the study, participants worked through three modules: PrepMate Practice, Session 1 (chapter on lightning) and Session 2 (chapter on pumps). Chu, Jamieson, Winne, and Field (1998) designed all modules collaboratively using STUDY (Winne & Field, 1998), a general instructional programming system.

Windows

Each module consisted of four types of windows: Notes and Organiser, Objectives window, Chapter window and Figure window (see Figure 1). Upon opening PrepMate, the Notes and Organiser window appeared at the top right of the screen. It was initially empty. This window provided a space for participants to record notes as they studied and was analogous to a paper notebook. In this window, participants could use several study tactics: highlight text in notes, paste information copied from other windows, paraphrase chapter information to make notes, generate questions, write a mnemonic, create an analogy, generate examples, and cut and paste within their notes. The Notes and Organiser window contained buttons that provided links to the Objectives window and the Chapter window. Participants could view one of these windows by clicking on the appropriate button at the bottom of the Notes and Organiser window.

The Objectives window contained the objectives for the session and opened in the upper left corner on the computer screen when students clicked the objectives button in the Notes and Organiser window (see Figure 1). In textbooks, objectives are often found at the beginning of the chapter. To review the objectives, students must refer back to the first page. To mimic this in PrepMate, the contents of the Objectives window became invisible when any other window was active. This feature also allowed the researcher to count how often students referred to the objectives as they studied. Available study tactics in the Objectives window comprised: highlighting, and copying and pasting selected text into the Notes & Organiser window.

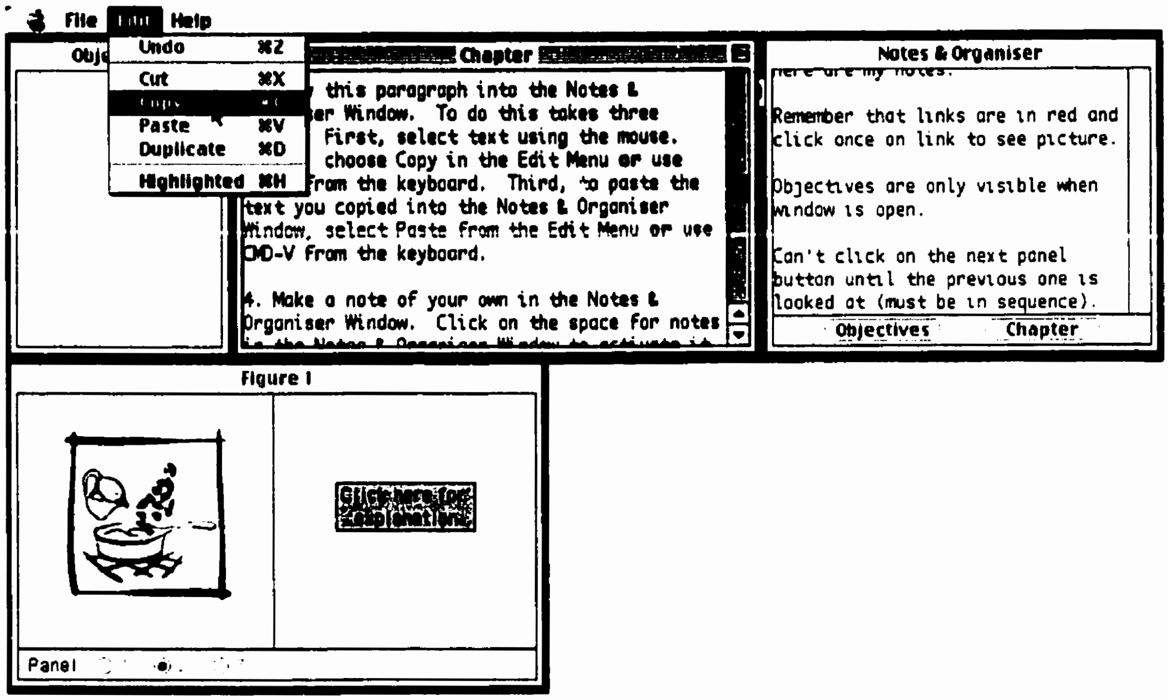

Figure 1. Screen capture of the PrepMate practice module.

Note: The Objective, Chapter, Notes and Organiser, and Figure windows open. The pull-down menu shows the two functions available for the active Chapter Window, copying and highlighting. The objectives in the Objectives window are invisible because the Chapter window is active.

The Chapter window contained the chapter text and appeared in the top middle section of the computer screen (see Figure 1). In the practice module, this window contained instructions on how to use the software features. In the two studying sessions, it contained a chapter's text. To open this window, students must click on the chapter button in the Notes and Organiser window. The Chapter window always remained open and visible. Available study tactics in the Chapter window comprised highlighting within the chapter or copying and pasting selected text into the Notes and Organiser window.

Limiting students to these two study tactics encouraged them to use the Notes and Organiser window for notes and to prevent the original text from being altered. Once all four windows were opened, they could not be closed, resized or moved and participants re-activated any window by clicking on it.

Figures

Red underlined text within parentheses in a chapter identified links to a series of illustrations, otherwise referred to as Figures, which were housed in the Figure window. To open the Figure window, which was positioned below the Objective and Chapter windows, participants clicked the first Figure link embedded in the chapter text. Each of the Figure links in the chapter corresponded to a panel number button located at the bottom of the Figure window. Each button connected to a specific panel in a series of illustrations (see Figure 2). When a link in a chapter was activated, it also activated a corresponding panel number button within the Figure window. Only one figure and hence one panel in the Figure window could be viewed at a time.

The use of hyperlinks was similar in PrepMate Practice and in the first studying session. Clicking the first link in the practice module opened the Figure window of this module and displayed in it the first panel of a three panel series of illustrated instructions on how to make soup (see Figure 1). Clicking the first link in Session 1 opened the Figure window in this session and displayed in it the first panel of a five panel series of illustrated instructions on the development of lightning (see Figure 2).

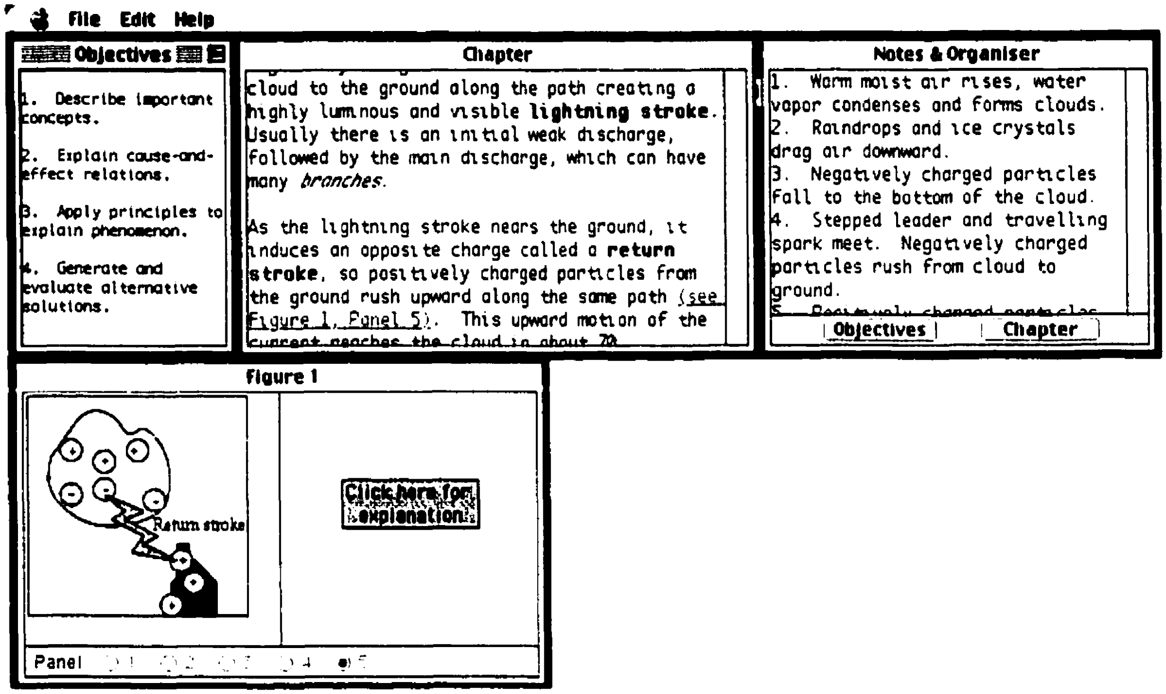

Figure 2. Session 1 Module with all windows open and the Objectives window active.

Since the chapters described a cause and effect relationship, when viewing panels corresponding to the sequenced figures for the first time, participants were constrained to viewing each figure in sequence. To activate subsequent figures in the Figure window, students clicked on hyperlinks in the chapter or on panel buttons in the Figure window. Clicking on a hyperlink out of sequence displayed a message window and message indicating that a preceding figure must be viewed first. Clicking on the next panel button in the sequence activated the next panel. Therefore, once a preceding panel button was activated, subsequent panels could be viewed by clicking on the next panel button in the series regardless of where students were in reading the chapter. Once viewed, participants could re-view a figure in any sequence relative to other previously seen figures using either the chapter hyperlinks or panel buttons.

A clickable Explanation button to the right of the Figure panel revealed a text explanation about the associated Figure panel. Explanation text could be copied and pasted into the Notes and Organiser window. When the Figure window became inactive, the explanation disappeared and the panel reverted to the Explanation button.

However, in Session 2 each one of the four hyperlinks in the chapter corresponded to a unique Figure window and not panels within a Figure window as in the Practice and Session 1 modules. Each Figure window presented a different type of pump. Clicking on a link opened a new Figure window and displayed the first panel of a three panel series of illustrations. Unlike the preceding two modules, participants could click on the chapter's hyperlinks in any order since information about each type of pump was unrelated. Once opened, each Figure window remained open (see Figure 3) and its panels, panel buttons, and explanation button behaved identically to those of the Practice and Session 1 modules.

PrepMate recorded participants' use of study tactics into a log file. Information on every action included a time stamp. This allowed noting the sequence of study tactics. For example, time stamped traces appeared in the log file when participants looked at chapter objectives, or when they examined figures or viewed explanations associated with the figures. Other examples of logged trace data include: highlighted text and its source window; copied, pasted, or cut text along with source and target windows; opening of a window for the first time; viewing of figure panels and the time; activating different windows; and the contents of the Notes and Organiser window at the end of the session. For an example of a log file, see Appendix H.

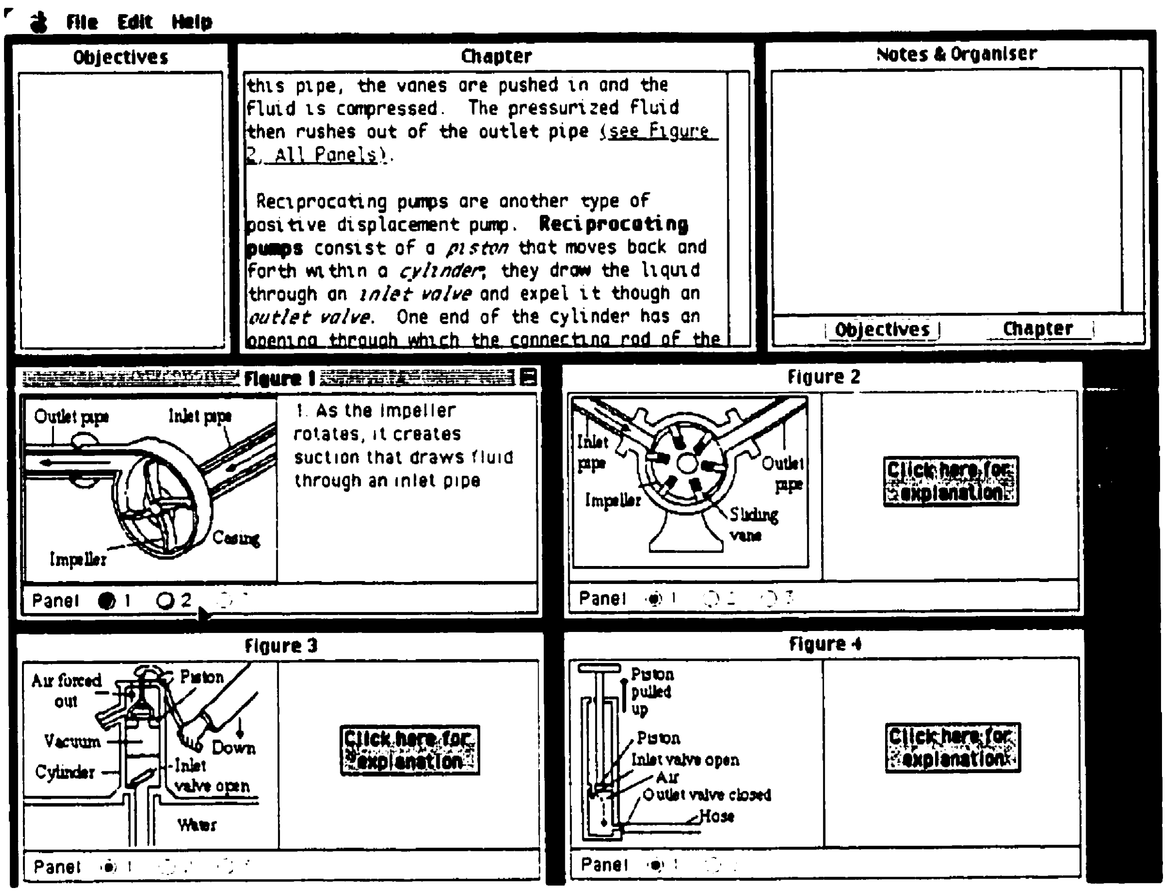

Figure 3. Session 2 module with all windows open, including the four Figure windows.

Measures

Demographics and Prior Knowledge

The pre-session questionnaire (see Appendix I) contained three sections. The first section collected demographic information: age, sex, grade-point-average, number of credits taken at the university, number of hours worked per week, number of hours spent studying per week, number of courses currently enrolled, whether or not English was a second language and the age at which English verbal and written skills were developed, and short-answer responses concerning difficulties with studying.

The second section provided data for a separate study (Jamieson, 1999) to determine goal orientation towards learning. Adapted from materials used by Mayer, Bove, Bryman, Mars, and Topancgo (1996) and Mayer and Gallini (1990) the final section of the questionnaire assessed prior knowledge of meteorology and of pumps, respectively. Given a checklist of science courses and space to write other related courses, students indicated courses taken in high school and at the post-secondary level. Then, participants responded to seven statements about meteorology, such as "I regularly read weather maps in the newspaper." and "I know what this symbol means." (symbol for a warm front). Students also responded to seven statements on household mechanics indicating their prior knowledge about pumps. Items included, " I own a set of tools including screwdrivers, pliers and wrenches." and " I have installed plumbing pipes or plumbing fixtures." Lastly, students indicated their knowledge of how to fix household appliances and machines, by placing marking a five-level scale ranging from, "very little", "average", to "very much".

Performance Measures: Test Questions for Lighting and Pumps Chapters

The test formats in Sessions 1 and 2 were identical. Participants received six short-answer questions presented on letter-size paper with two questions per page. As part of another study (Jamieson, 1999), questions were adapted from Mayer et al. (1996) and designed to assess cognitive dimensions in Bloom's taxonomy. Table 2 lists test questions for the lightning and pumps chapters.

Table 2

Test Questions for the Lightning and Pumps Chapters.

Chapter	Questions
Lightning	1. Based on your understanding of the passage, please describe how lighting works. (10 marks) 2. What are the ideal conditions for a lightning storm to develop? Justify why the conditions you have specified are important. (5 marks) 3. What does air temperature have to do with lightning? (5 marks) 4. Suppose you see clouds in the sky, but no lightning. Why not? (5 marks) 5. How does lightning form? (5 marks) 6. What determines the intensity of a lightning storm? (5 marks)
Pumps	1. Based on your understanding of the passage, describe how pump systems work. (10 marks) 2. What are the similarities and differences between the pump systems? (5 marks) 3. Suppose you push down and pull up the handle of a pump several times but no air comes out. What could have gone wrong? (5 marks) 4. A sliding vane pump fails to work. What could create this failure? What could be done to make the pump work properly and more reliably? (5 marks) 5. What are two types of pumps? Provide an example of each. Why are they good examples? (5 marks) 6. What could be done to increase the efficiency and effectiveness of a pump system? (5 marks)

After each test question was a space for the response, a statement of the question's worth (5 or 10 marks), and a question asking participants to predict their mark on that question. Each test comprised one 10 mark question and five 5 mark questions. At the end of each test, participants indicated on 10-point scales, the amount of effort they had put into studying the chapter and the amount of effort they put into answering the questions. A score of 0 represented no effort, 5 indicated moderate effort and 10 denoted complete effort. The two types of effort will be referred to from hereafter, as ratings of reported studying and reported test-taking effort.

Study Tactics Questionnaires

Study Tactics questionnaires were used in both sessions and designed collaboratively with Jamieson (1999) (see Appendix J). Students received the questionnaire after they had finished studying and completed the achievement test. Typed on letter-size paper, the questionnaires contained five sections. Only two sections are relevant to the current study. To complete the questionnaires, students considered their earlier studying behaviours in the session. The first section of the questionnaire presented a list of self-regulating behaviours. For each item, participants responded with a yes or no to whether they planned a method, planned their time, and set objectives while studying. Sixteen self-regulating items were listed in the second sub-section (see Table 3). Responses were based on a 7 -point scale for the chapter on lightning and an 8-point scale for the chapter on pumps to corresponded to the number of paragraphs in the chapter (see Appendix J).

Table 3

Sixteen Self-regulating Items Presented in Section 1 of the Study Tactics Questionnaires.

Item
1. Stop to check your understanding of the paragraph
2. Think about what you already knew about the subject matter in the paragraph
3. Check your understanding of the paragraph with what you already knew
4. Ask yourself questions before you read the paragraph
5. Ask yourself questions while you read the paragraph
6. Ask yourself questions to review your understanding of the paragraph
7. Go back and make connections with information in earlier paragraphs
8. Go back and review information that was not clear in earlier paragraphs
9. Go back and look at your notes from earlier paragraphs
10. Go back and look at your highlighting from earlier paragraphs
11. Go back and look at your pictures from earlier paragraphs
12. Check to see how much time you had left
13. Review your method for learning the material in a paragraph
14. Review your objectives and their relation to the paragraph
15. Check your overall progress while studying a paragraph
16. Change your overall approach to studying the chapter while studying one paragraph

The second section of the questionnaire listed seven study tactics that corresponded to traces recorded in the PrepMate log files (see Table 4). Again, students reported their use of studying tactics using a 7 or 8-point scale corresponding to study Sessions 1 and 2, respectively. The scale corresponded to the number of paragraphs in the chapter (see Appendix J).

Table 4

Seven Statements on Studying Activities as Presented in Section 2 of the Study Tactics Questionnaires.

Item
1. Highlight in a paragraph
2. Copy a part of the text directly into a note on information in a paragraph
3. Make a note using your own words for a paragraph
4. Create a mnemonic (e.g. ROY G BIV) for information in a paragraph
5. Generate questions in a note on information in a paragraph
6. Create an analogy (e.g. memory is like a computer) in a note on information in a paragraph
7. Make examples in a note on information in a paragraph

Ideal Response Checklists

An Ideal Response Checklist was created for each achievement test item. For example, a question worth 5 marks had at least 5 statements listed. If partial marks were allotted in the scoring system for a text item, several statements worth partial marks were listed. The statements were created based on the materials adapted from Mayer et al. (1996) by taking key points and steps from the chapters and by asking people with knowledge about the topics. See Table 5 for an example of checklist items. After completing each achievement test, students were given a list of components of an ideal answer. Students checked components included in their responses. In spaces provided, students could write other responses not covered by the checklist and to explain their appropriateness to the question. See Appendix K for the Ideal Response Checklist for the lighting questions and Appendix L for the pump questions.

Study Tactics Feedback Form

The researcher designed the Study Tactics Feedback Form to provide students with feedback on how and why they could use study tactics and to increase students' awareness of their tactic use prior to studying in Session 2. Typed on legal-size paper, the form included each planning, strategic and studying activity listed in Sections 1 and 2 of the Study Tactics questionnaire (see Appendix M). To give students a better understanding of each activity, an explanation and tactic were presented. Table 6 provides an example of an activity, explanation and purpose of its use.

Table 5

Sample Question and Checklist Items.

Question	Checklist Items
Based on your understanding of the passage, please describe how lightning works.	___ warm moist air rises ___ water vapour condenses ___ as raindrops and ice crystals form, they create friction (electric potential) ___ negatively charged particles fall or move to the bottom of the cloud ___ a stepped leader containing negatively charged particles moves down in small steps ___ a travelling spark containing positively charged particles moves up ___ the stepped leader and travelling spark meet on the same path creating the lightning stroke ___ return stroke produces the light associated with the lightning stroke ___ dart leaders continue to carry negative charges from the cloud to the ground ___ colliding air particles make thunder ___ Other response ______________________________ ______________________________ ___ Explain ______________________________ ______________________________
Suppose you push down and pull up the handle of a pump several times but no air comes out. What could have gone wrong?	___ there is no air in the pump ___ a valve is stuck ___ a seal is broken ___ the supply line is blocked ___ the outlet line is blocked ___ the piston has become unattached from the handle ___ the supply to the pump is closed or empty ___ Other response ______________________________ ______________________________ ___ Explain ______________________________ ______________________________

Table 6

Sample Studying Tactic Items with Explanations and Descriptions.

Studying Tactic	Explanation	Description "It will help you to:"
Highlighting	Select key terms, concepts, definitions & main arguments	Guide review of chapter content
Generating Questions	Invent questions before reading the chapter (e.g. How much do I know about this topic?), during reading the chapter (e.g. Does this relate to anything I already know?), and after reading the chapter (e.g. What was this chapter about?)	• Before: Decide about information upon which to focus • During: Evaluate your understanding about information in the chapter • After: Evaluate your understanding of the chapter
[Self-regulating]*	• Stop to check your understanding of the paragraph • Check your understanding of the paragraph with what you already knew • Ask yourself questions while you read the paragraph • Check to see how much time you had left • Check your overall progress while studying a paragraph • Change your overall approach to studying the chapter while studying one paragraph	• Identify and select important information • Identify whether the strategies are working • Adjust your first impressions about the expectations for learning • Check whether you identified important points in the paragraph • Ensure there is adequate time to finish studying the chapter • Ensure there is adequate time to finish all the test questions • Use information you've learned so far to generate better ideas about questions that might be asked on the test

Note. Self-regulation while studying was not explicitly stated to the students as an activity, but rather it was inferred by providing students general studying strategies.

As seen in Appendix M, two columns were located on the left of each activity. The first column labelled, "Before (chapter 1)" contained participants' responses to the Study Tactics for Session 1 questionnaire. The second labelled, "Now (chapter 2)" provided space for participants to report their predictions on how often each activity would be used (out of seven paragraphs) while studying the forthcoming chapter. Providing respondents with their reported use of activities in Session 1 gave students' a basis for making predictions for Session 2.

Traces

PrepMate logged fourteen traces of studying behaviour for each session. These traces corresponded to items in the Study Tactics questionnaires and the Study Tactics Feedback form. In the log file, each trace except for clicks on buttons in Figure Windows, was recorded with a paragraph reference to where it occurred within the chapter text. To code the data, notes were made in the margins next to the log file entry for each studying tactic. Using paragraph references, the number of paragraphs in which students used specific tactics was identified.

To compare actual studying behaviours and responses to items in the Study Tactics questionnaires and the Study Tactics Feedback form, the following traces were coded from the log files. At the start of each log file, indications of "planning a method" for studying and "setting objectives" were sought. Evidence of the former was indicated by scrolling through the chapter prior to studying. Presumably students were engaged in planning by overviewing or skimming the chapter. Setting objectives was considered if students opened the Objectives window prior to accessing the chapter text. It was presumed that by viewing the session's objectives first, students were setting studying objectives for themselves.

As participants studied the chapters, opportunities arose for typical studying behaviours to occur. These included: highlighting, copy text from the chapter or explanation of a figure panel into a note, and generating studying products — original notes, mnemonics, questions, analogies, and examples. PrepMate recorded specific incidences of highlighting, copying and pasting, and creating notes by registering the selected or typed text and the window where the action occurred. To facilitate coding and comparison with the responses in the questionnaires, the occurrences of each activity per paragraph were logged. At the end of a studying session, PrepMate downloaded contents of the Notes and Organiser window to the end of the log file. These data indicated when students created mnemonics, questions, analogies, and examples, as well as the content of these products.

Several traces concentrated on review activities. Again, these were coded on a per paragraph basis. First, the number of times students referred back to the objectives was coded as "reviewing objectives." Second, "reviewing information" was coded when students scrolled back and focused on notes, highlights, and text they had already read. In most cases, review was coded only if participants had read the entire chapter. The sole exception consisted of the review of a preceding paragraph. In this case, review was deemed to have occurred because the student scrolled back to previously read text. Third, after viewing figures for the first time, subsequent activation of the figure window was coded as "going back and looking at figures".

It was presumed that time is a factor in cognitive processing. It was decided that when students stopped or paused for a minimum of 10 seconds while reading or scrolling, they were actively deliberating. However, the time stamps in the log files did not state time as minutes and seconds, but rather tenths of a second. Therefore, active processing was coded when there was a difference of 600 tenths of a second between two time stamps.

Final Questions Questionnaire

As the final activity in the study, participants reported whether the feedback they received affected their studying and test behaviours. Three versions of the Final Questions questionnaire were created corresponding to each of the three feedback conditions. For the corrective feedback group, the questionnaire contained four sections (see Appendix N). In the first section, participants rated how much the corrective feedback on the chapter about lightning influenced their approach to studying the chapter on pumps. Using a 10-point scale, a score of 0 indicated no influence at all, while 10 indicated complete influence. Next, students who responded with anything other than a 0 were asked to provide specific information on how they changed their studying behaviour based on the ideal response feedback they received. Lastly, students reported why the ideal response feedback led them to change or not change their approach to studying the second chapter. Section 2 of the questionnaire focused on how feedback affected their approach to taking the test. The three questions in this section were structured identically to those in section 1, but with "approach to taking the test" replacing "approach to studying."

The final two sections of the questionnaire concentrated on participants' perceived effort in studying and answering test questions. In section 3, the researcher copied students' effort ratings reported at the end of each achievement test to remind them of what they reported. Students were asked to explain why they rated their effort the same or different for studying the two chapters. Section 4 contained a statement with participants' reported effort ratings on answering the test questions on each chapter. An open-ended question asked students why they rated their effort the same or different when they responded to effort questions at the end of the two achievement tests.

Similarly, the Final Questions questionnaire for process feedback contained four sections (see Appendix O). The format for the first two sections was similar to that of corrective feedback, except the focus was on the effect of process feedback. The effort questions in the last two sections of this questionnaire were identical to the questionnaire described above.

The process-plus-corrective feedback group received a two-page questionnaire with the first two sections from both of the two questionnaires already described. Thus, the first four sections asked students to rate how much the corrective and process feedback influenced their approaches to studying the chapter on pumps and to taking the test on pumps. Then, students reported how and why they changed their studying and test taking due to the feedback they received. For the final two sections of the questionnaire, students were informed of their reported effort ratings for studying the chapters and answering the test questions on lightning and pumps and asked to explain why their effort ratings differed or remained the same between the two sessions.

Treatments

The researcher randomly assigned participants to one of four feedback conditions: a corrective feedback group (n=22), a process feedback group (n=21), a process-plus-corrective feedback group (n=26), and a no feedback group (n=19). At the end of each session, the members of the fourth condition departed after completing the achievement test while members of the other three conditions completed the Study Tactics questionnaire. In the second session however, only the process feedback and process-plus-corrective feedback groups received feedback based on the Study Tactics questionnaire and the corrective feedback and process-plus-corrective feedback groups received feedback on their test responses compared with ideal answers. These two groups also received outcome feedback, their grade. See Table 7 for a summary of the types of feedback received by each condition group. The study spanned two weeks. Meagre participation at the onset prompted the researcher to randomly assign students to the corrective feedback and process-plus-corrective feedback groups in the first week. As numbers increased during the second week, participants were for the most part, randomly assigned to the process feedback and no feedback groups.

Table 7

Treatment Groups.

	Type of Feedback Received		
Condition	Outcome (Grade)	Corrective (Ideal Response)	Process (Study Tactics)
Corrective (Ideal Response)	Yes	Yes	No
Process (Study Tactics)	No	No	Yes
Process-plus-corrective (Ideal Response & Study Tactics)	Yes	Yes	Yes
No Feedback	No	No	No

Procedure

Pre-session

Besides appealing to students in several classes in different disciplines, researchers posted flyers and sent e-mail to advertise the study. After contacting and receiving approval from course instructors, the researchers attended class lectures and briefly described the research project, explaining that the research would investigate participants' views on studying and how they studied using a computer-based environment. All participants would be paid $15 upon completing both sessions and would be entered into a random draw to win one of four $50 prizes. Packages comprised of a consent form (see

Appendix P), the Perspectives on Learning questionnaire and contact information were left behind for potential participants. Interested students were asked to contact the researchers to schedule Sessions 1 and 2. Students responding to poster and e-mail advertisements contacted the researchers by e-mail or phone to discuss the study, schedule sessions and arrange to pick up the information and questionnaire package. Participants were expected to bring the completed package to the first session.

Session 1

Upon arrival, students submitted their completed package. If package items were incomplete or missing, participants completed the required documents at this point. Participants were then seated in front of a Macintosh computer terminal, given an outline of the session and briefly introduced to PrepMate. Next, participants familiarised themselves with the computer interface by working through the PrepMate Practice module for approximately ten minutes. Upon completing the practice module, students began the first session module, studying a chapter on lightning.

After studying the chapter for approximately twenty minutes, students closed the computer program and proceeded to answer the six achievement questions on paper. Participants were given 20 minutes but could take longer if desired. Assistance was available from the researcher but the researcher did not provide clarification on the meaning of questions when students asked because the questions were designed specifically for another study (Jamieson, 1999) to determine students' task understanding.

Depending on treatment group, participants completed either a series of questionnaires or departed after completing the achievement test. After scheduling their second session, the no feedback group left. The corrective feedback group and the process-plus-corrective feedback group completed the Study Tactics questionnaire and the Ideal Response Checklist for Session 1. Participants completed the exams using pencils, but responded to the questionnaires in pen. The use of two different writing instruments enabled researchers to ensure that students did not add items from the Ideal Response Checklist to their test answers. Finally, participants assigned to the process feedback group responded to the Study Tactics questionnaire before leaving. Table 8 provides a summary of events in Session 1 for each treatment.

Creating Feedback

Between sessions 1 and 2, a colleague (D. Jamieson) and I independently marked the achievement test. We met to discuss each test score until we came to a consensus. Grades for participants in the process feedback and no feedback groups were merely recorded in a data file. However, for students requiring feedback on ideal responses, the grade was also written beside each question on their completed first Ideal Response Checklist. The mark participants assigned themselves was also written beside each question so they could compare their predicted grade with the grade assigned by the examiner. Furthermore, elements of each question on the first Ideal Response Checklist were compared with students' responses. I marked on the checklist items the student had included in his or her response. Finally, I provided written feedback after each question or at the end of the Ideal Response Checklist (see Table 9).

To provide feedback on studying tactics for the process feedback and process-plus-corrective feedback groups, students' estimations of their use of tactics as written in the Study Tactics for Session 1 questionnaire were transposed to the Study Tactics Feedback form. By reviewing this form, participants would be informed of their reported uses of study tactics and how and why each tactic may be implemented.

Table 8

Summary of Events for Session 1 by Treatment.

Corrective Feedback	Process Feedback	Process-plus-corrective Feedback	No Feedback
Schedule of events explained.	Schedule of events explained.	Schedule of events explained.	Schedule of events explained.
Practised PrepMate (10 min.)	Practised PrepMate (10 min.)	Practised PrepMate (10 min.)	Practised PrepMate (10 min.)
Studied chapter on Lightning using PrepMate (20 min.)	Studied chapter on Lightning using PrepMate (20 min.)	Studied chapter on Lightning using PrepMate (20 min.)	Studied chapter on Lightning using PrepMate (20 min.)
Answered open-ended questions on the chapter (20 min.)	Answered open-ended questions on the chapter (20 min.)	Answered open-ended questions on the chapter (20 min.)	Answered open-ended questions on the chapter (20 min.)
Completed: 1. Study Tactics questionnaire for Session 1. 2. Ideal Response Checklist for Session 1.	Completed: 1. Study Tactics questionnaire for Session 1.	Completed: 1. Study Tactics questionnaire for Session 1. 2. Ideal Response Checklist for Session 1.	
End of Session 1.	End of Session 1.	End of Session 1.	End of Session 1.

Table 9

Sample of Corrective Feedback for the Lightning Chapter.

Question 1: Based on your understanding of the passage, please describe how lightning works.

- Discuss more of the cause and effect process starting with the cooling of moist air.
- Since this question is worth a lot of points, completing this first may have helped.
- Could use headings to organise your response to question 1.

Question 2: What are the ideal conditions for a lightning storm to develop? Justify why the conditions you have specified are important.

- Focus on the chain of events (cause and effect) that lead up to the storm conditions. When you describe your justification (outcome/why), make the links explicit.
- Note that "conditions" is plural, therefore more than one condition needs to be stated and explained.

Question 3: What does air temperature have to do with lightning?

- You're right. However there is a relationship between the different air processes that contribute to the lightning process that need to be described.
- Need to focus on how the air temperature helps create lighting conditions throughout each stage.

Question 4: Suppose you see clouds in the sky, but no lightning? Why not?

- Could extend your explanations to describe the process in more.
- Could make some references about the cause and effect process here -- extrapolate beyond the chapter and create solutions for the problem.

Questions 5: How does lightning form?

- **When they wrote, "See Q#1**: Need to focus on the final stage with reference to the travelling spark, stepped leader, and the return stroke. It's the function of these that create lightning.

Question 6: What determines the intensity of a lightning storm?

- You need to think about the elements that create the storm.
- Make more inferences based on the information in the chapter.

General

- One suggestion is to try to grasp the general concepts and then focus on specific ideas, rather than worrying about the details first.
- Could extend your explanations to describe the process in more detail.
- Generate as many responses as possible. If you indicate that you're on the right track, you may get more points.
- Could use some key terminology here, but the main ideas are here.
- You need to make inferences about the conditions and the cause and effect relationships to generate an answer. Using key concepts may help.
- Effective use of links in relation to the cause and effect sequence.

Session 2

Session 2 occurred between one to three days after Session 1. Upon arrival, researchers outlined the schedule of events for the session. Members of the no feedback group immediately began to study the chapter on pumps. The other participants received feedback appropriate to their treatment. Meanwhile, recipients of corrective feedback received ten minutes to review their previously completed test paper and the Ideal Response Checklist for Session 1. The checklist included feedback statements, grades for each question (outcome feedback), self-reported grades (to compare with the mark assigned by the examiner), and items in the checklist the researcher considered to be included in the participant's responses. Although students in this feedback condition completed the Study Tactics for Session 1 questionnaire, they did not receive feedback on their use of study tactics. Instead, the data would be used to assess calibration for study tactics.

Participants in the process feedback group received a completed Study Tactics Feedback form and ten minutes to examine the contents and to estimate how often they planned on using each studying tactic while studying the forthcoming chapter. Reported uses of each study tactic were listed in one column, thereby allowing students to reflect on past studying behaviours while estimating upcoming behaviours. Members of this feedback condition did not receive outcome feedback (their grades) for the test on lightning.

Process-plus-corrective feedback participants received ten minutes to review their test, the Ideal Response Checklist for Session 1, their marks and the Study Tactics

Feedback form and to report on their expected use of studying activities. Researchers encouraged participants to ask for clarification or discuss items. After the review period, the three treatment groups returned the documents to the researcher and began studying the pumps chapter.

Following approximately 20 minutes of studying, students closed the computer program. All participants responded to a 20-minute, six-item short answer test on pumps. Following test completion, researchers debriefed and paid the participants before they left. The corrective feedback group completed the Study Tactics for Session 2 questionnaire, the Ideal Response Checklist for Session 2, and their Final Questions before being debriefed and paid. Similarly, participants assigned to the process-plus-corrective feedback treatment responded to the same questionnaires and their version of the Final Questions. Members of the process feedback group responded to the Study Tactics for Session 2 and their Final Questions before leaving. See Table 10 for an outline of the activities in this session.

Post-session Coding

Although students did not receive feedback on Session 2 activities, their materials still needed to be coded. Thus, the two researchers independently graded student responses to the test questions on pumps. Discussion ensued until the coders reached consensus. Then, I compared each participant's response to the items on the completed Ideal Response Checklist for Session 2 and indicated items deemed to have been included by the participant.

Table 10

Summary of Events for Session 2 by Treatment.

Corrective Feedback	Process Feedback	Process-plus-corrective Feedback	No feedback
Schedule of events explained	Schedule of events explained	Schedule of events explained	Schedule of events explained
Received graded Ideal Response Checklist for Session 1.	Received Study Tactics Feedback form.	Received graded Ideal Response checklist for Session 1 **and** Study Tactics Feedback form.	
Asked to review feedback on Ideal Response Checklist for Session 1 (10 min.)	Asked to review Studying Tactics feedback and complete form (10 min.)	Asked to review and complete both documents (10 min)	
Studied chapter on Pumps (20 min.)	Studied chapter on Pumps (20 min.)	Studied chapter on Pumps (20 min.)	Studied chapter on Pumps (20 min.)
Answered open-ended questions on the chapter (20 min.)	Answered open-ended questions on the chapter (20 min.)	Answered open-ended questions on the chapter (20 min.)	Answered open-ended questions on the chapter (20 min.)
Completed 1. Study Tactics questionnaire for Session 2. 2. Ideal Response Checklist for Session 1. 3. Interview Questionnaire corrective feedback group.	Completed 1. Study Tactics questionnaire for Session 1. 2. Interview Questionnaire for process feedback group.	Completed 1. Study Tactics questionnaire for Session 2. 2. Ideal Response Checklist for Session 2. 3. Interview Questionnaire for process-plus-corrective feedback group.	
Debriefing. End of Session 2.	Debriefing. End of Session 2.	Debriefing. End of Session 2.	Debriefing. End of Session 2.

CHAPTER 4

Results

Overview of the Results

This study investigated four facets of feedback effects on: subsequent use of studying tactics, subsequent achievement, calibration for studying activities, and calibration for achievement. A fifth facet, regarding effort, also surfaced as a result of these data analyses. First, to supply some background about the participants, this chapter begins by presenting data on demographics and prior knowledge. Second, recall from the previous chapter that participants were semi-randomly assigned to the treatment groups. As a result, data from session 1, which were free of intervention effects, were used to examine differences between groups prior to treatment. Third, interrater and intrarater reliabilities for scoring the achievement tests are presented. Fourth, findings are introduced for the facets noted above. The final section presents a summary of findings. Some analyses include all 88 participants. Other analyses use only 69 participants, these being analyses that investigated the effects of feedback and, therefore, the control group was not included.

Descriptives

Demographics

Eighty-eight undergraduate university students participated in the study. The ages of the 64 women and 24 men ranged between 17 and 43 years (M=21.68, SD=4.84) Predominately in their first year at the university (n=71, 81%), participants came from various disciplines and were enrolled in 1 to 6 courses that semester (*M*=3.97, *SD*=.93). Over half of the participants (*n*=48) were English as a Second Language (ESL). The average age these students learned to speak in English was 8.18 years (*SD*=4.26) and learned to write in English was 9.38 years (*SD*=4.17).

When asked what they perceived to be the most difficult aspect(s) of studying, eighty-three students reported difficulties, while five did not. Responses were coded under 9 categories. Table 11 presents primary and secondary difficulties. Thirty-seven students did not report any secondary difficulties with studying.

When asked how many hours the students worked at a job per week, seventy-nine of them answered the question. Thirty-five of the students who responded reported that they did not work while the remaining 44 ranged from 2 to 50 hours per week (*M*=14.03, *SD*=8.87). All students responded to the question asking them to report how many hours they spent studying per week. Hours ranged from 3 to 60 (*M*=16.59, *SD*=10.95).

Table 11

Frequencies and Percentages of Reported Studying Difficulties.

Difficulty	Primary Response	Percentage	Secondary Response	Percentage
Course Materials	25	28	7	8
Focus/Motivation	15	17	7	8
Time	10	11	5	6
Procrastination/Distractions	10	11	6	7
Studying Environment	9	10	3	3
Memory	6	7	1	1
Knowing Exam Content	4	5	5	6
Studying Behaviour	2	2	3	3
ESL	2	2	0	0
None reported	5	6	0	0

Prior Knowledge

Participants also answered questions about their knowledge of science, weather systems, and household mechanics. Participants reported completing from 1 to 4 (M=2.52, SD=.92) high school science courses and from 0 to 5 (M=1.18, SD=1.37) college science courses. General science knowledge, indicated by the total number of science courses reportedly taken, was also calculated. The number of courses ranged from 1 to 9 (M= 3.70, SD=1.86).

To assess prior knowledge of weather systems, students responded to 7 dichotomously scored questions (*M*=1.82 questions, *SD*=2.00). Thirty-one students reported no knowledge of weather systems while 38 indicated some knowledge by answering 1 to 3 questions. The remaining 17 participants had high knowledge of weather systems, answering 5 to 7 questions. Figure 4 illustrates responses to prior knowledge items for weather phenomena.

Forty participants demonstrated no knowledge about household mechanics while 41 indicated little knowledge by answering 1 to 3 questions. Only seven students indicated a high knowledge of household mechanics by answering 4 to 6 questions. Responses averaged 1.13 items (*SD*=1.35). Responses to prior knowledge items for household mechanics are shown in Figure 5.

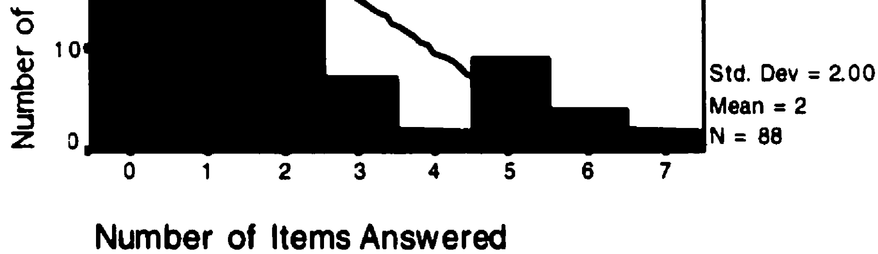

Figure 4. Distribution of prior knowledge of weather phenomenon.

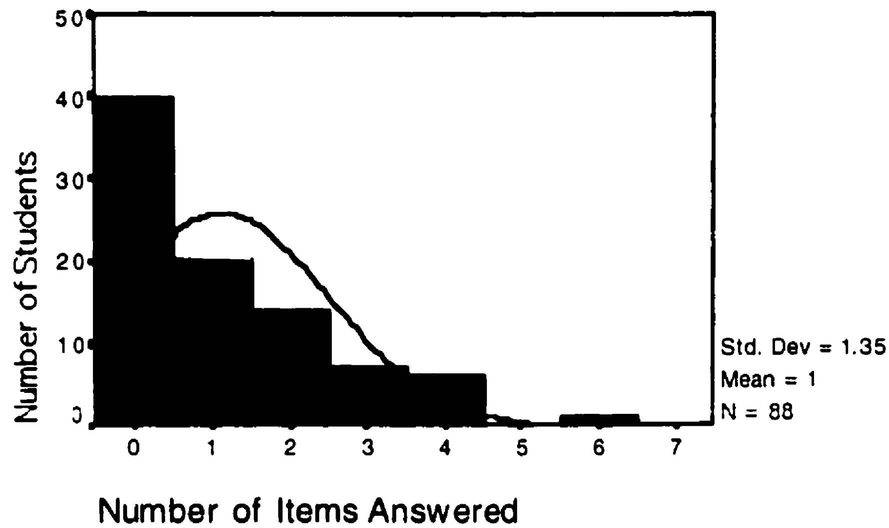

Figure 5. Distribution of prior knowledge of household mechanics.

Addressing the Semi-random Assignment of Participants to Groups

As stated in Chapter 3, participants were mainly assigned to the corrective feedback and process-plus-corrective feedback groups during the first week of the study, while participants were mainly assigned to the process feedback and no feedback groups during the second week. To address the possibility that samples differed between the two weeks, a dichotomous condition variable was created to contrast corrective feedback and process-plus-corrective feedback recipients versus process feedback and no feedback recipients.

A MANOVA examined differences between these two groups on: test grade for session 1, general science background, prior knowledge of weather, prior knowledge of pumps, age, number of credits enrolled in at the time of the study, actual use of low-order study tactics, actual use of high-order study tactics, participants' reported test effort in session 1, and participants' reported study effort in session 1. Group assignment effects were not statistically significant, Pillais Trace exact $F(1,81)=1.41$, $p=.19$, effect size=.17.

However, univariate tests indicated that the two groups did differ in their scores on the test on lightning, $F(1,80)=9.75$, $p=.002$. Anecdotal observations by the researcher also suggested that there might be differences between samples over the two weeks. Subjects in the first week appeared to be more enthusiastic and interested in the study while those in the second week seemed to lack enthusiasm and were more interested in completing the study for financial remuneration. Due to these observations and the statistically significant finding of differences in scores in session 1, an explanation for the differences was pursued.

Correlations were examined between the dichotomous condition variable, reported studying effort in sessions 1 and 2, reported test effort in sessions 1 and 2, grade in session 1, prior knowledge of weather, prior knowledge of pumps, general science knowledge, actual use of low-order tactics, and actual use of high-order tactics. Results indicated a statistically significant correlation between students' scores on the lightning test and three other variables: studying effort in session 1 ($r=.32$, $p=.003$), test effort in session 1 ($r=.35$, $p=.001$), and prior knowledge of weather ($r=.23$, $p=.03$). After examining the correlations, the question of why there was a statistically significant difference in grade between groups remained. At this point, I must digress to explain how examining the correlations resulted in the creation of new variables. These variables are used in all analyses hereafter.

Exploring the Effort Variables: Are they the Same or Different?

Recall that students were asked to report their effort during studying and effort applied during test-taking in both sessions. Correlations revealed a very strong relationship between study and test efforts in session 1 (r=.63, p<.001), and between study and test efforts in session 2 (r=.70, p<.001). All four variables were also correlated with each other ($r \geq .47$, p<.001). This suggested that perceived studying and test effort may actually be the same and that reported effort might be relatively stable. To investigate this, further analyses were performed.

Three factor analyses were computed. The first investigated whether studying and test effort in both sessions 1 and 2 were the same. This analysis indicated one factor that would account for 68% of the variance among all four measures of effort. Variables had rather modest loading on the solo factor (.30 to .31), leaving it ambiguous whether the four effort measures were unifactorial. Therefore, two more factor analyses were computed. The first examined studying and test effort in session 1 while the second investigated session 2. In both analyses one factor accounted for much of the variance: 81% for Session 1 and 85% for session 2. Each variable had moderate loading on the factor (.55 and .54)

The two types of effort variables seem to be the same within each session. As a result, for each session's data, study effort scores were added to test effort scores, thereby creating two new overall effort variables: effort in session 1 and effort in session 2. A paired t-test was performed to investigate whether the means for these two variables were different, and they were; M=13.41 for session 1, M=15.58 for session 2,

$t(87) = -7.48$, $p<.001$. Thus, a decision was made not to use an all-encompassing effort variable in further analyses.

Exploring Differences between Groups Prior to Treatment

After making decisions about the effort variables, the question about what to do about differences between groups was once again pursued. A MANOVA was performed to investigate a group of variables obtained from the first session—grade, use of both types of study tactics, general science and specific weather knowledge, and effort—which may account for differences between the four groups prior to treatment. This analysis used the four condition groups and was more refined than the initial exploratory MANOVA previously reported. It included variables that were statistically significantly correlated with the achievement score in session 1 and variables that had theoretical merit, such as general knowledge. The multivariate analysis indicated that group assignment effects were not statistically significant, Pillais Trace $F(1,82)=1.33$, $p=.18$, effect size=.08, but univariate tests indicated that the four treatment groups did differ in their scores on one variable — the achievement test on lightning, $F(3,79)=3.11$, $p=.03$. Additional analyses were performed to further examine the significant difference found in the univariate tests, however results were still unclear (see Appendix Q). As a result, it was deemed that the statistically significant univariate finding may have been the result of Type I error rather than a result of the semi-random sampling. Thus, to avoid capitalising on the Type I error, the multivariate result was taken into account and groups were treated as being equal in the first session for all analyses hereafter.

Interrater and Intrarater Reliability

A colleague and I independently assigned a grade to each student's response to the six questions for each session's achievement test and these were correlated to examine the consistency between coders. Interrater reliability was measured using a Pearson correlation (see Table 12). After grading each question independently, the two coders discussed the scores until consensus was met about the final grade. The final grades were then correlated with each researcher's initial score. Interrater reliability indicated the degree of consistency between the initial and final scores assigned by the coders. Table 12 provides the interrater reliability for each coder and each question for both achievement tests.

Table 12

Interrater and Intrarater Reliabilities for Each Achievement Test Question.

		Question						
		1	2	3	4	5	6	Entire Test
Session 1								
	Interrater	.89	.70	.69	.75	.81	.76	.89
	Intrarater 1	.95	.82	.83	.86	.92	.85	.95
	Intrarater 2	.94	.89	.85	.93	.89	.92	.95
Session 2								
	Interrater	.76	.58	.75	.89	.59	.74	.84
	Intrarater 1	.86	.75	.84	.88	.70	.85	.91
	Intrarater 2	.90	.79	.89	.94	.93	.89	.94

* $p<.001$

The Research Facets

The Effect of Feedback on Subsequent Studying: Research Facet 1

Low-order Study Tactics: Between Groups Effects

Examining the Data

Prior to performing a multiple regression analysis on the use of low-order study tactics in session 2, assumptions were tested. The standardised scatterplot of the predicted values and the residuals, as seen in Figure 6, shows a normal distribution for low-order tactic use. A normal P-P plot of the predicted and residual values for low - order tactics (Figure 7) shows that the distribution was homoscedastic and no multivariate outliers were present. With the use of $p<.001$ yielding a critical value of $x^2=10.83$ for the Mahalanobis Distance, no outliers among the cases were found.

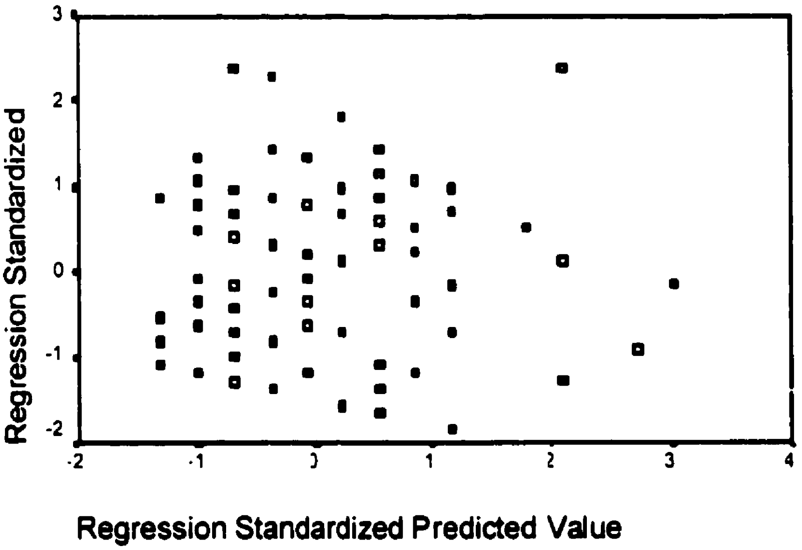

Figure 6. Distribution of residual scores on low-order study tactics.

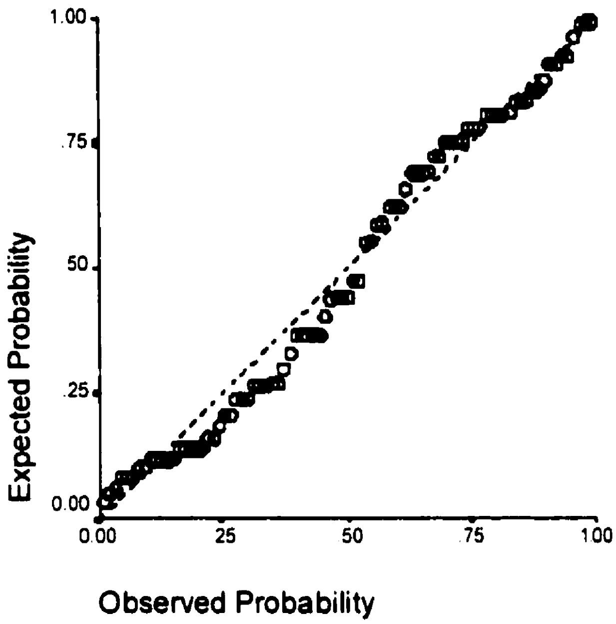

Figure 7. P-P Plot of the regression solution for low-order study tactics.

Multiple Regression Analysis

The regression examined whether the feedback students received contributed to differential use of low-order study tactics in session 2 after accounting for the effects of general science knowledge, prior low-order tactic use, effort in session 2 and prior knowledge about pumps. Three blocks of independent variables included: first, general science knowledge and low-order tactic use in session 1; second, reported effort in session two and prior knowledge of pumps; and third, feedback treatment using dummy coding comparing each feedback treatment group to the control group.

P-values of .10 and .15 were used to determine when variables were entered or removed in the model, respectively. Given these parameters, the only variable to enter the model was low-order tactic use in session 1, β=.29, $t(82)=2.72, p<.001$. Eight percent of the variance in session 2 low-order tactic use was accounted for after the sole predictor entered the regression model (R^2=.08) and R was statistically different from 0, $F(1, 82)=7.41$, $p=.008$. After accounting for the variance of this lone predictor, feedback treatment had no affect on low-order study tactic use in session 2.

Low-order Study Tactics: Within Groups Effects

A one-way MANOVA with feedback condition as a between-subjects factor examined change in the use of low-order study tactics from session 1 to session 2. No statistically significant changes in low-order study tactic use within the four groups were found as indicated by the session by condition interaction. $F(3, 81)=.50$, $p=.68$. Therefore, further investigation of feedback effects was not warranted.

High-order Study Tactics: Between Groups Effects

Examining the Data

Prior to performing a multiple regression analysis on the use of high-order study tactics in session 2, assumptions were tested. The standardised scatterplot of the predicted values and the residuals, as seen in Figure 8, shows a normal distribution for high-order tactic use. A normal P-P plot of the predicted and residual values for high-order tactics (Figure 9) shows that the distribution was homoscedastic and no multivariate outliers were present. With the use of $p<.001$ yielding a critical value of $x^2=13.82$ for the Mahalanobis Distance, no outliers among the cases were found.

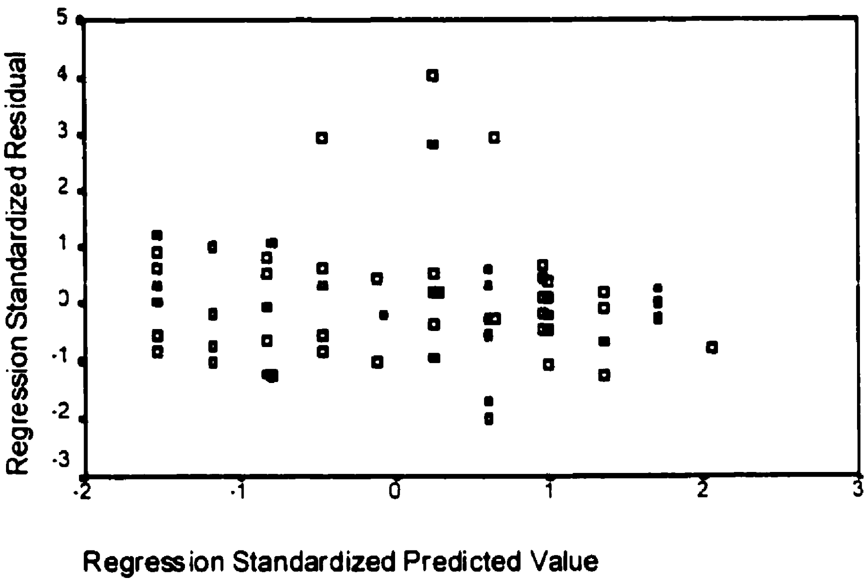

Figure 8. Distribution of residual scores on high-order study tactics.

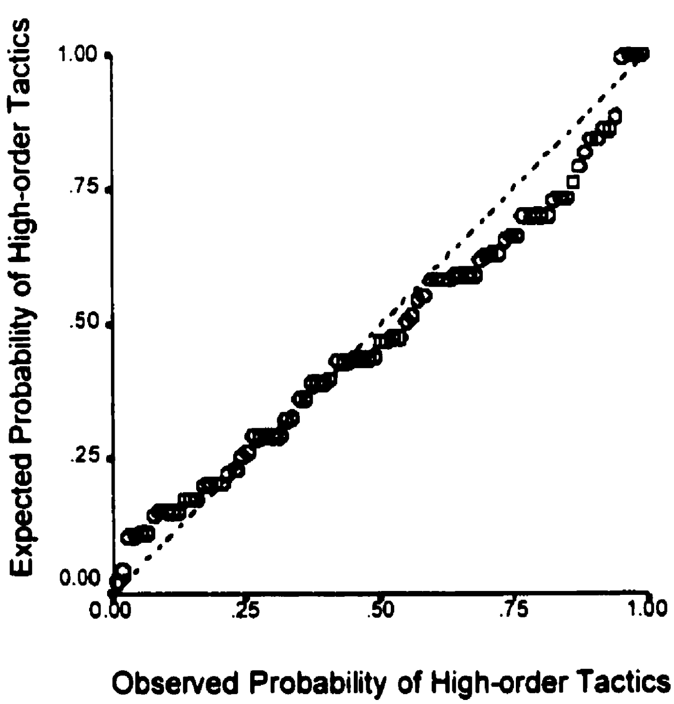

Figure 9. P-P Plot of the regression solution for high-order study tactics

Multiple Regression Analysis

The regression examined whether the feedback students received contributed to differential use of high-order study tactics in session 2 after accounting for the effects of general science background, use of high-order tactics in session 1, effort in session 2 and prior knowledge about pumps. Three blocks of independent variables included: first, use of high-order study tactics and general science background; second, effort in session 2 and pumps prior knowledge; and third, feedback treatment. Twenty-three percent of the variance was accounted for by the regression model (R^2=.23) and R was statistically different from 0, $F(2, 83)$=.36, p<.001 (see Table 13).

Specifically, p-values of .10 and .15 were used to determine when variables were entered or removed in the model. Given these parameters, high-order study tactics use in session 1 entered into the model in step 1, β=.46, $t(82)$=4.63, p<.001 and accounted for 21% of the variance. Effort and prior knowledge in block 2 above did not enter the model. High-order tactics continued to remain in the model in step 2 when a dummy coded term contrasting process-plus-corrective feedback to the control group entered and added 2% to the variance, β=.17, $t(82)$=1.66, p=.10. The analysis indicated that, after accounting for the variance of high-order study tactic use in session 1, process-plus-corrective feedback elevated the use of high-order study tactics in session 2 relative to the control group that received no feedback.

Table 13

Regression Table for Predicted Use of High-order Study Tactics in Session 2.

Step		b	β	incre R^2	t	cum R^2	F
1	High-order Tactics Use in Session 1	.72	.46	.21	4.63, *p*<.001	.04	21.41, *p*<.001
2	High-order Tactics Use in Session 1	.67	.42		4.23, *p*<.001		
	Process-plus-Corrective Feedback	1.40	.17	.02	1.66, *p*=.10	.23	13.32, *p*<.001

High-order Study Tactics: Within Groups Effects

Change in the use of high-order study tactics from session 1 to session 2 was examined through a one-way MANOVA with feedback condition as a between-subjects factor. Findings indicated no statistically significant differences in high-order study tactic use within the four groups, as indicated by the session by condition interaction, $F(3, 81)=2.00$, $p=.12$. Therefore, subsequent examination of change was not justified.

Reported Effects of Feedback on Studying

Corrective Feedback and Studying

At the end of the second session, the process-plus-corrective feedback and corrective feedback groups received open-ended questions asking them to indicate whether feedback affected their studying in the second session and then why it did. Responses were coded across several dimensions into mutually exclusive categories. Percentages for the students' answers are presented.

How much did corrective feedback affect studying?

The forty-eight recipients of corrective or process-plus-corrective feedback responded to how much the "ideal response" feedback influenced their approach to studying the chapter on pumps. Responses ranged from 0 (no influence at all) to 10 (complete influence). Students reported that corrective feedback moderately affected their approach to studying (M=5.22, SD=2.50).

How did corrective feedback affect studying?

When asked how their studying changed due to the feedback, 40 of the 48 recipients of corrective feedback responded. The eight who did not respond either chose not to answer the question or indicated previously that the feedback had no effect on their studying. Twenty-one respondents (53%) acknowledged that they changed their approach to studying in the second session by using study strategies and tactics learned about or not previously considered in the first session. Fourteen other students (35%) reported that they changed their approach by using the suggestions presented in the feedback they received. For example, students said they looked more closely at details, realised answers could be stated in a general manner, considered cause and effect relationships, and focused on key concepts. Four other participants (10%) commented that their change was due to prior test experience where they gained a better idea of what to study, and one student (3%) felt more encouraged due to his test score.

Why did corrective feedback affect or not affect studying?

Seven categories were derived from the explanations given by 43 respondents concerning why the "ideal response" feedback lead them to change (or not) their approach to studying the second chapter. Thirteen students (30%) noted that the feedback provided information applicable to the next test, while 12 other students (28%) reported that the feedback prompted a desire to improve their performance in the second session. Other responses were that students wanted to remember or gain a better understanding of the material (n=6, 14%) and strategy and tactic use could improve studying or make studying easier (n=6, 14%). For three students (7%), the feedback generated feelings that were applicable to the next session (i.e., they felt encouraged by the marks, their grades led to increased confidence, or they achieved better performance than they had expected). One student (2%) just wanted to give the feedback a try, while it did not occur to two participants (5%) to change their approach to studying.

Process Feedback and Studying

How much did process feedback affect studying?

At the end of the second session, the process-plus-corrective feedback and process feedback groups answered questions about the effect of process feedback on their studying. Forty-seven participants responded to how much the "studying tactics" feedback they received influenced their approach to studying the chapter on pumps. Responses ranged from 0 (no influence at all) to 10 (complete influence). Process feedback was reported to moderately influence students' approach to studying (M=5.75, SD=2.49).

How did Process Feedback Affect Studying?

When asked how their studying changed due the "studying tactics" feedback, 39 of 47 students responded. The eight participants who did not respond either chose not to answer the question or reported in the previous question that the feedback had no influence on their studying. Thirty-six students (92% of respondents) used study strategies and tactics learned about or not previously considered in the first session. Three students (8%) changed their studying by using their prior knowledge about the format of test questions.

Why did Process Feedback Affect or not Affect Studying?

Seven categories were derived from the reasons participants gave for why the "studying tactics" feedback changed (or not) their approach to studying the chapter on pumps. Forty mutually exclusive responses were coded. Thirteen participants (33% of respondents) felt that paying attention to the feedback may improve studying or may make studying easier or more efficient. Nine other students (23%) stated that the feedback informed them of study strategies and tactics not known or not used before. Eight other participants (20%) believed that their understanding and recall of the material during a test would improve due to the feedback. Five students (13%) gave other reasons for why the feedback affected studying. Two categories were created for explanations to why the feedback did not have an effect on studying: three students (8%) claimed that there was no reason for them to change while two students (5%) acknowledged that time constraints prevented them from implementing new study strategies and tactics.

The Effect of Feedback on Subsequent Achievement: Research Facet 2

Between Groups Effects

Examining the Data

Before performing a multiple regression analysis predicting achievement in session 2, assumptions were tested. The standardised scatterplot of the predicted values and the residuals test scores as seen in Figure 10 shows a normal distribution. Figure 11 displays the P-P plot for the distribution of observed probability against expected probability. Distribution appeared to be normal and no multivariate outliers were present as points reside near the normal distribution line. Using Mahalanobis Distance, a critical value of x^2=16.27, p=<.001 also indicated there were no multivariate outliers.

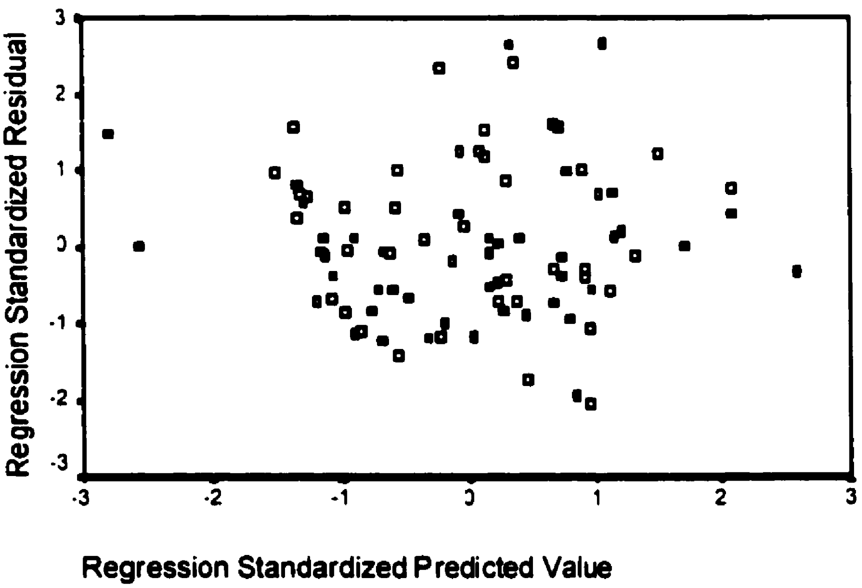

Figure 10. Distribution of residual scores on the pumps achievement test.

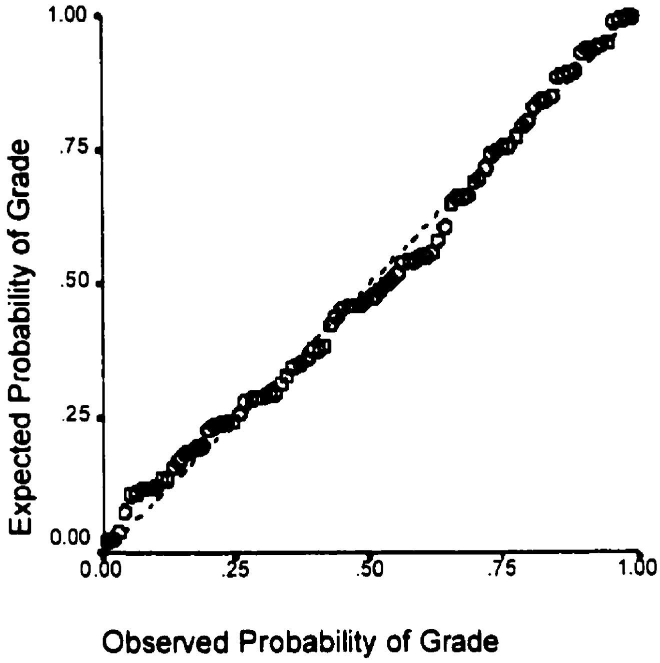

Figure 11. P-P plot of the regression solution for the pumps test scores.

Multiple Regression Analysis

The regression examined whether the feedback students received contributed to differential scores on the second achievement test after accounting for the effects of the general science knowledge and grade in session 1, reported effort in session 2 and prior knowledge about pumps. Three blocks of predictors included: first, session 1's grade and general science knowledge; second, reported effort in session 2 and prior knowledge of pumps; and third, feedback treatment. To examine feedback effects, the three dichotomous dummy variables that were created and used in previous regression analyses were used.

Using p-values of .10 and .15 as entry and removal parameters, grade in session 1 was the only predictor added in the first step; β=.57, $t(82)$=6.62, p<.001, accounting for

35% of the variance; R^2=.35, $F(1, 82)$=43.82, p<.001. In the second step, reported effort in session 2 was entered, adding 2% to the variance; β=.21, $t(82)$=2.31, p=.02. At the final step of the equation, 39% of the total variance was accounted for by the addition of the dummy variable contrasting process-plus-corrective feedback treatment to the control group; β=.17, $t(82)$=1.95, p<.001; R^2=.39, $F(3, 82)$=19.02, p<.001 (see Table 14).

Table 14

Regression Table for Predicted Achievement in Session 2

Step		b	β	incre R^2	t	cum R^2	F
1	Grade in Session 1	.57	.59	.35	6.62, p<.001	.35	43.82, p<.001
2	Grade in Session 1	.53	.54		6.06, p<.001		
	Effort in Session 2	.43	.21	.02	2.31, p=.02	.37	25.76, p<.001
3	Grade in Session 1	.49	.51		5.64, p<.001		
	Effort in Session 2	.44	.21		2.37, p=.02		
	Process-plus-Corrective Feedback	2.23	.17	.02	1.95, p=.05	.39	19.02, p<.001

Within Groups Effects

A one-way MANOVA within feedback condition as a between-subjects factor examined change in grade from session 1 to session 2. Results suggested that there were no statistically significant changes in achievement within the four groups, as indicated by the session by condition interaction, $F(3, 84)=.07$, $p=.97$. As a result, further investigation of feedback effects was not warranted.

Reported Effects of Feedback on Test-taking

Corrective Feedback and Test-taking

How much did Corrective Feedback Affect Test-taking?

In response to the question of how much the "ideal response" feedback influenced participants' approach to taking the test on pumps, 48 of the corrective feedback recipients (process-plus-corrective feedback and corrective feedback groups) responded. Responses ranged from 0 (no influence at all) to 10 (complete influence). Corrective feedback was reported to moderately affect students' approach to test-taking ($M=4.10$, $SD=3.03$).

How did Corrective Feedback Affect Test-taking?

Thirty students answered the question concerning how the "ideal response" feedback influenced their approach to test-taking. Eighteen other participants chose not to respond to the question or reported in the previous question that the feedback had no effect on their test-taking. Twenty-two students (73% of respondents) reported that they used the suggestions on how to answer the test questions, while eight (27%) used study strategies and tactics they learned about or did not previously consider in the first session.

Why did Corrective Feedback Affect or not Affect Test-taking?

Five mutually exclusive categories were created for the explanations from 38 respondents concerning why the "ideal response" feedback led them to change (or not) their approach to test-taking in the second session. Twelve students (32% of respondents) considered their first test scores: either the feedback provided information upon which to improve performance in the second session or students were not concerned with their marks. Ten participants (26%) felt that the feedback provided suggestions applicable to the next test. Six students (16%) stated that the feedback helped them to improve their studying such as by changing their approach or concentrating more. Several respondents felt that the feedback did not have any effect on their test-taking. Eight students (21%) believed that there was no reason to change their test-taking because tests are always the same; studying is the key to understanding and recall, so test-taking techniques do not matter; or it never occurred to the student to change. Two respondents (5%) remarked that the feedback did not indicate a need for improvement or suggest new test-taking methods.

Process Feedback and Test-taking

How much did Process Feedback Affect Test-taking?

All of the forty-seven recipients of process feedback (process-plus-corrective feedback and process feedback groups) responded to how much the "studying tactics" feedback they received influenced their approach to taking the test on pumps. Responses ranged from 0 (no influence at all) to 10 (complete influence), with 19 (40% of respondents) reporting that the feedback had no effect on test-taking. Process feedback was reported to have a small effect on students' approach to test-taking (M=3.28, SD=3.39).

How did Process Feedback Affect Test-taking?

Twenty-three of the respondents answered the question concerning how the "study tactics" feedback influenced their test-taking behaviour. The twenty-four process feedback recipients who did not answer the question either chose not to oı reported in the previous question that the feedback had no effect on test-taking. All respondents indicated they used study strategies and tactics learned about or not previously used in the first session. These strategies and tactics helped participants to prepare for and to think about the test.

Why did Process Feedback Affect or not Affect Test-taking?

Seven predominant reasons were coded for the question concerning why the "studying tactics" feedback led students to change their approach to test-taking and two categories were derived as reasons for why change did not occur. Forty-two students responded. Several students believed that paying attention to the feedback could help them to improve: understanding, learning and remembering the information (n=8, 19% of respondents); performance (n=5, 12%), studying (n=2, 5%), and focus or concentration (n=2, 5%). Change occurred for four participants (10%) because they viewed the test to be indirectly affected by changes in studying. Three students (7%) indicated that their previous experience (e.g., disappointment with lack of study skills, knowing what to expect) led to change. Three participants (7%) claimed that the feedback provided information applicable to the next test. Unexpectedly, 11 (26%) responses indicated that test-taking behaviour did not change because there was nothing wrong with their test-taking approach or because test-taking is invariable. The remaining four students (10%) felt that there was no relevant relationship between studying and test-taking, or were more focused with the test than using tactics or felt that there was not any feedback about the test.

Calibration for Studying Activities: Research Facet 3

Two kinds of study tactic data were obtained from the research: actual use of study tactics and self-reported postdictions about study tactic use. Actual tactic use was derived from the trace data in the PrepMate log files while postdicted use was acquired from the Study Tactics questionnaire administered after studying. In addition, both types of data on study tactics were categorised as low- or high-level based on types of cognitive processing they traced. Highlighting and copying a part of the text were combined to create a lower-order tactics variable. Instances where students made a note using their own words, created a mnemonic, generated questions, created an analogy, and made examples were summed to create the higher-order tactics variable. Similarly, self-report items on the questionnaire matched to those trace variables were grouped to create low- and high-order subscales. Since the no feedback group was not asked to make postdictions concerning their use of study tactics, n=69 for all analyses under this facet unless otherwise stated.

Overall Findings

Calibration for study tactic use was measured using correlations. Moderate calibration was found between students' actual and recalled use of low-order study tactics as observed in the correlations for session 1; r=.61 (n=65), p<.01. Moderate calibration was also observed between participants' actual and recalled use of high-order study tactics for session 1; r=.65 (n=66) p<.01.

Table 15 displays two additional measures of calibration adapted from Schraw et al. (1993). Mean bias was used to ascertain the direction of judgement error. It was calculated as the signed difference of frequency of tactic use compared to self-report about frequency of tactic use. A negative number indicates underestimation, while a positive number denotes overestimation. Overall, students overestimated their use of low- and high-order study tactics by 18% and 1%, respectively. Mean accuracy consisted of the absolute value of the mean bias. It was used to assess the magnitude of judgement error irrespective of under- or overestimation. Students were less accurate in their calibration for low-order tactic use with a 19% magnitude of judgement error versus a 6% magnitude for high-order tactic use.

Feedback Effects

Feedback effects on calibration for studying tactics were examined in the data from the second session. Correlations for postdictions and actual use of low-and high-order tactics by treatment are presented in Table 16. For purely exploratory purposes, Fisher z-tests were computed to probe for calibration differences within each treatment group,. Using a two-tailed $z=\pm2.58$, p<.01, there did not appear to be any significant differences in calibration across sessions within each feedback group (see Table 17). Caution is necessary in interpreting these data because these are dependent correlations and the *z*-test does not take that dependency into account.

Table 15

Descriptives for Actual and Reported Use of Study Tactics, Bias, and Accuracy Scores for Session 1 (pre-treatment).

	n	*Mean*	*SD*
Low Tactics			
Actual Use	66	4.15	2.84
Reported Use	68	6.56	3.63
Bias	65	2.45 (18%)	3.00
Accuracy	65	2.66 (19%)	2.81
High Tactics			
Actual Use	66	3.71	2.50
Reported Use	69	3.99	3.77
Bias	66	.44 (1%)	2.87
Accuracy	66	2.02 (6%)	2.08

Note: The scale for actual and reported tactics use is 14 for low-order tactics and 35 for high-order tactics. Bias scores for range from -14 to 14 for low-order tactics and –35 to 35 for high-order tactics. Accuracy scores range from 0 to 14 for low-order tactics and 0 to 35 for high-order tactics.

Table 16

Correlations of Postdictions and Actual Studying Tactics Use by Feedback Condition Group.

	Corrective Feedback		Process Feedback		Process-plus-Corrective Feedback	
Session 1	*n*	*r*	*n*	*r*	*n*	*r*
Low-order Tactics	20	.75**	20	.55*	26	.50**
High-order Tactics	20	.78**	21	.76**	25	.40*
Session 2						
Low-order Tactics	22	.42	21	.36	26	.80**
High-order Tactics	22	.90**	21	.47*	25	.53**

** $p < .01$ (2-tailed) * $p < .05$ (2-tailed)

Table 17

Fisher z-tests for Calibration of Studying Tactics Use by Feedback Group.

	Corrective Feedback	Process Feedback	Process-plus-Corrective Feedback
Low-order Tactics: Session 1 vs. 2	1.70	.77	-1.98
High-order Tactics: Session 1 vs. 2	-1.38	1.58	-.59

To test for calibration differences between each treatment group, Fisher *z*-tests were computed for calibration of low-and high-order study tactics. Using a two-tailed $z=\pm2.58$, $p<.01$, results indicated significant differences in calibration between feedback groups (see Table 18). Specifically, there were significant differences between the corrective feedback group and each of the two other feedback groups. In the second session, corrective feedback recipients were better calibrated in their use of high-order study tactics than the process feedback group and the process-plus corrective group.

Table 18

Fisher z-tests to Compare Calibration of Studying Tactics Use by Feedback Group.

	Corrective vs. Process	Corrective vs. Process-plus-Corrective	Process vs. Process-plus-Corrective
Session 1			
Low-order Tactics	1.12	1.42	.23
High-order Tactics	.16	2.07	1.93
Session 2			
Low-order Tactics	.23	-2.25	-2.43
High-order Tactics	3.15*	3.02*	-.27

* two-tailed, $z=\pm 2.58$, p<.01

Actual and reported use of low-order tactics, bias, and accuracy scores and confidence intervals are reported in Table 19 for each treatment group. A MANOVA examined within group differences for bias on low-order study tactic use between sessions 1 and 2. A statistically significant difference was detected for within group differences on bias; $F(2, 62)=3.28, p=.04$. Based on three follow-up paired t-tests, process-plus-corrective feedback statistically significantly decreased in bias from sessions 1 to 2; $t(24)=-2.77, p=01$. Generally, the three feedback groups overestimated their reported lower-order study tactic use when compared to their actual use. Bias ranged from 11 to 21%. A second MANOVA indicated no statistically significant change in the accuracy (magnitude of judgement) within treatment groups; $F(2, 62)=1.32, p=.27$. Judgement error for the groups ranged from 12 to 23%.

Table 19

Descriptives for Actual and Reported Use of Low-order Study Tactics, Bias, and Accuracy Scores by Condition Group.

	Session 1					Session 2				
	n	*Mean*	*SD*	*Lower CI*	*Upper CI*	*n*	*Mean*	*SD*	*Lower CI*	*Upper CI*
Corrective F/B										
Actual Use	20	4.10	2.92	2.73	5.47	22	5.05	3.70	3.41	6.68
Reported Use	22	7.05	3.87	5.33	8.76	22	6.77	4.71	4.68	8.86
Bias	20	2.95 (21%)	2.70	1.68	4.22	22	1.73 (11%)	4.61	-.32	3.77
Accuracy	20	3.15 (23%)	2.46	2.00	4.30	22	3.18 (20%)	3.71	1.54	4.83
Process F/B										
Actual Use	21	3.86	2.65	2.65	5.06	21	5.71	3.08	4.31	7.12
Reported Use	20	5.85	2.83	4.52	7.18	21	8.86	4.33	6.89	10.83
Bias	20	2.20 (16%)	2.57	1.00	3.40	21	3.14 (20%)	4.33	1.17	5.11
Accuracy	20	2.30 (16%)	2.47	1.14	3.46	21	3.33 (21%)	4.18	1.43	5.23
Process-plus-Corrective F/B										
Actual Use	25	4.44	3.20	5.68	3.00	26	5.62	4.21	3.92	7.31
Reported Use	26	6.69	3.99	5.08	8.30	26	5.85	4.12	4.18	7.51
Bias	25	2.24 (16%)	3.56	.77	3.71	26	.23* (1%)	2.66	-.84	1.30
Accuracy	25	2.56 (18%)	3.33	1.19	3.93	26	1.85 (12%)	1.89	1.08	2.61

Note: The scale for low-order tactics use is 14 for session 1 and 16 for session 2. Bias scores for session 1 range from -14 to 14, and from -16 to 16 for session 2. Accuracy scores range from 0 to 14 for session 1 and 0 to 16 for session 2.

Table 20

Descriptives for Actual and Reported Use of High-order Study Tactics, Bias, and Accuracy Scores by Condition Group.

	Session 1					Session 2				
	n	*Mean*	*SD*	*Lower CI*	*Upper CI*	*n*	*Mean*	*SD*	*Lower CI*	*Upper CI*
Corrective F/B										
Actual Use	20	3.65	2.30	2.57	4.73	22	5.86	5.03	3.63	8.09
Reported Use	22	3.32	3.73	1.66	4.97	22	8.14	8.71	4.28	12.00
Bias	20	-.01 (0%)	2.48	-1.21	1.11	22	2.27 (6%)	4.72	.18	4.37
Accuracy	20	3.55 (10%)	3.81	1.85	5.24	22	1.75 (4%)	1.71	.95	2.55
Process F/B										
Actual Use	21	2.86	2.74	1.61	4.11	21	5.24	3.02	3.87	6.61
Reported Use	21	3.52	3.78	1.80	5.24	21	8.10	5.37	5.65	10.54
Bias	21	.67 (2%)	2.48	-.46	1.79	21	2.86 (7%)	4.75	.70	5.02
Accuracy	21	3.43 (10%)	4.33	1.46	5.40	21	1.62 (4%)	1.96	.73	2.51
Process-plus-Corrective F/B										
Actual Use	25	4.48	2.28	3.54	5.42	26	7.23	2.89	6.06	8.40
Reported Use	26	4.92	3.75	3.41	6.44	26	11.73	7.47	8.71	14.75
Bias	25	.64 (2%)	3.47	-.79	2.07	26	4.50 (11%)	6.53	1.86	7.14
Accuracy	25	5.50 (16%)	5.67	3.21	7.79	26	2.56 (6%)	2.38	1.58	3.54

Note: The scale for actual and reported high-order tactics use is 35 for session 1 and 40 for session 2. Bias scores for session 1 range from -35 to 35, and from -40 to 40 for session 2. Accuracy scores range from 0 to 35 for session 1 and 0 to 40 for session 2.

Table 20 displays the confidence intervals, bias, accuracy, actual and reported scores for high-order tactic use. A MANOVA examined within group differences for bias scores for high-order study tactic use between sessions 1 and 2. No statistically significant differences were found on bias; $F(2, 63)=.66, p=.52$. Students were fairly accurate in their calibration for high-order tactic use with overestimation ranging from 0 to 11 percent. A second MANOVA examined within group differences for magnitude of judgement error. No change in accuracy scores was observed; $F(2, 63)=.69, p=.51$. Judgement error for the groups ranged from 4 to 16%.

Calibration for Achievement: Research Facet 4

Overall Findings

After each test question, students were asked to predict their grade. A postdicted test score was calculated from the sum of these predictions. The maximum score for a test was 40. Pearson correlations were used to examine calibration of achievement for all participants in the study. Results suggest moderate calibration between students' estimates and actual scores on the lightning test in session 1; $r=.63$ ($n=81$), $p<.01$.

Mean bias and accuracy measures of calibration for achievement are displayed in Table 21. Students generally overestimated their scores by 5% and their magnitude of judgement error was 12%.

Table 21

Descriptives for Actual and Postdicted Achievement, Bias, and Accuracy Scores for Session 1 (pre-treatment).

	n	*Mean*	*SD*
Actual Achievement	88	17.57	6.09
Reported Achievement	81	19.56	6.85
Bias	81	2.13 (5%)	5.64
Accuracy	81	4.96 (12%)	3.40

Note: Achievement scores are reported out of 40. Bias scores range from -40 to 40. Accuracy scores range from 0 to 40.

Feedback Effects

Feedback effects on calibration for achievement were examined in the data from the second session. Correlations for postdictions and actual score on the achievement test are presented in Table 22 for each condition group. Due to the dependent nature of the correlations, Fisher's *z*-tests were used for purely exploratory purposes to probe for calibration differences within each of the feedback groups. Using a two-tailed $z = \pm 2.58$, $p < .01$, there did not appear to be any significant differences in calibration. The *z*-scores were: .43 for corrective feedback, -.51 for process feedback, and -.31 for process-plus-corrective feedback.

Table 22

Correlations of Postdictions and Actual Achievement Scores by Feedback Condition Group.

	Corrective Feedback		Process Feedback		Process-plus-corrective Feedback	
	n	*r*	*n*	*r*	*n*	*r*
Session 1	19	.65**	20	.45*	23	.72**
Session 2	17	.56*	20	.57**	25	.56*

** $p < .01$ (2-tailed) * $p < .05$ (2-tailed)

Fisher *z*-tests were also computed to test for differences between each treatment group on achievement. Each test compared the Fisher's *z*-scores of two feedback groups. Using a two-tailed $z=\pm2.58$, p<.01, results did not indicate any significant differences in calibration between feedback groups (see Table 23).

Table 23

Fisher z-tests for Calibration of Achievement Scores by Feedback Group.

	Corrective vs. Process	Corrective vs. Process-plus-Corrective	Process vs. Process-plus-Corrective
Session 1	.91	-.43	-1.38
Session 2	-.04	-1.16	-1.16

Table 24

Descriptives for Actual and Postdicted Achievement, Bias, and Accuracy Scores by Treatment Group.

	Session 1					Session 2				
	n	*Mean*	*SD*	*Lower CI*	*Upper CI*	*n*	*Mean*	*SD*	*Lower CI*	*Upper CI*
Corrective F/B										
Actual Ach.	22	19.34	5.26	17.01	21.67	22	19.77	5.68	17.26	22.29
Reported Ach.	19	18.26	7.96	14.42	22.10	17	19.88	6.50	16.54	23.23
Bias	19	-.84 (-2%)	6.09	-3.78	2.09	17	-.35 (-1%)	5.92	-3.39	2.69
Accuracy	19	5.37 (13%)	2.72	4.06	6.68	17	5.00 (13%)	2.93	3.50	6.50
Process Feedback F/B										
Actual Ach.	21	15.79	4.73	13.63	17.94	21	16.26	5.93	13.56	18.96
Reported Ach.	20	22.55	4.68	20.36	24.74	20	25.15	5.01	22.80	27.50
Bias	20	6.95 (17%)	4.98	4.62	9.28	20	8.78 (22%)	5.23	6.33	11.22
Accuracy	20	7.55 (19%)	3.96	5.70	9.40	20	8.78 (22%)	5.23	6.33	11.22
Process-plus-Corrective Feedback F/B										
Actual Ach.	26	19.42	6.49	16.80	22.04	26	20.37	6.34	17.81	22.93
Reported Ach.	23	19.93	6.38	17.17	22.69	25	22.36	4.37	20.56	24.16
Bias	23	.26 (1%)	4.98	-1.89	2.42	25	1.66 (4%)	5.23	.50	3.82
Accuracy	23	3.87 (10%)	3.04	2.56	5.18	25	4.66 (12%)	2.76	3.52	5.80
No Feedback										
Actual Ach.	19	14.95	6.64	11.75	18.15	19	15.13	4.21	13.10	17.16
Reported Ach.	19	17.24	7.40	13.67	20.81	17	21.82	6.89	17.64	24.73
Bias	19	2.29 (6%)	2.88	.90	3.68	17	5.74 (14%)	5.01	3.16	8.32
Accuracy	19	3.13 (8%)	1.87	2.23	4.03	17	6.14 (15%)	4.48	3.84	8.45

Note: Achievement scores are reported out of 40. Bias scores range from -40 to 40. Accuracy scores range from 0 to 40.

Actual and postdicted achievement, bias, and accuracy scores and confidence intervals are reported in Table 24 for each treatment group. A MANOVA examined within group differences for bias on achievement between sessions 1 and 2. There was not a statistically significant change found for within group differences for mean bias; $F(2, 54)=.63$, $p=.54$. Based on a second MANOVA, a within groups effect was not observed for magnitude of judgement error; $F(2, 54)=2.28$, $p=.11$. Mean bias ranged from -1 to 4% for the corrective feedback and process-plus-corrective feedback groups and an overestimation ranged from 6 to 22% for the process feedback and no feedback groups. Magnitude of judgement error scores ranged from 6 to 22%.

Investigating Feedback and No Feedback

To investigate whether feedback had an effect on calibration for achievement at all, a dummy variable was computed for additional comparisons. The no feedback group was recoded as zero, while the three feedback groups were combined and coded as 1. Feedback recipients, regardless of type of feedback, were moderately correlated in their calibration in sessions 1 and 2; $r=.51$, $p< .01$ and $r=.40$, $p< .05$; respectively. Calibrations were very strong for the no feedback group; $r=.92$, $p<.01$ for session 1 and $r=.70$, $p<.01$ for session 2.

Fisher z-tests were also computed to test for differences between the two groups. Using a two-tailed $z=\pm2.58$, p<.01, results indicated a significant difference in calibration between the combined feedback groups and no feedback group in session 1; $z=-3.91$, $p<.01$. Specifically, the no feedback group was highly calibrated. Although the correlations are dependent, Fisher z-tests were used to merely explore changes in calibration. There appeared to be a decrease in calibration between sessions within the no feedback group; z=2.75, p<.01 (see Table 25).

Table 25

Correlations and Fisher z-tests for Calibration of Achievement Scores by Combined Feedback and No Feedback Groups.

	Combined Feedback Group		No Feedback Group		Fisher z-test
	n	r	n	r	
Session 1	62	.51**	19	.92**	-3.91**
Session 2	62	.40*	19	.70**	-1.69
Fisher z-test		.53		2.75**	

** $p < .01$ (2-tailed) * $p < .05$ (2-tailed)

Actual and postdicted achievement, bias, and accuracy scores and confidence intervals are reported in Table 26 for the combined feedback group and no feedback group. A MANOVA examined within group differences for bias on achievement between sessions 1 and 2. There was not a statistically significant change across sessions for mean bias; $F(1, 72)$=.99, p=.32, nor was there a change in magnitude of judgement error across sessions; $F(1,72)$=2.85, p=.10.

Table 26

Descriptives for Achievement, Bias and Accuracy Scores by Combined Feedback and No Feedback Groups.

	Session 1					Session 2				
	n	*Mean*	*SD*	*Lower CI*	*Upper CI*	*n*	*Mean*	*SD*	*Lower CI*	*Upper CI*
Feedback										
Actual Ach.	69	18.29	5.78	16.90	19.68	69	18.93	6.19	17.44	20.41
Reported Ach.	62	20.27	6.57	18.60	21.94	62	22.58	5.54	21.17	23.99
Bias	62	2.08 (5%)	6.27	.49	3.67	62	3.40 (6%)	6.57	1.74	5.07
Accuracy	62	5.51 (14%)	3.57	4.61	6.42	62	6.08 (15%)	4.16	5.02	7.14
No Feedback										
Actual Ach.	19	14.95	6.64	11.75	18.15	19	15.13	4.21	13.10	17.16
Reported Ach.	19	17.23	7.40	13.67	20.81	17	21.18	6.89	17.64	24.73
Bias	19	2.29 (6%)	2.88	.90	3.68	17	5.74 (14%)	5.01	3.16	8.32
Accuracy	19	3.13 (8%)	1.87	2.23	4.03	17	6.14 (15%)	4.48	3.83	8.45

Reported Effort: Additional Research Facet 5

At the end of each test, participants were asked how much effort they put into studying the chapter. Zero indicated no effort while 10 indicated complete effort. In the final questionnaire at the end of the second session, participants in the treatment groups were reminded of their ratings from the first session and asked to explain why their studying and test-taking efforts remained the same or differed between sessions.

Recall that no statistically significant difference was found between studying effort and test effort. Therefore, for analyses of students' rating of effort, a new variable was created by adding study effort and test effort. The statistical analyses of self-report ratings used this aggregate variable. However, in responding to the effort questions at the end of each achievement test, students responded to separate questions that differentiated between the two types of effort in explaining why and how their effort changed. Analyses of their explanations address changes in studying separately from test-taking effort.

Differences between Treatment Groups

Examining the Data

Before performing a multiple regression analysis predicting effort in session 2, assumptions were tested. The standardised scatterplot of the predicted values and the residuals test scores as seen in Figure 12 shows a normal distribution. Figure 13 displays the P-P plot for the distribution of observed probability against expected probability. Distribution appeared to be normal and no multivariate outliers were present as points reside near the normal distribution line. Using Mahalanobis Distance, a critical value of x^2=10.83, *p*=<.001 also indicated there were no multivariate outliers.

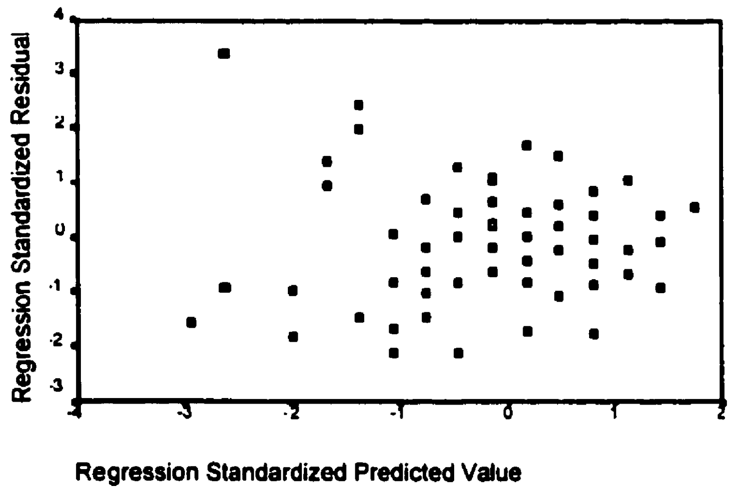

Figure 12. Distribution of residual scores on reported effort.

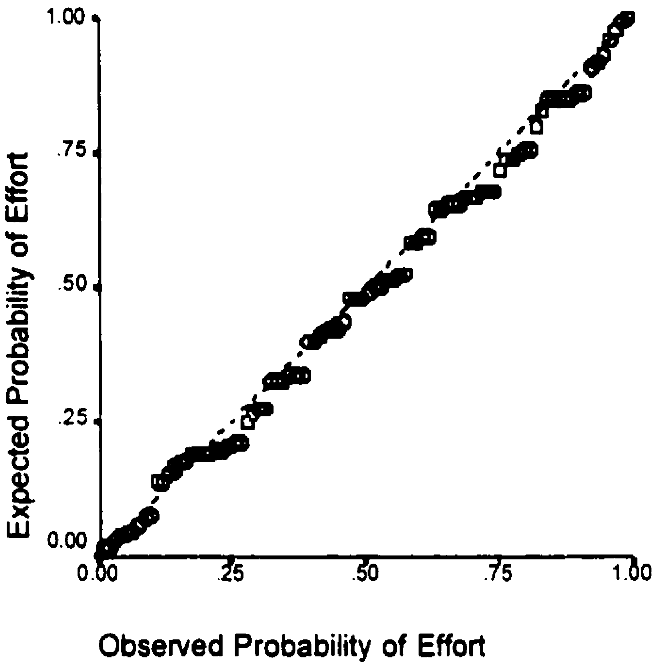

Figure 13. P-P plot of the regression solution for reported effort.

Multiple Regression Analysis

The regression examined whether the feedback students received contributed to reported effort after accounting for the effects of general science background, reported effort in session 1 and prior knowledge of pumps. Three blocks of predictors included: first, general science knowledge and effort in session 1; second, prior knowledge of pumps; and third, each feedback treatment.

Using p-values of .10 and .15 as entry and removal parameters respectively, 35% of the total variance was accounted by the only factor entered into the model — effort in session 1; β=.59, R^2=.35, $F(1, 82)$=44.77, p<.001.

Within Groups Effects

Change in reported effort from session 1 to session 2 was examined using a one-way MANOVA with feedback condition as a between-subjects factor. Based on the session by condition interaction, statistically significant differences were not found in reported effort within any of the four groups and thus, subsequent analysis was not justified; $F(3, 84)=.35$, $p=.79$.

Reported Studying Effort and Explanations

To ascertain the direction of changes in studying effort, a student's rating from the first session was subtracted from that of the second session. A positive number indicated an increase in effort, while a negative number indicated a decrease in effort in session two. This calculation was repeated with the effort ratings for test-taking.

Did Reported Studying Effort Change between the Two Sessions?

All 88 participants responded. Differences in studying effort between the two sessions ranged from –2.00 to 7.00. Perceived effort decreased in the second session for eleven students (13%), remained the same for 20 students (23%), and increased for the remaining 57 students (65%). Figure 14 depicts the distribution of changes in reported studying effort between the two sessions.

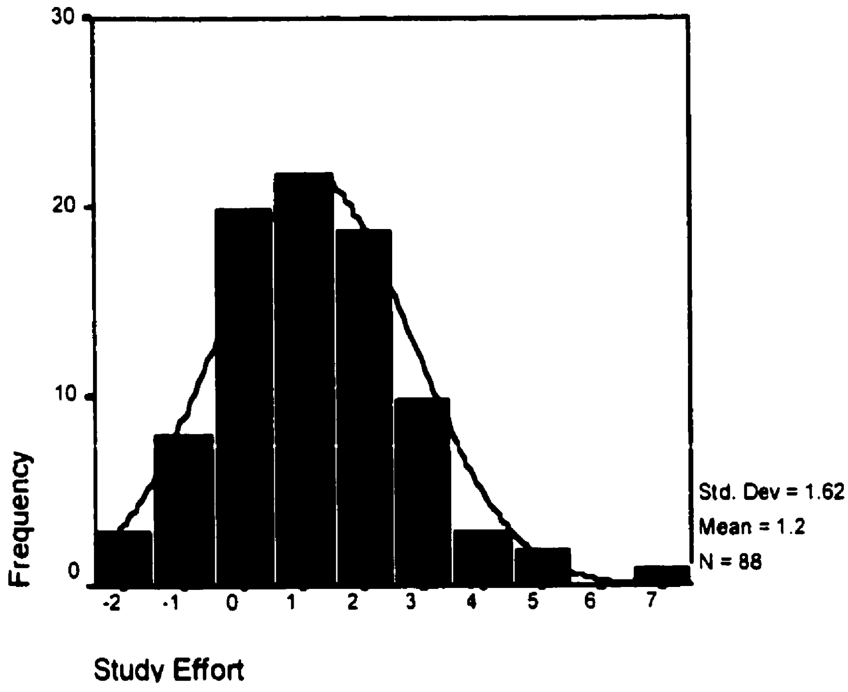

Figure 14. Distribution of changes in reported studying effort.

Why did Studying Effort Change or not Change?

Sixty-three of the eighty-eight students who rated their studying effort explained why their reported effort changed or did not change. Responses were coded into 10 categories. The most common reason for a change in effort was that students tried to change or changed their studying (n=16, 25% of respondents). Nine students (14%) reported differences in concentration or focus between the two study sessions and nine other students reported differences with the level of difficulty or prior knowledge about the topics. See Table 27 for frequencies and percentages for each category.

Table 27

Frequencies and Percentages of Reasons for Studying Effort

Reason	Frequency	Percentage (of respondents)
Tried to change or changed studying (studying differed)	16	26
Conditions did not warrant any change in effort	9	14
Difference in concentration or focus	9	14
Prior knowledge or level of difficulty (topic)	9	14
Prior experience with test resulted in knowing what to expect and do	5	8
Wanted to improve performance	4	6
Difference in the level of interest in the topic	4	6
Focused on how, rather than what was being studied	3	5
Time (needed more, took more)	2	3
Test was not "real"	2	3

Reported Test-taking Effort

Did Reported Test-taking Effort Change between the Two Sessions?

Differences in test-taking effort between the two sessions ranged from –2.00 to 7.00. Effort decreased in the second session for twelve students (13.6%), remained the same for 22 students (25%), and increased for the remaining 54 students (61.4%). Figure 15 illustrates the distribution of changes in reported test-taking effort between the two sessions.

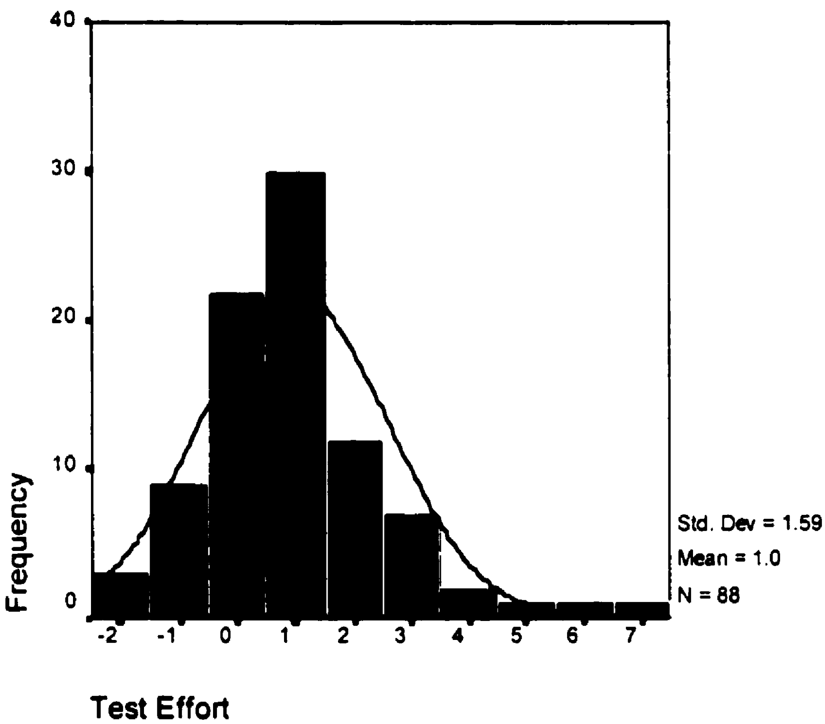

Figure 15. Distribution of changes in reported test-taking effort.

Why did Test-taking Effort Change or not Change?

As before, sixty-three responses were coded into 11 categories. The most common reason for a change in effort was that students changed their effort in studying which then changed their effort in test-taking (n=15, 24% of respondents). The level of difficulty of test questions was the next reason cited by participants (n=7, 11%). See Table 28 for frequencies and percentages for each category.

Table 28

Frequencies and Percentages of Reasons for Test-taking Effort

Reason	Frequency	Percentage (of respondents)
Change in studying effort which then changed test-taking effort	15	24
Same conditions therefore change was not warranted	11	22
Level of test difficulty	7	11
Difference between chapters	5	8
Wanted to improve performance	4	6
Difference in concentration or focus	4	6
Prior experience with test	4	6
Feelings or attitude (e.g. discouraged, tired)	4	6
Changed test-taking	4	6
Time	2	3
Level of interest in the topic	1	2

Summary of Findings

Feedback and Study Tactic Use

When the effects of feedback on study tactic use and achievement were examined, results did not support many expectations. No difference was found between treatment groups when observing the use of low-order study tactics. Prior low-order study tactic use in session 1 was the only unique contributor to the regression model. Furthermore, the model only accounted for 8% of the variance in low-order tactic use in session 2.

Similarly, prior high-order study tactic use in session 1 was a statistically significant contributor to the model predicting high-order tactic use in session 2. A statistically significant difference was found between treatment groups when the process-plus-feedback was compared to the control group. The model accounted for 23% of the variance in high-order study tactic use in session 2.

Analyses examining the effects of feedback within condition groups suggested that there were no statistically significant changes in low- and high-order study tactic use due to feedback. Therefore, further investigation of change from session 1 to session 2 within each condition group was not warranted.

Although feedback effects between groups were not observed based on the statistical analyses, many participants none-the-less reported that feedback did affect their studying. Many students reported that corrective feedback had a moderate influence on their studying and they cited several reasons. Most respondents stated that they changed their approach to studying in the second session by using study strategies and tactics learned about or not previously considered in the first session. The two foremost reasons why corrective feedback affected studying was that it provided information applicable to the next test or prompted a desire to improve their performance in the second session.

Process feedback was also perceived by recipients to moderately influence their approach to studying. The majority of students reported using study strategies and tactics learned about or not previously considered in the first session. Reasons for using the feedback included the belief that paying attention to the feedback may improve studying, or may make studying easier or more efficient, or the feedback informed them of study strategies and tactics not known or not used before.

Feedback and Achievement

The effects of feedback on achievement were also investigated. Previous achievement score in session 1 was found to be a statistically significant predictor in the model and was entered in the first step. Reported effort in session 2 was included in the second step. A difference among feedback groups was found when the process-plus-corrective feedback treatment group was compared to the control group. The model accounted for 39% of the total variance in achievement for session 2. An analysis investigating change in achievement within feedback groups from session 1 to session 2 yielded no statistically significant results.

Although findings on the effect of feedback on achievement were not observed, students reported that corrective feedback moderately affected their approach to test-taking. Most participants reported that they used the suggestions on how to answer the test questions while several students used study strategies and tactics they learned about or did not previously consider in the first session. When explaining why the feedback influenced their test-taking, several participants considered their test scores while many others felt that the feedback provided suggestions applicable to the next test.

Process feedback was perceived by the students to have a small effect on their approach to test-taking. The majority indicated that they used study strategies and tactics learned about or not previously used in the first session. These strategies and tactics helped participants to prepare and to think about the test. Many students believed that paying attention to the feedback could help them to improve their understanding, learning, recall, performance, studying and focus.

Calibration

General findings in session 1 indicated that students were moderately calibrated between their actual and recalled use of low-order study tactics, high-order study tactics and achievement. Compared to students' use of high-order study tactics, they made greater overestimations and had higher magnitudes of judgement error for their use of low-order study tactics. Overestimation of achievement occurred, but was rather small. Magnitude of judgement error was low as well.

Feedback was expected to influence calibration for studying. Moderate calibration occurred for all groups and all groups overestimated their use of study tactics, but no significant change in calibration appeared to have occurred between session 1 and session 2 for any of the three feedback groups. However, when calibration between the three groups was examined, statistically significant differences were found. Corrective feedback recipients were better calibrated in their use of high-order study tactics than either the process feedback group or the process-plus-corrective feedback group. Furthermore, when bias within each group was examined, process-plus-corrective feedback recipients decreased their overestimations of low-order study tactic use. No changes in bias for low-order study tactics were detected. Furthermore, magnitude of judgement error did not change

Feedback had no effect on calibration for achievement when the three feedback groups were investigated. There did not appear to be any changes in calibration for any of the three feedback groups and differences in calibration between the groups were not observed. No changes occurred for bias or magnitude of judgement error for any of the groups.

When further analyses compared combined feedback, consisting of the three pooled feedback groups, and no feedback, statistically significant differences in calibration between groups in session 1 were noted. The no feedback group was better calibrated. However, exploratory analyses suggested that this group appeared to suffer a statistically significant decrease in calibration between sessions 1 and 2. Lastly, no changes in bias or magnitude of judgement error were noted for either of the two groups.

Feedback and Reported Effort

Finally, feedback did not affect overall reported effort between groups. The model accounted for 35% of the variance in reported effort in session 2, however only reported effort for session 1 was entered into the model. A test of change in reported effort from session 1 to session 2 with condition groups did not yield any statistically significant results.

Again, results do not coincide with students' reports. Specifically, the majority of students reported an increase in their effort in the second study session. The most common reason for how change occurred was an attempt to change their studying.

Several other students reported differences in concentration or focus between the two study sessions. Participants also reported an increase in their effort in the second test session, commonly declaring that a change in their effort in studying lead them to change their effort in test-taking.

Although statistically significant results were found for feedback effects on high-order study tactic use and achievement in session 2, effect sizes were relatively small. Process-plus-corrective feedback accounted for 2% of the variance in two regression models equations. Therefore, interpretation of the findings should be made with care.

In summary, some of these findings are consistent with the literature, however others were not expected. The hypotheses within the four research facets presented at the end of chapter 2 will be addresses in the next chapter. Specifically, the results will be interpreted, explained, discussed and compared to those found in the literature. Considerations for future research will also be presented.

CHAPTER 5

Discussion

Overview of the Discussion

This chapter discusses and explains findings in chapter 4 and relates them to the literature. In the first section, feedback effects on studying, achievement, and calibration are considered. Subsections address specific hypotheses introduced in chapter 2 that are related to each type of feedback. This is followed by the presentation of other findings and a summary for each of the four research facets. The second section discusses specific hypotheses and additional findings for general calibration. A discussion on reported effort and feedback effects on reported effort is presented in the third section. The fourth section presents conclusions and implications of the study. The fifth section addresses general or reoccurring limitations not considered previously. Lastly, the chapter closes with suggestions for future research.

Feedback Effects on Studying, Achievement and Calibration

Corrective Feedback

Corrective feedback will improve achievement. (Hypothesis 1 for Research Facet 2: The Effect of Feedback on Subsequent Achievement)

The dummy coded term comparing corrective feedback to the control group did not enter in the regression model investigating differences in achievement between treatment groups. Nor did an analysis examining feedback's effects on achievement across sessions 1 and 2 show statistically significant findings. Therefore, this hypothesis was not supported. Students may not have made the connection between studying and achievement. More than half of the corrective feedback recipients reported that they changed their approach to studying in the second session by using study tactics learned about or not previously considered in the first session. However, results suggested that students may not have known how to use tactics appropriately to address deficiencies in their previous responses. As a result, students may have had difficulties in applying this knowledge to subsequent studying and test-taking in the second session. Furthermore, in the discussion for the next hypothesis, an explanation regarding differences between the chapter text may also account for why corrective feedback did not affect achievement.

Corrective feedback will improve calibration between reported and actual achievement. (Hypothesis 3 for Research Facet 4: Calibration for Achievement)

Corrective feedback was not found to improve calibration between predicted and actual achievement in the second session. One possibility may have been the nature of the texts. Although the chapters for sessions 1 and 2 were science texts, they were different domains within science. Thus, task demands may have differed for students, resulting in students' inability to transfer knowledge gained from the corrective feedback from session 1 and to apply it in session 2.

Process Feedback

Process feedback will increase study tactic use. (Hypothesis 1 for Research Facet 1: The Effect of Feedback on Subsequent Studying)

The dummy coded term comparing the process feedback condition to the control group was not entered in the equation for the regression models examining traces reflecting students use of low- or high-order tactics. Feedback had no statistically significant effect. One explanation may be that students lacked a link between the process feedback and specific instances during studying that might have benefited from applying a studying tactic. Unlike corrective feedback, where information specific to deficiencies in students' responses to the achievement test were given, process feedback presented various study tactics and explanations on how and when to use them, but not in the context of students' own performance in session 1. Students might have understood when to use various tactics in general, but did not have sufficient personal understanding for their application. Therefore, participants did not improve their estimations of their use of study tactics.

The proposed increase in study tactic use by the process feedback group will result in improved achievement. (Hypothesis 2 for Research Facet 2: The Effect of Feedback on Subsequent Achievement)

The hypothesis is not supported because process feedback was not found to increase study tactic use or to improve achievement in session 2. Explanations regarding insufficient conditional knowledge, as presented earlier for process feedback, are applicable here as well.

Due to the availability of trace data for study tactic use, this study is an initial attempt to investigate the connection between studying and achievement. However, when the trace data were entered into the regression model predicting achievement, a connection was not found. It appeared that students perceived studying and achievement to be separate entities. For example, 36% of the 42 respondents to the question on why process affected or did not affect test-taking reported that their test-taking behaviour did not change because there was nothing wrong with their approach or because test-taking is invariable. A further 10% of responses indicated that there was not a relevant relationship between studying and test-taking or that students were more focused on the test than the use of tactics or process feedback did not provide information about the test. Given these comments, feedback on studying would not be expected to have an effect on achievement.

Process feedback will improve calibration between reported and actual use of study tactics. (Hypothesis 2 for Research Facet 3: Calibration for Studying Activities)

Statistically significant changes in calibration for both low- and high-order study tactics were not found for process feedback recipients. Unexpectedly, feedback about the use of study tactics after the first session did not lead to less biased self-reports about tactic use in the second session. Process feedback's aforementioned deficiency in providing sufficient contextual information may explain why students did not improve in their calibration between reported and actual use of studying tactics. Students may not have been able to apply the information provided by the feedback to their own experiences. Thus, increased awareness and better monitoring did not occur.

The proposed improvement in calibration for studying activities due to process feedback will then improve calibration between reported and actual achievement. (Hypothesis 2 for Research Facet 4: Calibration for Achievement)

Since there was no improvement in calibration for studying activities and results indicated an overestimation of achievement, the hypothesis was not supported. Again, the explanation from the previous hypothesis regarding a lack of sufficient conditional knowledge is applicable. Without specific feedback addressing deficiencies in students' use of study tactics, a connection was not made between the suggestions and their own behaviour. Thus, calibration for studying tactics use did not improve. Since contextual information about their use of study tactics was not made available to students, it would be unlikely that they would improve their calibration for studying, let alone calibration for achievement. Furthermore, as previously noted in the prior explanation for the effect of process feedback on achievement, the comments made by students indicated that they perceived studying and test-taking as separate entities. Therefore, feedback on studying would not be expected to have an effect on achievement let alone calibration of achievement.

Furthermore, Schraw and Dennison (1994) examined reported metacognitive awareness and the link between knowledge and regulation of cognition. They found that knowledge of cognition, such as the use of strategies, was related to achievement, while regulation of cognition was not. This suggests that the two aspects of metacognition make unique contributions to cognitive performance. Furthermore, studies on calibration seem to imply that studying and performance are different entities as well, since most studies focus on performance (e.g. Glenberg, et al., 1987; Hunter-Blanks, et al., 1998; Pressley & Ghatala, 1990; Schraw, 1997; Schraw, et al., 1993).

Process-plus-Corrective Feedback

Process-plus-corrective feedback will improve students' use of studying tactics.

(Hypothesis 2 for Research Facet 1: The Effect of Feedback on Subsequent Studying)

The dummy coded term comparing process-plus-corrective feedback to the group receiving no feedback added statistically to the prediction of high-order study tactic use in session 2 when it entered the regression model. This feedback included not only explanations on when and how to use high-order tactics and the benefits of doing so (process feedback), but also supplied students with specific information on areas for improvement and indicated the effectiveness of their use of study tactics (corrective feedback). Therefore, it is not surprising that students learned to value and use high-order tactics in the second session. In a meta-analysis of learning skills interventions by Hattie, Biggs, and Purdie (1996), relational interventions which combine informed use of strategies to specific and transferable contexts, were found to be highly effective in performance, study skills and affect.

The proposed increase in study tactic use in the second study session will result in improved achievement for the process-plus-corrective feedback group. (Hypothesis 3 for Research Facet 2: The Effect of Feedback on Subsequent Achievement)

This hypothesis was supported. Compared to receiving no feedback, process-plus-corrective feedback did result in increased high-order study tactic use and it was a statistically significant predictor of achievement in the regression model. This implies that the combination of process and corrective feedback alerted students to their studying processes and test expectations, and students applied the feedback to their studying and test-taking in the next session. Improved studying methods were not sufficient to improve achievement (as indicated in the findings for the process feedback group); corrective feedback was also needed.

Process-plus-corrective feedback will improve calibration between reported and actual use of study tactics. (Hypothesis 2 for Research Facet 3: Calibration for Studying Activities)

After receiving process-plus-corrective feedback, students did not improve their estimations of low- and high-order study tactic use in the second session. This finding is not consistent with expectations. It was believed that process feedback would provide information about how students carry out studying tactics while corrective feedback was presumed to cue students about how to adapt studying tactics. The problem regarding a lack of context for the process feedback group would not apply to this treatment group since the corrective feedback provided contextual information in relation to which students could make connections and monitor their behaviour. The influence of both types of feedback appeared to induce monitoring and assessment of performance and thus, it was expected that calibration between reported and actual study tactic use would improve. Cognitive overload may have been a factor.

Placed in an unfamiliar and fixed study environment, having a set timeline and only two sessions, learning to use new computer software, trying to learn the content in the study sessions, and applying the given feedback, presented a multitude of expectations and goals to the participants and thus, may have overwhelmed them. Winne (1995b) noted that learners divide their effort between the task of learning the information presented and the task of regulating the strategies they apply in trying to learn the content. Winne further suggested that students who are less skilled or knowledgeable might find monitoring more taxing on their cognitive resources. Since most students in this study had little prior subject-matter knowledge and skill in using the software, students' monitoring of their learning was not yet automated.

Another explanation could be an issue of grain-size. This study asked students to monitor their behaviour at a very fine level. Students were asked to make postdictions within specific guidelines. For example, participants were asked to recall their use of individual study tactics based on the number of paragraphs in the chapter which is different from asking students to provide an overall estimate of the frequency with which they used each tactic while studying. Furthermore, students were informed of the structure of the second session and its achievement test. Since improvement in calibration did not occur, this suggests that students were not monitoring effectively and perhaps they may have been unable to monitor their behaviour at such precise levels.

Process-plus-corrective feedback will improve calibration between reported and actual achievement. (Hypothesis 4 for Research Facet 4: Calibration for Achievement)

The combination of process and corrective feedback was not found to improve calibration in the second session. Several of the aforementioned reasons may explain this lack of improvement in calibration for achievement. The process feedback may not have provided sufficient personal and contextual information with which students could relate the feedback. Furthermore, it may have been difficult and unnatural for students to monitor their studying at precise levels. Although the corrective feedback provided students with information about deficiencies in their test responses and process feedback informed students of various study tactics, students may have had difficulty integrating and applying the two types of information to their monitoring of their achievement. The issue of cognitive overload as discussed previously, might indicate that too much information was provided by the feedback and thus, overrode any potential benefits.

Additional Feedback Effects for the Four Research Facets

The Effect of Feedback on Subsequent Studying: Research Facet 1

Only process-plus-corrective feedback had an effect on tactic use relative to receiving no feedback, specifically on high-order tactic use. Although trace data indicated no difference in study tactic use between the two sessions, students reported that the feedback had a moderate effect on their approach to studying in the second session. Specifically, the feedback was not reported to lead many students to change their approach and to use strategies and tactics not used or considered in the first session. When asked why the feedback was perceived to affect their studying, common responses included that the feedback provided applicable information to the next test, prompted a desire to improve performance or may improve studying.

The Effect of Feedback on Subsequent Achievement: Research Facet 2

Process-plus-corrective feedback recipients improved their estimates of achievement in the second session. This suggests that the feedback provided contextual information for change and enabled learners to engage in effective monitoring during test-taking or studying. Students who were well-calibrated, as indicated in the overall findings of moderate calibration for achievement, may have adjusted to test demands and in turn, used this information to plan more effectively for the second session (Schraw, et al., 1993). Since statistically significant improvement in achievement was only found for the process-plus-corrective feedback group, this suggests the importance of both types of feedback to provide sufficient conditional knowledge for improving one's performance.

Students reported that corrective feedback had a moderate effect on their approach to test-taking, while process feedback was viewed to have a small effect. Many participants reported that they used the suggestions provided by corrective feedback to answer the test questions in the second session. Results indicated that corrective feedback recipients were better calibrated in their use of high-order study tactics in the second session, compared with the other two feedback groups. However, improvement in achievement was not the case. Thus, it seemed that students recognised the effect of the corrective feedback in addressing their deficiencies in test-taking and were more aware of their use of strategies that may alleviate their problems, but the feedback did not have an effect on their achievement score.

Many students reported that they applied the feedback they received due to some aspect of their previous test scores (e.g. wanted to improve, regardless of their score). Process feedback recipients applied the feedback by using study strategies and tactics not previously used in the first session and believed that attention to the feedback could help in the second session. In response to the rating question asking students how much process feedback affected their approach to test-taking, a small effect was found and leads to two possible implications. One, students do not associate or acknowledge that study strategies and tactics have influence on test-taking and, two, test-taking behaviour is relatively consistent and not easily changed.

The Effect of Feedback on Calibration for Studying: Research Facet 3

Calibration was moderate for low- and high-order study tactic use and did not significantly change between sessions 1 and 2 for any of the three feedback groups. The lack of feedback effects on calibration for studying activities may suggest that calibration is a fairly stable attribute and not easily changed over one incidence of feedback.

The Effect of Feedback on Calibration for Achievement: Research Facet 4

Generally, feedback was not found to affect calibration of achievement and results are consistent with the finding by Schraw et al. (1993) that feedback had no effect on bias or accuracy. One explanation is that feedback contributed little added value to the self-generated feedback participants acquired during the first session (Glenberg, et al., 1987).

Feedback did not appear to improve monitoring and therefore, did not have a statistically significant effect on calibration for achievement. Results also support Pressley and Ghatala's (1990) proposition that neither domain familiarity or general intellectual ability seems to affect postdiction accuracy. Explanations for these findings such as difficulties processing and applying the different types of feedback will be covered in the conclusions and implications section.

General Calibration for Studying Activities and Achievement

Students will have poor calibration between reported and actual use of studying tactics independent of feedback. (Hypothesis 1 for Research Facet 1: Calibration for Studying Activities)

Results indicated moderate calibration between actual and recalled use of both low- and high-order study tactics in session 1. This differs from Winne et al. (1999) who found calibration to be relatively poor. The difference may be due to the creation of two variables in this study by combining all low-order study tactics and all high-order study tactics. Winne et al. examined calibration between perceived and actual use of individual studying tactics whereas this study examined calibration for two levels of studying tactics.

Students will have moderate calibration between reported and actual performance independent of feedback. (Hypothesis 1 for Facet 2: Calibration for Achievement).

Results in session 1 supported the general finding in the literature that students are moderately calibrated between postdictions and achievement (see Glenberg, et al., 1987; Hunter-Blanks, et al., 1998; Pressley & Ghatala, 1990; Schraw, et al., 1993) and implies that students use a general monitoring skill instead of domain knowledge to assess their achievement. This is consistent with Schraw's (1997) finding that metacognitive knowledge rather than domain knowledge facilitates monitoring of performance.

Additional Findings for General Calibration

Based on the findings in session 1, students overestimated their use of low-order study tactics and had higher magnitudes of judgement error for these tactics. One explanation may be that students use high-order tactics less frequently, thus they are more aware of when they did or did not use them. A second explanation is how the two levels of study tactics were computed and how this affects interpretation of the data.

Each variable consisted of the sum of all study tactics under that level. High-order study tactics consisted of five different types of tactics whereas low-order study tactics consisted of only two types. Since there are more opportunities for the count of actual high-tactic use to match with reported use regardless of the actual type of tactic, students have a higher likelihood of being categorised as being better calibrated. For example, a student may have stated that she created one analogy and one example. By adding these together, the reported score of high-order study tactic use would be two. However, trace data may have indicated that the student created two examples and no analogies; summed this would also equal two. Thus, if the actual and reported uses of high-order tactic were correlated, the results would indicate that the student was perfectly calibrated, whereas in reality she was not.

Furthermore, students were found to overestimate their achievement slightly and to have a modest magnitude of judgement error. This is consistent with the finding that students are moderately calibrated and thus, one would not expect high levels of over- or underestimation or large displays of inaccuracy.

Reported Effort: Additional Research Facet 5

Analyses examining self-reported ratings of study effort and test effort indicated no statistically significant differences between the two and led to the creation of an overall effort variable for each session. In one analysis, effort during session 1 was found to improve achievement in the session. In another analysis, effort in session 2 was entered into the regression model for achievement in session 2 as well. These findings support the notion of self-regulated learning that suggests that motivation is needed for self-regulation, and effort is expended when a student is motivated (Pintrich & DeGroot, 1990; Winne, 1995b). Thus, a higher level of effort indicates a higher level of engagement in the activity and thus, may improve self-regulation and achievement.

Although a difference was found between overall effort ratings with effort in session 2 rated as higher, both overall effort scores were highly correlated and were reported to be moderate. This suggests that effort may have been relatively consistent in the study. Specifically, students' effort is necessary for engaging in effective problem solving (Mayer, 1998). Different monitoring heuristics are used in different conditions (Butler & Winne, 1995). Since the task demands in the two sessions were alike, a similar monitoring heuristic would be used in both sessions, requiring about the same amount of effort. Although effort is relatively stable, a difference between the two sessions was found. Students in this study reported that they applied the feedback they received in the second session and this might account for the increase in effort ratings.

Questions concerning effort and studying indicated that there were no statistically significant differences in reported effort between the feedback groups. In open-ended responses, students cited the most common reason for change in effort was that they tried to change their studying. Similarly, no statistically significant differences in reported effort ratings and test-taking were found between the feedback groups. Compared to the first study session, there was a slight overall increase in perceived test-taking effort for the second session. The most common reason why students' effort changed was that they altered their effort in studying and therefore felt that a change in their test-taking effort was appropriate.

Conclusions and Implications

This study examined calibration and the effects of instructional feedback. Using a custom-designed computer study tool, traces of studying behaviour allowed for the examination of postdicted and actual use of low- and high-order study tactics. Regardless of the type of feedback students received, findings indicated that students were moderately calibrated between their recalled and actual study tactic use, slightly overestimated their use of tactics, and had a small magnitude of judgement error. Furthermore, students were moderately calibrated between their postdicted and actual performance, slightly overestimated achievement and had a modest magnitude of judgement error. In general, these results suggest that students are relatively accurate when considering their behaviour. Students seem to be aware of the tactics they use in studying. This awareness, in turn, is important for monitoring. Therefore, results sustain Schraw, Dunkle, Bendixen, and Roedel's (1995) finding that confidence, bias, and discrimination do not change across testing conditions. This implies that students have a general monitoring skill.

Students appear to be slightly overconfident about calibration of their behaviour. Overconfidence is common (Cervone & Wood, 1995; Glenberg & Epstein, 1987; Schraw et al., 1993) and may have been a result of students' epistemological beliefs such as that learning is simple or a result of inadequate internal feedback leading to deficiencies in monitoring (Butler & Winne, 1995). A second explanation may be that there was a warm-up effect and students were more aware of what was expected from them and what they were doing in the second session. Since participants were performing the same types of tasks in both sessions and were aware that they would be doing so, this may have influenced their thinking about their behaviour. Familiarity may have led to increased confidence resulting in increased overestimation of students' use of study tactics in the second session.

Results suggest that self-regulation is an important part of the studying and achievement cycle implies how motivation, effort, and self-efficacy are related to study tactic use and performance. In self-regulation, internal or external standards are used to evaluate one's behaviour (Schraw et al., 1993) and feedback provides information upon which to judge one's behaviour against the standards (Winne, 1995b). Therefore, feedback in this study was anticipated to make students more aware of their knowledge and depending on the type of feedback they received, to improve their understanding of tactics and strategies which may then be used to progress towards their studying or achievement goals.

Schunk (1991) noted that students derive cues that signal how well they are learning (Mayer, 1998). The cues are then used to assess efficacy in students' learning and motivation is enhanced when students perceive they are progressing. Motivation is needed for self-regulation and effort is expended when a student is motivated (Pintrich & DeGroot, 1990). Thus, a higher level of effort indicates level of engagement in the activity and thus, may improve self-regulation and achievement.

Open-ended responses suggest that students were more self-regulating in the second session due to the feedback and as a result, effort seemed to increased. However, results do not strongly support the effects of feedback. Process-plus-corrective feedback effects on high-order study tactic use and achievement imply increased self-regulation in session 2, yet effect sizes were relatively small. Corrective and process feedback recipients seemed to have difficulties in self-regulating because statistically significant changes were not found for their calibration, use of study tactics, and achievement. In previous research, strong correlations have been found between self-efficacy and the use of active learning strategies (Pintrich & DeGroot, 1990). Since the use of studying strategies did not change across the two sessions in this study, this suggests that corrective feedback or process feedback by itself may not enhance self-efficacy, whereas providing both types of feedback may.

In terms of feedback effects on calibration, some results were unexpected. For example, process feedback had no affect on calibration. One explanation is that process feedback may not have been presented at the appropriate time. In this study, some students were given outcome, corrective and process feedback all at the same time and may have been overwhelmed. In addition, providing students with process feedback after studying has occurred may not have been conducive to its application in the next studying session. Instead, process feedback could be supplied prior to studying to cue students to make relationships between study tactics that are available and what they do when they actually study. Or process feedback may be provided to students within the software tool during the study session. Process feedback would then be targeted at specific tactics which would, in turn, induce cognitive processing and help subsequent maintenance and transfer of tactics (Butler & Winne, 1995). Feedback that enables students to gauge their progress toward a goal has also been linked to improved self-efficacy judgement and performance (Cervone & Wood, 1995).

Inferences about the timeliness of feedback also support the social cognitive perspective. When beginning to learn complex skills, students require social guidance to prepare them to engage in effective self-regulatory practices (Zimmerman & Kitsantas, 1997). Otherwise, when left ө to their own accord, students are more likely to focus on performance outcomes, may attribute outcomes to uncontrollable personal characteristics such as ability, may fail to think favourably of future chances of success and may not gain metacognitively from previous experience (Zimmerman & Kitsantas, 1997). Therefore, if process feedback was provided while students engaged in studying, it may guide self-directed practice and self-monitoring and improve self-perceptions of efficacy and motivation to continue developing skills.

A second explanation for the why process feedback was not found to have an effect on studying or achievement was a lack of personally meaningful contextual information upon which students could base judgements about appropriate study tactic use. In order for strategy instruction to be successfully embedded within academic tasks, students need to acquire the metacognitive skills of when and how to use the new strategies (Mayer, 1998). Furthermore, Mayer adds that, "for more complex problems, students may lack the ability to organise and control the basic skills within the context of solving the higher-level task" (p. 52). Therefore, the lack of change in calibration across sessions in this study may have been due to students' inability to organise these skills or to change their approach towards the second session to the extent where differences in achievement would be fostered.

Process-plus-corrective feedback also had a small yet statistically significant effect on achievement, whereas the other treatment groups did not. This is not consistent with previous general findings that feedback groups outperform control groups (e.g. Lhyle & Kulhavy, 1987) and may have been a result of the previously discussed issues related to the lack of sufficient information provided by corrective feedback and process feedback, separately. The results also suggest that students did not discern the connection between studying and test-taking and how changes in studying can also be applied to test-taking. Although feedback about the use of study tactics and strategies was provided to some students and they reported applying the suggestions, the effects did not appear to carry over to the achievement test. In fact, a few students noted that process feedback did not have any relationship to test-taking.

Although process and process-plus corrective feedback were hypothesised to influence studying and achievement because the added information has generally been found to be more helpful than simply corrective feedback (Bangert-Drowns, Kulik, Kulik, & Morgan, 1991), its effects were minimal. This implies that a one-time offering of process feedback may not enough to promote the development of tactics and strategies and their application to studying and achievement tasks. Instead, cognitive strategy instruction should be made a routine part of content-based instruction as suggested by Kardash and Amlund (1991).

Perhaps the effect of feedback was not apparent even though students claimed a moderate influence on studying and achievement because the feedback did not address students' goals and therefore, they had difficulties applying the suggested tactics and strategies. Performance feedback and assigned goals enhances achievement when effort is exerted on simple or well-learned tasks (Cervone & Wood, 1995) whereas in this study, the multitude of tasks (learning to use the software, learning new content, applying feedback) was complex and new to the students.

Due to the complexity of this study, students may have reacted more negatively to their own self-evaluations compared to their performance in simpler tasks. Evaluation of performance may have led students to dwell upon personal shortcomings, foster negative emotions and redirect attention from important task cues such as feedback and thereby interfere with complex performance (Cervone & Wood, 1995). Even though feedback provided in this study was not explicitly negative, it may have indicated substandard performance and generated negative self-evaluations thereby inhibiting the expected benefits of feedback.

Results support the importance of clear goals and specific feedback on self-regulation and performance. Specifically, Cervone and Wood (1995) found that the combination of clear goals toward which learners are working and specific feedback moderated relations and reciprocal links between self-regulatory processes and performance. Students in this study were given specific feedback, but not a specific goal. Rather, participants were given several different and imprecise goals: learn and become familiar with the software, study the content, answer test questions, and review the feedback. Without specific goals and resulting standards, students may have been unclear of the feedback's worth and therefore, may not have used it appropriately to appraise and adapt their performance.

Furthermore, feedback had no effect on calibration for achievement. Students adopt strategies because of beliefs that specific strategies are effective for acquiring goals (Winne & Marx, 1989). It is possible that in this study, students' understanding for the task did not match the researcher's goals and therefore, the information provided by the feedback was used without result in the second session.

The information provided by the feedback may not have led to change. Pittman and Heller (1987) as cited in Winne and Marx (1989) concluded that people habitually act in a manner consistent with their goals. A departure from their chosen path would require an encounter with widely discrepant information. Whereas, the feedback provided to participants in this study was fairly tame and thus, may not have induced change.

Lastly, the issue of cognitive overload has several implications. First, if participants allotted more effort and cognitive resources to monitoring, then focus on the actual content may have suffered and learning may have been compromised. Therefore, statistically significant changes in achievement were not detected. Second, if students' cognitive focus was already taxed, then giving students feedback may have further complicated their juggling of cognitive resources. Even students who acknowledged the benefits of various study tactics, may have reverted to strategies they relied on in the past due to cognitive overload. Thus, appropriate and increased use of study tactics and the potential effects of the different feedback may have been overridden.

Furthermore, the difference between students' reports of feedback effects on studying and achievement and the results found in this study may also be attributed to cognitive overload. Perhaps, students did not ignore the feedback but instead, the use of tactics was not triggered under certain conditions because monitoring was not yet automated. Students did not have sufficient time and opportunity to practice applying tactics, let alone develop or change any strategies for studying and test-taking.

Limitations

Due to the complex nature of this study, some general limitations emerged: the studying environment, the time frame allotted for tasks, the new computer environment, and personal factors such as interest and motivation. Lastly, the issue of the semi-random sampling should be addressed.

Students tend to tailor their studying environment to make it personally suitable and comfortable (Winne & Hadwin, 1998). However in this case, participants were asked to study in an unfamiliar context where they were seated in a computer lab surround by up to five other students. The inability to engineer one's studying environment may have lead to studying behaviours not typical of the student. For example, anecdotal comments by a few students included that they had difficulty studying due to environmental factors such as background noise.

The second related problem is the inflexibility of the study's timeline. Students were asked to participate in the two sessions at set times and to comply with general timeframes for various tasks. Unlike when students study by themselves, students could not postpone tasks or take breaks within their sessions. This inflexibility may not have been conducive to learning. For example, some participants commented that they were tired and therefore, could not concentrate or focus. In reality, they most likely would not have continued studying, whereas they did in this experiment. Furthermore, limiting the amount of time students spent on studying may have suppressed achievement. Previous research suggested that time spent on studying was predictive of academic achievement (Zimmerman, 1998).

In addition, exposure to only two studying sessions may not have been a sufficient experience to affect self-efficacy beliefs. Self-efficacy beliefs about strategy use is related to self-regulation and persistence in academic tasks (Pintrich & DeGroot, 1990). Specifically, self-efficacy has been proposed to "play a facilitative role in relation to cognitive engagement, but that cognitive engagement variables are more directly tied to performance" (p. 37). The difference in reported effort between the two sessions may not have resulted in a change in calibration, study tactic use or achievement in session 2 because students' beliefs concerning how to approach the tasks did not change. One session was not sufficient to process the given feedback, to adapt this information and to apply it. Furthermore, without an explicit model of how to change their approach, students were even less likely to make necessary changes to studying in such little time.

Students were faced with a new computer-based studying environment. Some students remarked that they had difficulties with the computer software. If students were not comfortable with using the computer to study, they may not have engaged in the same study behaviours as they normally would. Furthermore, not being comfortable with the software and the short time students had to use the software may have affected the development and application of study strategies. Most of the process feedback provided to students consisted of the use of study tactics and set the foundation for the development of strategies—sets of tactics used under specific conditions. Students probably did not have enough time and practice to develop strategies and to understand when to apply them.

Furthermore, personal factors such students' levels of interest and motivation were not examined explicitly in this study but may have played a role in explaining the results. Some students, for example, remarked to the researchers that they were not interested in the topics. A lack of interest may, in turn, influence motivation and students' goals. Students who were not interested in the content may have set a simple goal to merely complete the study. There may have been mismatch between students' perceptions of goals and the intended instructional goals and thus, no statistically significant changes in behaviour occurred or were detected. Furthermore, limited and fragmented content knowledge and a lack of personal investment in the domain may be cognitively overwhelming rather than motivationally stimulating (Alexander, 1995). Therefore, some students in the study may have been less self-regulating and thus, studying, achievement and calibration did not change significantly.

A final limitation was the semi-random assignment of samples. Initial examination of the data resulted in a multivariate test indicating there were not significant differences between the groups, while univariate tests indicated a difference. Additional pains were taken to examine the possible differences between groups due to the assignment procedure, yet results remained unclear. Although it was concluded that the groups were not statistically significantly different and a decision was made to continue further analyses, a decision in either direction was debatable. Therefore, I would hesitate to generalise the results of this study to the population from which the samples came. Instead, this study would be best viewed as exploratory research.

Future Research

To address the aforementioned limitations, suggestions for future research include: allowing sufficient time for students to become comfortable in using PrepMate, installing the software in the students' own personalised studying environment, and allowing students to study at their own pace. This would enable students to work in a familiar manner and environment, become accustomed to using the software, study at their own rate, and reduce cognitive overload. Examining the log files over a longer period of time, such as over a semester would provide details on how students use the feedback to change their studying and test-taking behaviours over time.

Furthermore, a longer time frame or repeated trials would allow for repeated studying in the content domain and perhaps result in less errors and increased automation of the monitoring process, thereby enabling more cognitive resources to be allotted to actually learning the subject matter. Then, feedback introduced at a later date would not overwhelm students and may be put to better use. Over time, students would be accustomed to the software, have some domain knowledge and have practised using studying and test-taking tactics and have had the opportunity to develop and refine strategies. In addition, this study examined specific tactics. Future research may gain a better understanding of how students self-regulate by examining not only individual tactics, but all traces of studying, including patterns and indications of the development of strategies.

Rather than investigating the effect of feedback on multiple facets: calibration, studying, achievement, and calibration for these two activities, it would be worthwhile for future research to narrow the breadth of this study. Specifically, future studies consisting of a more thorough and encompassing examination of the effects of feedback on one facet, may provide a more complete understanding of the effects of feedback. Additional variables that would add to the multifaceted understanding of the effects of feedback may include personal factors such as epistemological beliefs, interest, motivation, self-efficacy and personal goals. Other content matter rather than science texts could also be used to address these individual differences.

Furthermore, other means of providing feedback need to be investigated and the timeliness of different feedback needs to be considered. As previously discussed, providing up to three kinds of feedback—outcome, process and corrective feedback all at once, may have overwhelmed students and the timing of feedback needs to be considered.

Finally, the debatable issues related to the semi-random sampling in this study greatly supports the need for replicating this study. Replication would assist in determining whether these findings were indeed representative of the population or a result of the semi-random sampling procedure.

In summary, this study provided an introductory and exploratory examination of calibration and the effects of instructional feedback and has only touched upon some of the important issues and considerations. Thus, further research is needed to understand why and how feedback may help students to better monitor their studying and test-taking activities and thereby, make better predictions of their performance. In addition, further research may determine the types of feedback, appropriate timing and methods necessary to improve studying and achievement.

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Appendix A

Introductory Passage Embedded in the Chapter Window for PrepMate Practice

Welcome to *PrepMate* !

PrepMate is a computer tool for studying. Using *PrepMate*, you can:
- read a chapter
- highlight text you select
- copy information from a chapter to your notes
- create notes in your own words
- examine figures
- view explanations
- review any notes you make and any material you've studied

Instructions for using *PrepMate*

1. If you haven't already opened the Objectives Window, click on the Objectives button in the Notes & Organiser window.

The contents of the Objectives Window will become invisible when you click on another window. To see the objectives again, click on the Objectives Window.

Note: Click on any window to make it active. That is, has a greyed bar with horizontal lines at the top.

2. Highlight this sentence.

Do this in three steps: First, select the sentence using the mouse—CLICK and hold down the mouse button, then drag the cursor across text. Second, let go of the mouse button. Third, choose Highlight in the Edit Menu **or** use CMD-H from the keyboard. (The command key is on either side of the space bar and has an apple on it. You must press it and the H key at the same time as the command key.)

To de-highlight text: Select the highlighted text you want to de-highlight using the mouse. Choose Highlight in the Edit Menu or use CMD-H and the selection will de-highlight. Try this with the sentence you just highlighted.

3. Copy this paragraph into the Notes & Organiser Window. To do this takes three steps. First, select text using the mouse. Second, choose Copy in the Edit Menu **or** use

CMD-C from the keyboard. Third, to paste the text you copied into the Notes & Organiser Window, select Paste from the Edit Menu **or** use CMD-V from the keyboard.

4. Make a note of your own in the Notes & Organiser Window. Click on the space for notes in the Notes & Organiser Window to activate it. Then type your note into the window.

5. You can delete or cut text in the Notes & Organiser Window. To do this: Select the text you want to delete using the mouse. Choose Cut in the Edit Menu or use CMD-X from the keyboard. When you cut text, it is temporarily copied first. If you want to move text in your notes from one place to another, do this. First, cut the text. Then, put the cursor where you want the text to be pasted and paste it (see #3). Try cutting the note you made in step #4 and pasting it in front of the paragraph you copied and pasted in step #3.

6. A link to a Figure Window is underlined and violet. A link like <u>see Figure 1, Panel 1</u> directs you to a Figure Window and A specific panel, namely, panel 1. You'll see these types of links in Session 1. A link like <u>see Figure 1, All Panels</u> directs you to a Figure Window that starts off at Panel 1 and continues with several panels for you to view. You'll see these types of links in Session 2. To view a figure window, click on the link.

Now look at the example on how to cook a package of noodles, <u>see Figure 1, All Panels</u>.

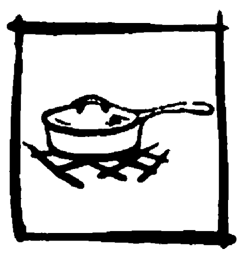
7. The Figure Window contains a series of illustrations called panels. To view the next panel in a series of panel, click on the buttons at the bottom of the Figure Window.

8. To read an explanation about the panel you are currently viewing, click on the Explanation Button.

Once you have finished, practice using PrepMate's various features. If you are ready to start studying the first chapter, please let the Researcher know.

Appendix B

Figures and Related Explanations in the PrepMate Practice Module

Panel	Figure	Explanation
1		1. Stir flavoring sachet in 2 cups boiling water.
2		2. Reduce heat and add sliced meat, tofu, or vegetables and simmer 10 minutes.
3		3. Add noodles and simmer 5 minutes.

Appendix C

Lightning Passage Embedded in the Chapter Window for Session 1

The Process of Lightning

Origin

Lightning is formed by a strong electrical field in storm clouds, between positively and negatively charged parts of the cloud. The potential can be build up in the clouds, between clouds, between clouds and the earth's surface or between clouds and the upper levels of the atmosphere. Thus **lightning** can be defined as the discharge of electricity resulting from the difference in electrical charges between the cloud and the ground usually occurring in a storm. *Storms* are the result either of a very quick drive upwards of warm air to great heights (thermal storms) or of the coming together of a warm moist air mass with a well-developed cold front (frontal storm). Lightning varies in length and complexity with strokes following different tracks from straight linear lines, to forks, in sheets, or as a fireball.

Development

Warm moist air near the earth's surface rises rapidly. As the air in this *updraft* cools, water vapor condenses into *water droplets* and forms a cloud. The cloud's top extends above the *freezing level*. At this altitude, the air temperature is well below freezing which causes either tiny ice crystals or super-cooled water droplets to form. Usually both forms are present and the alternation between ice and water droplets produces a high electrical potential (see Figure 1).

Eventually, the water droplets and ice crystals become too large to be suspended by updrafts. As raindrops and ice crystals fall through the cloud they drag some of the air in the cloud downward, producing *downdrafts*. The rising and falling air currents within the cloud may cause hailstones to form (see Figure 2). When downdrafts strike the ground, they spread out in all directions, producing gusts of cool wind people feel just before the start of the rain.

Within the cloud, the moving air causes electrical charges to build. The negative and positive charges are separated owing to the different speeds at which ice and water fall. The clouds act as generators. When the air becomes overcharged, the pressure is released as lightning and a new potential is generated. Thus most believe that the charge results from the collision of the cloud's light, rising water droplets and tiny pieces of ice against hail and other heavier falling particles. The negatively charged electrons fall to the bottom of the cloud, and most of the positively charged electrons rise to the top (see Figure 3).

Formation

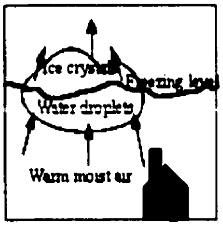
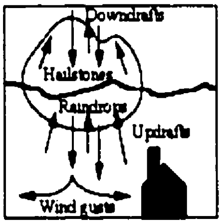
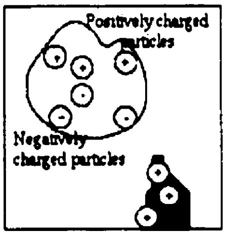
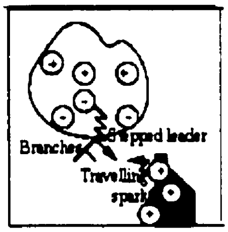
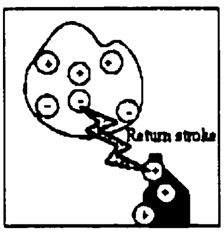
The first stroke of a flash of cloud-to-ground lightning is started by a **stepped leader**, an invisible discharge. A stepped leader moves downward in a series of steps with each of the steps advancing about 50 meters. Many scientists believe that it is triggered by a local discharge between the small pocket of positive charge at the base of a thundercloud and the lower part of the negatively charged region. This discharge releases electrons which were previously attached to precipitation particles in the negatively charged region. These free electrons neutralize the small pocket of positive charge and then move toward the ground. As the stepped leader nears the ground, it induces *positive charges* from the ground to move upward from such objects as trees and buildings to meet the *negative charges* which is called a **travelling spark** (see Figure 4). Usually, the travelling spark from the tallest object is the first to meet the stepped leader and complete a path between the cloud and earth. The stepped leader and travelling spark generally meet about 10-100 meters above the ground. Negatively charged electrons then rush from the cloud to the ground along the path creating a highly luminous and visible **lightning stroke**. Usually there is an initial weak discharge, followed by the main discharge, which can have many *branches*.

As the lightning stroke nears the ground, it induces an opposite charge called a **return stroke**, so positively charged particles from the ground rush upward along the same path (see Figure 5). This upward motion of the current reaches the cloud in about 70 microseconds. A *return stroke* produces the bright light that people notice in a flash of lightning, but the current travels so quickly that its upward motion cannot be perceived. Despite the downward flow of electrons, both the return stroke and the ground, to which it is linked, remain positively charged in response to the remainder of the negative charge in the lower region of the cloud. The lightning stroke usually consists of an electrical potential of several million volts. The air along the lightning channel is heated briefly to a very high temperature. **Thunder** is caused by a compression wave set up by the expansion of air, through which the lightning has passed, and by the collision of the air particles returning to fill the vacuum which has, as a result, been created.

A flash of lightning may end after the return stroke, however, subsequent strokes can occur along the same main channel, provided that additional electrons from higher within the cloud are supplied. K or J streamers fulfill this function by providing negatively charged electrons to the top of the previous stroke within 100ms of the current. **Dart leaders** which are similar to stepped leaders, carry the negative charges from the cloud down the main path of the previous stroke creating another return stroke. This process commonly occurs 3 or 4 times in one flash, but can occur more than 20 times. People can sometimes see the individual strokes of a flash. At such time the lightning appears to flicker.

Appendix D

Figures and Related Explanations on the Development of Lightning in Session 1

Panel	Figure	Explanation
1		1. Warm moist air rises, water vapor condenses and forms clouds.
2		2. Raindrops and ice crystals drag air downward.
3		3. Negatively charged particles fall to the bottom of the cloud.
4		4. Stepped leader and travelling spark meet. Negatively charged particles rush from cloud to ground.
5		5. Positively charged particles from the ground rush upward along the same path.

Appendix E

Pumps Passage Embedded in the Chapter Window for Session 2

Pump Systems

A **pump** is a mechanical device or machine designed for elevating or conveying liquids against the action of gravity, or for exhausting air or other gases from a closed vessel (via systems of pipes and valves). Pumps serve five functions: to convey liquid from one point to another, generate pressure, reduce pressure, provide circulation or provide metered quantities of liquid. A pump for liquid may be intended primarily for elevating the liquid from a supply source below the pump up to the pump, or for forcing the liquid either to a much higher level or to some distant point by connecting the pump with a suitable pipe. A mechanical device for withdrawing air from a closed vessel is ordinarily classified as a pump but, if designed for compressing air or other gases, it is known as a compressor, fan or blower.

Pumps are classified either with reference to some constructional feature or the particular class or service for which they were designed. There are two major types of pumps--dynamic pumps and positive displacement pumps. **Dynamic pumps** maintain a steady flow of fluid. **Positive displacement pumps**, on the other hand, trap individual portions of fluid in an enclosed area before moving them along.

Dynamic Pumps

Centrifugal pumps consist of a motor-driven propeller like device, called an *impeller*, which is contained within a *circular casing*. The **impeller** is a wheel of curved blades that rotates on an axis. Before most centrifugal pumps can start pumping liquid, they must be **primed** (filled with liquid). As the impeller rotates, it creates pressure through suction that draws a continuous flow of fluid through an *inlet pipe*. Fluid enters the pump at the center of the impeller and travels out along the blades due to centrifugal (outward) force. The curved ends of the blades sweep the fluid to an *outlet pipe* (see figure 1). Centrifugal pumps are inexpensive and can handle large amount of fluid. They are widely used in chemical processing plants and oil refineries.

Positive Displacement Pumps

Rotary pumps are the most widely used positive displacement pumps. **Rotary pumps** differ from centrifugal pumps in that water or other fluid is forced through the pump by the direct application of pressure from rotating pistons or impellers and independently of centrifugal action. The pumping element depending on the type of pump, rotates, and with each rotation forces a fixed amount of liquid through a discharge opening. They are often used to pump such viscous (sticky) liquids as motor oil, paint and syrup. One main type of rotary pump is the sliding vane pump.

Sliding vane pumps consist of a slotted impeller mounted off-center in a circular casing. *Sliding vanes* (blades) are attached to the *impeller* by springs. The vanes move in and out of the slots as the impeller rotates. At high speeds the vanes are pressed against the inside of the casing. As each vane recedes from the *inlet pipe*, it draws in liquid behind it, thus sweeping up fluid and trapping it against the pump wall. The distance between the impeller and the pump wall narrows near the *outlet pipe*. As the fluid is carried around to this pipe, the vanes are pushed in and the fluid is compressed. The pressurized fluid then rushes out of the outlet pipe (see figure 2).

Reciprocating pumps are another type of positive displacement pump. **Reciprocating pumps** consist of a *piston* that moves back and forth within a *cylinder*; they draw the liquid through an *inlet valve* and expel it though an *outlet valve*. One end of the cylinder has an opening through which the connecting rod of the piston passes. As the piston is retracted, the space within the pump chamber increases, thus giving rise to a partial vacuum. This vacuum causes the inlet valve to be raised and the outlet valve to be closed. At the same time liquid enters the pump chamber. During the return stroke of the piston, the pressure in the chamber increases, thus causing the inlet valve to close and the outlet valve to open. Liquid is discharged through the outlet valve. When the pressure in the pump chamber decreases again, the outlet valve closes immediately so that the liquid above the valve cannot flow back. Common reciprocating pumps include lift pumps and bicycle tire pumps.

Lift pumps draw water from wells. In a lift pump, the *inlet valve* is at the closed end of the cylinder and the *outlet valve* is on the *piston*. When the handle is pushed down, the piston rises and forces out air. As the piston is raised, the inlet valve opens; water is drawn up into the *cylinder* through the inlet valve to replace the air. Pulling up on the handle lowers the piston through the water. As the piston moves down, the inlet valve closes, forcing water through the outlet valve and above the piston. Pushing down on the handle raises the piston. As the piston is raised again, the outlet valve closes and the water above the piston is lifted to an opening, where it leaves the pump. At the same time, more water is drawn through the inlet valve (see figure 3). It is theoretically possible for a lift pump to raise water almost 10.4 meters. However, because of leakage and resistance, it cannot raise water that is deeper than about 7.6 meters.

Air pumps are used to extract gas or air from a vessel in order to produce or maintain a partial vacuum. Bicycle tire pumps vary in the number and location of the valves they have and in the way air enters the cylinder. Some simple bicycle tire pumps have the *inlet valve* on the piston and the *outlet valve* at the closed end of the cylinder. A bicycle tire pump has a *piston* where the connecting rod passes through the cylinder. As the rod is pulled out, air passes though the piston and fills the areas between the piston and the outlet valve. As the rod is pushed in, the inlet valve closes and the piston forces air through the outlet valve (see figure 4).

Appendix F

Figures and Related Explanations on Centrifugal and Sliding Vane Pumps in Session 2

Figure Window 1

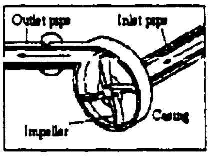
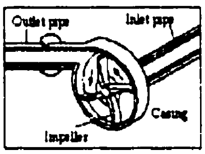
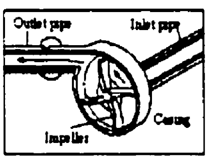
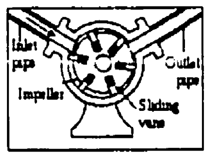
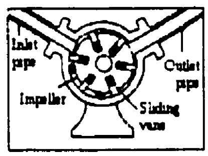
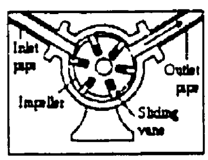
Panel	Figure	Explanation
1		1. As the impeller rotates, it creates suction that draws fluid through an inlet pipe.
2		2. Fluid enters the pump at the center of the impeller, and travels out along the blades due to centrifugal (outward) force.
3		3. The curved blades sweep the fluid to an outlet pipe.

Figure Window 2

Panel	Figure	Explanation
1		1. As the vanes rotate by the inlet pipe, they sweep up fluid and trap it against the pump wall.
2		2. As the fluid is carried around to the outlet pipe, the distance between the impeller and the pump narrows, the vanes are pushed in and the fluid is compressed.
3		3. The pressurized fluid then rushes out of the outlet pipe.

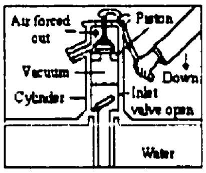
Appendix G

Figures and Related Explanations on Lift and Air Pumps in Session 2

Figure Window 3

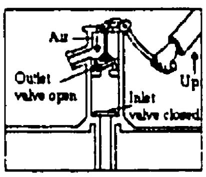
Panel | Figure | Explanation

1



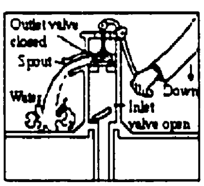
1. As the handle is pushed down, the piston rises and forces out air. The inlet valve opens and water is drawn into the cylinder through the inlet valve.

2



2. Pulling up on the handle lowers the piston through water. The inlet valve closes forcing water through the outlet valve and above the piston.

3

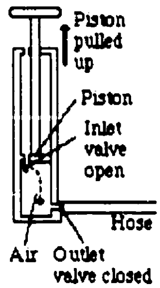


3. Pushing down on the handle raises the piston. The outlet valve closes and water above the piston is lifted to an opening where it leaves the pump. More water is drawn though the inlet valve.

Figure Window 4

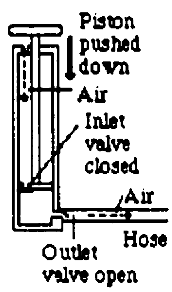
Panel | Figure | Explanation

1



1. As the rod is pulled out, air passes though the piston and fills the areas between the piston and outlet valve.

2



2. As the rod is pushed in, the inlet valve closes and the piston forces air through the outlet valve.

Appendix H

Sample Log File (Excerpt—original is 8 pages)

1449279; Starting PrepMate on Mon, Sep 28, 1998 3:28 PM
1449442;
1449442; Study user is 'Alberta'
1449442;
1449452; Setting focus to Notes & Organizer window
1449684; Setting focus to Objectives window
1450594; Setting focus to Notes & Organizer window
1450671; Setting focus to Chapter window
1450973; Scrolling chapter to 0%
1450984; Scrolling chapter to 0.00704225%
1450987; Scrolling chapter to 0.0140845%
1450989; Scrolling chapter to 0.0211268%
1450991; Scrolling chapter to 0.028169%
1450993; Scrolling chapter to 0.0352113%
1450994; Scrolling chapter to 0.0422535%
1451115; Scrolling chapter to 0.0492958%
1451355; Scrolling chapter to 0.916813%
1451589; Scrolling chapter to 0%
1451612; Scrolling chapter to 0.00704225%
1451652; Scrolling chapter to 0.0140845%
1452841; Setting focus to Notes & Organizer window
1454196; Setting focus to Chapter window
1454368; Setting focus to Objectives window
1454855; Setting focus to Chapter window
1456230; Setting focus to Notes & Organizer window
1462373; Setting focus to Chapter window
1462481; Scrolling chapter to 0.0211268%
1462495; Scrolling chapter to 0.028169%
1462508; Scrolling chapter to 0.0352113%
1463081; Setting focus to Notes & Organizer window
1463409; Setting focus to Chapter window
1463508; Copying phrase 'the cloud and the ground' in chapter
1463584; Setting focus to Notes & Organizer window
1463676; Pasting 'the cloud and the ground' into notes_organizer
1463964; Setting focus to Chapter window
1464007; Scrolling chapter to 0.0422535%
1464019; Scrolling chapter to 0.0492958%
1464022; Scrolling chapter to 0.056338%
1464024; Scrolling chapter to 0.0633803%
1464026; Scrolling chapter to 0.0704225%
1464031; Scrolling chapter to 0.0774648%
1464758; Setting focus to Notes & Organizer window
1465725; Setting focus to Chapter window
1466051; Copying phrase 'a very quick drive upwards of warm air to great heights (thermal storms)' in chapter
1466096; Setting focus to Notes & Organizer window
1466180; Pasting 'a very quick drive upwards of warm air to great heights (thermal storms)' into notes_organizer

1466430; Setting focus to Chapter window
1466676; Copying phrase 'the coming together of a warm moist air mass with a well-developed cold front (frontal storm)' in chapter
1466736; Setting focus to Notes & Organizer window
1466797; Pasting 'the coming together of a warm moist air mass with a well-developed cold front (frontal storm)' into notes_organizer
1467174; Setting focus to Chapter window

[cut]

1471453; Taking hypertext link to panel 1 of Figure_1
1471454; Viewing panel 1
1471464; Setting focus to Figure_1
1471465; Viewing panel 1
1471739; Viewing panel 2
1471849; Viewing panel 1
1471877; Displaying explanation for this figure
1472440; Viewing panel 2
1472476; Displaying explanation for this figure
1472622; Viewing panel 3
1472679; Displaying explanation for this figure
1472929; Viewing panel 4
1472954; Displaying explanation for this figure
1473390; Viewing 5
1473424; Displaying explanation for this figure
1473892; Setting focus to Chapter window
1474191; Scrolling chapter to 0.183099%

[cut]

1501103; Setting focus to Notes & Organizer window
1502363; Setting focus to Chapter window
1502565; Scrolling chapter to 0.916813%

[cut]

1505616; Scrolling chapter to 0.00836268%
1505617; Scrolling chapter to 0.001132042%
1506368; Exiting PrepMate Mon, Sep 28, 1998 3:44 PM
1506368; Contents of notes & organizer window upon closing

Lightning

-formed by strong electrical field in storm clouds, between + and -parts.
-can be build up between clouds, earth and cloud, earth and atmosphere
-discharge of electricity from difference in electric charges between the cloud and the ground

Storm

a very quick drive upwards of warm air to great heights (thermal storms)
the coming together of a warm moist air mass with a well-developed cold front (frontal storm)

Lightning

different length, complexity of strokes, forks, sheets, or fireball

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Appendix I

Perspectives on Learning and other Questions

Perspectives on Learning

Participant # _____

We are interested in your views on studying and how you study. Please answer the following questions. All responses are completely confidential.

Part 1

______ Age (in years) ______ Sex (F or M)
______ Grade Point Average in all your post-secondary studies (0-4.33, or %)
______ Number of courses enrolled in this semester
______ Number of courses taken at SFU, including this semester
______ Average hours worked per week
______ Average hours studying per week
______ Was English the first language you learned to speak? (Yes or No). If no, how old were you when you learned to speak English? ______
______ Was English the first language you learned to write? (Yes or No). If no, how old were you when you learned to write in English? ______

What makes studying difficult for you?

____
____
____

Part 2. Please respond to these statements in the context of your ________ course. There are no right or wrong answers, just answer as accurately as possible.

		not at all true of me						very true of me
1.	In a class like this, I prefer course material that really challenges me so I can learn new things.	1	2	3	4	5	6	7
2.	If I study in appropriate ways, then I will be able to learn the material in this course.	1	2	3	4	5	6	7
3.	I think I will be able to use what I learn in this course in other courses.	1	2	3	4	5	6	7
4.	I believe I will receive an excellent grade in this class.	1	2	3	4	5	6	7
5.	I'm certain I can understand the most difficult	1	2	3	4	5	6	7

	material presented in the readings for this class.							
6.	Getting a good grade in this class is the most satisfying thing for me right now.	1	2	3	4	5	6	7
7.	It is my own fault if I don't learn the material in this course.	1	2	3	4	5	6	7
8.	It is important for me to learn the course material in this class.	1	2	3	4	5	6	7
9.	The most important thing for me right now is improving my overall grade point average, so my main concern in this class is getting a good grade.	1	2	3	4	5	6	7
10.	I'm confident I can understand the basic concepts taught in this course.	1	2	3	4	5	6	7
11.	If I can, I want to get better grades in this class than most of the other students.	1	2	3	4	5	6	7
12.	I'm confident I can understand the most complex material presented by the instructor in this course.	1	2	3	4	5	6	7
13.	In a class like this, I prefer course material that arouses my curiosity, even if it is difficult to learn.	1	2	3	4	5	6	7
14.	I am very interested in the content area of this course.	1	2	3	4	5	6	7
15.	If I try hard enough, then I will understand the course material.	1	2	3	4	5	6	7
16.	I'm confident I can do an excellent job on the assignments and tests in this course.	1	2	3	4	5	6	7
17.	I expect to do well in this class.	1	2	3	4	5	6	7
18.	The most satisfying thing for me in this course is trying to understand the content as thoroughly as possible.	1	2	3	4	5	6	7
19.	I think the course material in this class is useful for me to learn.	1	2	3	4	5	6	7
20.	When I have the opportunity in this class, I choose course assignments that I can learn from even if they don't guarantee a good grade.	1	2	3	4	5	6	7
21.	If I don't understand the course material, it is because I didn't try hard enough.	1	2	3	4	5	6	7
22.	I like the subject matter of this course.	1	2	3	4	5	6	7
23.	Understanding the subject matter of this course is very important to me.	1	2	3	4	5	6	7
24.	I'm certain I can master the skills taught in this class.	1	2	3	4	5	6	7
25.	I want to do well in this class because it is important to show my ability to my family, friends, employer, or others.	1	2	3	4	5	6	7
26.	Considering the difficulty of this course, the teachers, and my skills, I think I will do well in this class.	1	2	3	4	5	6	7
27.	When I study the readings for this course, I outline the material to help me organize my	1	2	3	4	5	6	7

	thoughts.							
28.	During class time I often miss important points because I'm thinking of other things.	1	2	3	4	5	6	7
29.	When reading for this course, I make up questions to help focus my reading.	1	2	3	4	5	6	7
30.	I often feel so lazy or bored when I study for this class that I quit before I finish what I planned to do.	1	2	3	4	5	6	7
31.	I often find myself questioning things I hear or read in this course to decide if I find them convincing.	1	2	3	4	5	6	7
32.	When I study for this class, I practice saying the material to myself over and over.	1	2	3	4	5	6	7
33.	Even if I have trouble learning the material in this class, I try to do the work on my own, without help from anyone.	1	2	3	4	5	6	7
34.	When I become confused about something I'm reading for this class, I go back and try to figure it out.	1	2	3	4	5	6	7
35.	When I study for this course, I go though the readings and my class notes and try to find the most important ideas.	1	2	3	4	5	6	7
36.	If course readings are difficult to understand, I change the way I read the material.	1	2	3	4	5	6	7
37.	When studying for this course, I read my class notes and the course readings over and over again.	1	2	3	4	5	6	7
38.	When a theory, interpretation, or conclusion is presented in class or in the readings, I try to decide if there is good supporting evidence.	1	2	3	4	5	6	7
39.	I work hard to do well in this class even if I don't like what we are doing.	1	2	3	4	5	6	7
40.	I make simple charts, diagrams, or tables to help me organize course material.	1	2	3	4	5	6	7
41.	I treat the course material as a starting point and try to develop my own ideas about it.	1	2	3	4	5	6	7
42.	When I study for this class, I pull together information from different sources, such as lectures, readings and discussions.	1	2	3	4	5	6	7
43.	Before I study new course material thoroughly, I often skim it to see how it is organized.	1	2	3	4	5	6	7
44.	I ask myself questions to make sure I understand the material I have been studying in this class.	1	2	3	4	5	6	7
45.	I try to change the way I study in order to fit the course requirements and instructor's teaching style.	1	2	3	4	5	6	7
46.	I often find that I have been reading for this class but don't know what it was all about.	1	2	3	4	5	6	7
47.	I ask the instructor to clarify concepts I don't understand well.	1	2	3	4	5	6	7
48.	I memorize key words to remind me of important concepts in this class.	1	2	3	4	5	6	7

49.	When course work is difficult, I either give up or only study the easy parts.	1	2	3	4	5	6	7
50.	I try to think through a topic and decide what I am supposed to learn from it rather than just reading it over when studying for this course.	1	2	3	4	5	6	7
51.	I try to relate ideas in this subject to those in other courses whenever possible.	1	2	3	4	5	6	7
52.	When I study for this course, I go over my class notes and make an outline of important concepts.	1	2	3	4	5	6	7
53.	When reading for this class, I try to relate the material to what I already know.	1	2	3	4	5	6	7
54.	I try to play around with ideas of my own related to what I am learning in this course.	1	2	3	4	5	6	7
55.	When I study for this course, I write brief summaries of the main ideas from the readings and my class notes.	1	2	3	4	5	6	7
56.	When I can't understand the material in this course, I ask another student in this class for help.	1	2	3	4	5	6	7
57.	I try to understand the material in this class by making connections between the readings and the concepts from the lectures.	1	2	3	4	5	6	7
58.	I make sure that I keep up with the weekly readings and assignments for this course.	1	2	3	4	5	6	7
59.	Whenever I read or hear an assertion or conclusion in this class, I think about possible alternatives.	1	2	3	4	5	6	7
60.	I make lists of important items for this course and memorize the lists.	1	2	3	4	5	6	7
61.	I attend this class regularly.	1	2	3	4	5	6	7
62.	Even when course materials are dull and uninteresting, I manage to keep working until I finish.	1	2	3	4	5	6	7
63.	I try to identify students in this class whom I can ask for help if necessary.	1	2	3	4	5	6	7
64.	When studying for this course I try to determine which concepts I don't understand well.	1	2	3	4	5	6	7
65.	I often find that I don't spend very much time on this course because of other activities.	1	2	3	4	5	6	7
66.	When I study for this class, I set goals for myself in order to direct my activities in each study period.	1	2	3	4	5	6	7
67.	If I get confused taking notes in class, I make sure I sort it out afterwards.	1	2	3	4	5	6	7
68.	I try to apply ideas from course readings in other class activities such as lecture and discussion.	1	2	3	4	5	6	7

Additional Questions

Place a check mark next to the science courses you have taken in high school:

_____ Chemistry
_____ Physics
_____ Biology
_____ Earth Sciences
_____ Other (Specify:___________)

Place a check mark next to the science courses you have taken in college:

_____ Chemistry
_____ Physics
_____ Biology
_____ Earth Sciences
_____ Other (Specify:_________)

Please place a check mark next to the items that apply to you:

_____ I regularly read weather maps in the newspaper.
_____ I know what a cold front is.
_____ I can distinguish between cumulous and nimbus clouds.
_____ I know what a low-pressure system is.
_____ I can explain what makes the wind blow.
_____ I know what this symbol means
_____ I know what this symbol means

Please put a check mark next to the things that you have done:

_____ I own a set of tools including screwdrivers, pliers and wrenches.
_____ I own at least one power tool (such as a power saw or power drill).
_____ I have replaced the heads on a lawn sprinkler system.
_____ I have replaced the washer in a sink faucet.
_____ I have replaced the flush mechanism in a toilet.
_____ I have installed plumbing pipes or plumbing fixtures.

Please put a check mark indicating your knowledge of how to fix household appliances and machines:

______ Very Much
______
______ Average
______
______ Very Little

Please ensure that you bring this completed questionnaire with you to Session 1.

THANK YOU!

Appendix J

Study Tactics Questionnaire

Study Tactics for Session 1

Participant # _____

Section 1

1. When you started studying the chapter on lightning, did you: (yes or no)
   _____ Plan a method for the studying the chapter
   _____ Plan your time
   _____ Set objectives for yourself

2. There were 7 paragraphs in the chapter on lightning. In how many of the 7 paragraphs did you: (write a number from 0 to 7)

   _____ Stop to check your understanding of the paragraph
   _____ Think about what you already knew about the subject matter in the paragraph
   _____ Check your understanding of the paragraph with what you already knew
   _____ Ask yourself questions before you read the paragraph
   _____ Ask yourself questions while you read the paragraph
   _____ Ask yourself questions to review your understanding of the paragraph
   _____ Go back and make connections with information in earlier paragraphs
   _____ Go back and review information that was not clear in earlier paragraphs
   _____ Go back and look at your notes from earlier paragraphs
   _____ Go back and look at your highlighting from earlier paragraphs
   _____ Go back and look at your pictures from earlier paragraphs
   _____ Check to see how much time you had left
   _____ Review your method for learning the material in a paragraph
   _____ Review your objectives and their relation to the paragraph
   _____ Check your overall progress while studying a paragraph
   _____ Change your overall approach to studying the chapter while studying one paragraph

Section 2

There were 7 paragraphs in the chapter on lightning. In how many of the 7 paragraphs did you: (write a number from 0 to 7)

_____ Highlight in a paragraph
_____ Copy a part of the text directly into a note on information in a paragraph
_____ Make a note using your own words for a paragraph
_____ Create a mnemonic (e.g. ROY G BIV) for information in a paragraph
_____ Generate questions in a note on information in a paragraph
_____ Create an analogy (e.g. memory is like a computer) in a note on information in a paragraph
_____ Make examples in a note on information in a paragraph

Section 3

How many times did you do any of the following to guide your studying of the lightning chapter: (write a number)

_____ Use the objectives
_____ Try to learn terms in italics
_____ Compare the figures in relation to the chapter text
_____ Examine headings to see the structure of the passage
_____ Associate figure explanations with the illustration
_____ Try to memorise figure labels
_____ Compare one figure to another
_____ Try to learn terms in bold

Section 4

A) The objectives for the chapter were:
1. Describe important concepts.
2. Explain cause-and-effect relations.
3. Apply principles to explain phenomenon.
4. Generate and evaluate alternative solutions.

There were 7 paragraphs in the chapter on lightning. In how many of the 7 paragraphs did you use any of the following activities to achieve the objectives? (write a number from 0 – 7)

Activity	Objective 1	Objective 2	Objective 3	Objective 4
Compare the figures in relation to the chapter text				
Compare one figure to another				
Try to learn terms in bold				
Try to learn terms in italics				
Examine headings to see the structure of the passage				
Try to memorise figure labels				
Associate figure explanations with the illustration				

B) For each objective, make up you own test question to assess whether you learned everything necessary to achieve that objective.

Objective 1 ____
____
Objective 2 ____
____
Objective 3 ____
____
Objective 4 ____
____

Section 5

For each line, write all the numbers that describe how you studied the chapter on lightning.

0	1	2	3
Did not use: please also state why not in the space provided	**To Understand:** recall and interpret information	**To Apply:** to understand as well as to be able to use and explain relationships	**To Think Critically:** to understand and to apply, as well as to combine information to generate new ideas and to judge qualities of the information

______________________________	Highlight
______________________________	Copy a part of the text directly into a note
______________________________	Make a note using your own words
______________________________	Create a mnemonic (e.g. ROY G BIV)
______________________________	Create diagrams or tables
______________________________	Generate questions
______________________________	Create an analogy (e.g. "Memory is like a computer.")
______________________________	Make examples
______________________________	Compare the figures in relation to the chapter text
______________________________	Associate figure explanations with the illustration
______________________________	Try to memorise figure labels
______________________________	Compare one figure to another
______________________________	Try to learn terms in italics
______________________________	Try to learn terms in bold
______________________________	Use the objectives
______________________________	Examine headings to see the structure of the passage

Appendix K

Ideal Response Checklist #1

Ideal Response Checklist #1 **Participant # ______**

For each question in the test you just took about lightning, we have listed parts of the ideal answer below. For each question, check every part you included in your answer. If you included a part that is not on the list, add it at the end and explain why it is appropriate.

Question #1: Based on your understanding of the passage, please describe how lightning works.

____ warm moist air rises
____ water vapour condenses
____ as raindrops and ice crystals form, they create friction (electric potential)
____ the raindrops and ice crystals drop and air is dragged downward
____ negatively charged particles fall or move to the bottom of the cloud
____ a stepped leader containing negative particles moves down in small steps
____ a travelling spark containing positively charged particles moves up
____ the stepped leader and travelling spark meet on the same path creating the lightning stroke
____ colliding air particles make thunder
____ more than one stroke of lightning may be seen because dart leaders continue to carry negative charges from the cloud to the ground
____ Other response ______________________________
____

Explain ______________________________
____

Question #2: What are the ideal conditions for a lightning storm to develop? Justify why the conditions you have specified are important.

	Condition		Justification
____	when warm air quickly rises to great heights	____	this creates a thermal storm where difference in electrical charges between the cloud and the ground
____	when warm moist air comes together with cold air	____	this creates a frontal storm where difference in electrical charges between the cloud and the ground
____	when there is a cycle of condensation	____	because it produces high electrical potential
____	between or within clouds **or** between clouds and the earth's surface **or** between clouds and the upper levels of the atmosphere	____	because electrical potential is created
____	when electrical potential is created	____	because lightning is formed by a strong electrical field between positively and negatively charged parts of the cloud
____	______________________	____	______________________
____	______________________	____	______________________

Explain ______________________________
____

Question #3: What does air temperature have to do with lightning?

____ warm air rises
____ as air rises, water within the air mass cools
____ cool air mass creates a cloud
____ ice crystals form because the top of the cloud is at freezing level
____ ice crystals become too large to be suspended by updrafts
____ Other response ______________________________
____
Explain ______________________________
____

Question #4: Suppose you see clouds in the sky, but no lightning. Why not?

____ the cloud was not high enough to reach the freezing level needed to create the electrical potential
____ not enough negatively charged particles to fall to the bottom of the cloud to generate electrical potential
____ not enough super-cooled drops or ice crystals to produce a significant downdraft to create the electrical potential
____ not enough mixture of heavier and lighter moist air formed to generate electrical potential
____ not enough positive charge coming from the ground to create the final link needed for a lightning stroke
____ the process of water particles colliding that separates the positive and negative charges in the cloud has not been in effect long enough
____ Other response ______________________________
____
Explain ______________________________
____

Question #5: How does lightning form?

____ negatively charged particles fall to the bottom of the cloud
____ stepped leaders are formed by negative particles and extend to the ground
____ a travelling spark moves up from the ground
____ stepped leader and travelling spark meet
____ more negative charges rush from the cloud to create the lightning stroke
____ return stroke moves particle charges up to the negative charges
____ dart leaders continue to move negative particles to the ground, creating a great number of lightning strokes
____ Other response ______________________________
____
Explain ______________________________
____

Question #6: What determines the intensity of the lightning storm?

____ the initial amount of moisture in the air mass
____ how fast the warm air is transformed into ice crystals or super-cooled water droplets
____ the size of the ice crystals and water droplets
____ the number of negatively charged particles
____ the number of positively charged particles
____ Other response ______________________________
____
Explain ______________________________
____

Appendix L

Ideal Response Checklist #2

Ideal Response Checklist #2

Participant # ______

For each question in the test you just took about pumps, we have listed parts of the ideal response below. For each question, check every part you included in your answer. If you included a part that is not on the list, add it at the end and explain why it is appropriate.

Question #1: Based on your understanding of the passage, please describe how pump systems work.

____ a pump elevates liquid against the action of gravity, or exhausts air or other gases from a closed vessel
____ some pumps move a continuous amount of fluid
____ other pumps move a fixed amount of fluid
____ fluid flows through an inlet pipe into the pump due to the movement of different mechanisms
____ movement of different mechanisms creates a vacuum in the pump
____ pressure causes fluid to move through the pump
____ fluid is released through different mechanisms
____ for some pumps the inlet valve is in synch with the outlet valve
____ some pumps need to be primed (filled with liquid)
____ some pumps trap fluid against the pump wall
____ Other response ______________________________
____
Explain ______________________________
____

Question #2: What are the similarities and differences between the pump systems?

	Dynamic Pumps			Positive Displacement Pumps
____	maintain a steady flow of fluid	vs.	____	trap individual portions of fluid in an enclosed area before moving them along
____	vacuum is created by rotation of sliding vanes	vs.	____	vacuum is created by a piston
____	requires centrifugal force to move fluid	vs.	____	direct application of pressure from pistons or impellers to move fluid
____	moves large amounts of liquid	vs.	____	moves a fixed amount of liquid
____	liquid exits because of pressure	vs.	____	liquid or air exits because of pressure
____	____________	vs.	____	____________
____	____________	vs.	____	____________
____	____________	vs.	____	____________

Explain ______________________________
____

Question #3: Suppose you push down and pull up the handle of a pump several times but no air comes out. What could have gone wrong?

____ there is no fluid in the pump
____ a valve is stuck
____ a seal is broken
____ the supply inlet line is blocked
____ the piston has become unattached from the handle
____ the supply to the pump is closed or empty
____ Other response ____

____

Explain ____

____

Question #4: A sliding vane pump fails to work. What could create this failure? What could be done to make the pump work properly and more reliably?

	Problem		Solution
____	a sliding vane is broken	____	fix the sliding vane
____	a sliding vane doesn't move	____	check the springs to which the impellers are attached are working
____	there's a blockage near the outlet pipe	____	remove the blockage
____	there's not enough pressure	____	improve the movement of the sliding vanes
____	there's not enough pressure	____	narrow the space up to the outlet pipe
____	____________________	____	________________________________
____	____________________	____	________________________________
____	____________________	____	________________________________

Explain ____

____

Question #5: What are two types of pumps? Provide an example of each. Why are they good examples?

____ centrifugal pump
  ____ *example*: water pumping stations **or** chemical processing plants **or** oil refineries **or** other ______________________________
  ____ *reason*: it supplies a constant pressure **or** needs to be primed or filled with fluid
  or maintains a steady flow of fluid **or** requires centrifugal force **or** other

  ____

____ positive displacement pump
  ____ *example*: sump pump **or** tire pump **or** fuel pump **or** air compressor **or** paint sprayer **or** other ______________________________
  ____ *reason*: traps portions of fluid or air **or** direct application of pressure forces air or liquid out **or** uses a vacuum **or** other

  ____

____ centrifugal/dynamic Pump
  ____ *example*: water pumping stations **or** chemical processing plants **or** oil refineries **or** other ______________________________
  ____ *reason*: it supplies a constant pressure **or** needs to be primed or filled with fluid **or** maintains a steady flow of fluid **or** requires centrifugal force **or** other

  ____

____ sliding vane/rotary pump
  ____ *example*: air compressor **or** paint sprayer **or** other __________

____ *reason*: traps portions of fluid or air **or** direct application of pressure forces air or liquid out **or** uses a slotted impeller mounted off centre in a circular casing **or** other ________________________________

____ lift/reciprocating pump__________

____ *example*: coffee urn **or** sump pump **or** well **or** other __________

____ *reason*: traps portions of fluid **or** pushing down raises the piston and draws in liquid **or** direct application of pressure forces liquid out **or** uses a vacuum **or** / other ________________________________

____ air/reciprocating pump

____ *example*: bicycle tire pump **or** other __________

____ *reason*: traps portions of air **or** direct application of pressure forces air out **or** uses a vacuum **or** air enters the pump when the rod is pulled out and exits when pushed in **or** other ________________________

Question #6: What could be done to increase the efficiency and effectiveness of a pump system?

____ turn the impeller faster
____ use larger inlet pipes
____ use larger outlet pipes
____ increase the diameter of the cylinder
____ decrease the size of the casing in a sliding vane pump to create more pressure
____ move the pistons faster
____ increase the amount of fluid which move through the rotary pump
____ decrease the height of the outlet pipe
____ Other response ____

____

Explain ____

____

Appendix M

Study Tactics Feedback Form

Study Tactics Feedback

Participant # _____

These are the same studying tactics you rated in the Study Tactics Questionnaire plus reasons for using them.

The number in front of each studying tactic represents how often you reported using that tactic in the questionnaire you answered at the beginning of the experiment.

Chapter 2 is about pumps. You will be asked the same types of questions on the test about pumps as you were asked on the test about lightning. Rate how many times (out of 7) you will use each studying tactic as you in study the chapter about pumps.

BEFORE *(Chpt 1)*	***NOW*** *(Chpt 2)*	Study tactic		IT WILL HELP YOU TO:
___	___	Highlight: Select key terms, concepts, definitions & main arguments.	→	• Guide review of chapter content
___	___	Create a Note: Put chapter information into your own words (e.g. paraphrase).	→	• Check understanding • Review information
___	___	Create a Mnemonic: Generate a phrase or image to represent words or concepts (e.g., ROY G BIV for colours of the spectrum)	→	• Make information easier to learn & remember (personalise)
___	___	Generate Questions: Invent questions before reading the chapter (e.g. How much do I know about this topic?), during reading of the chapter (e.g. Does this relate to anything I already know?), and after reading the chapter (e.g. What was this chapter about?)	→	• Before: Choose information to focus on • During: Evaluate your understanding about information as you study • After: Evaluate your understanding of the chapter
___	___	Create an Analogy: Create a link between new and known concepts based on shared features (A is like B because ...).	→	• Make information easier to learn & remember
___	___	Create Examples: Generate a your own model or illustration of a concept or principle	→	• Use your prior knowledge to associate new information and check your understanding
___	___	Copy to a Note: Make a note using the exact words from the text	→	• Recall information • Memorise

BEFORE (Chpt 1)	NOW (Chpt 2)	ACTIVITY & HOW TO USE IT		IT WILL HELP YOU TO:
		• Think about what you already know about the subject matter • Plan your time • Set objectives for studying • Plan a method for studying the chapter	→	• Generate ideas on what the chapter might be about • Preview the chapter to see how long it is and decide how much time to spend on it • Determine how much time you can spend studying specific sections of a chapter • Generate ideas about kinds of questions that might be asked on the test • Set goals for learning • Identify information which may help you learn information about the subject • Select strategies appropriate to reach your goals • Be prepared to check what you're studying effectively
		• Stop to check your understanding of a paragraph • Check your understanding of a paragraph against what you already knew • Ask yourself questions while you read a paragraph • Check your overall progress while studying a paragraph • Change your overall approach to studying • Check to see how much time you have left	→	• Identify and select important information • Check whether you identified important points in the paragraph • Use information you've learned so far to generate better ideas about questions that might be asked on the test • Adjust your first impressions about goals for learning • Identify whether the strategies are working • Ensure there is adequate time to finish studying the chapter
		• Ask yourself questions to review your understanding of the paragraph • Go back and make connections with information in earlier paragraphs • Go back and review information that was not clear in earlier paragraphs • Go back and look at your notes from earlier paragraphs • Go back and look at your highlighting from earlier paragraphs • Go back and look at your pictures from earlier paragraphs • Review your method for learning the material in a paragraph • Review your objectives and their relation to the paragraph	→	• Determine whether you understand relationships across sections of the chapter • Evaluate whether you have extracted key points or explanations • Evaluate your understanding of explanations about these figures • Judge whether strategies you used helped you learn the material • Evaluate whether you reached the goals you set for yourself

Appendix N

Final Questions for the Corrective Feedback Group

Final Questions

Participant # _____

I. In Section I, we would like to know if the **Ideal Response feedback** you received at the beginning of this session affected your **studying the chapter on pumps**. Refer to your **Ideal Response Checklist #1** (yellow sheet) to answer these questions.

A. **How much** did the ideal response feedback you received influence your **approach to studying the chapter on pumps**?

0	1	2	3	4	5	6	7	8	9	10
not at all					moderate					completely

B. If you answered other than 0 (not at all) to question IA, **in what way(s) did you change your studying** when you studied the **chapter on pumps** because of the ideal response feedback you received?

C. **Why** did the ideal response feedback lead you to change or not to change your **approach to studying the chapter on pumps**?

II. In Section II, we would like to know if the **Ideal Response feedback** you received at the beginning of this session had an affect on your **approach to taking the test on pumps.**

A. **How much** did the ideal response feedback you received influence your **approach to taking the test** on pumps?

0	1	2	3	4	5	6	7	8	9	10
not at all					moderate					completely

B. If you answered other than 0 (not at all) to question IIA, **in what way(s) did you change your approach to taking the test** because of the ideal response feedback you received?

C. **Why** did the ideal response feedback lead you to change or not to change your **approach to taking the test**?

III. For the question after the test, "How much effort did you put into studying the chapter on lightning?" in session 1, you rated your effort as ____/10. For the question, "How much effort did you put into studying the chapter on pumps? in session 2, you rated your effort as ____/10. (0=no effort, 10=complete effort)

Why did you rate your effort the same or differently for studying these two chapters?

IV. For the question after the test, "How much effort did you put into answering the questions above on lightning?" in session 1, you rated your effort as ____/10. For the question, "How much effort did you put into answering the questions on pumps? in session 2, you rated your effort as ____/10. (0=no effort, 10=complete effort)

Why did you rate your effort the same or differently for answering the questions for these two chapters?

Appendix O

Final Questions for the Process Feedback Group

Final Questions

Participant # _____

I. In Section I, we would like to know if the **Studying Tactics feedback** you received at the beginning of this session affected your **studying the chapter on pumps**. Refer to your **Study Tactics Feedback** (pink sheet) to answer these questions.

A. **How much** did the studying tactics feedback you received influence your **approach to studying the chapter on pumps**?

0	1	2	3	4	5	6	7	8	9	10
not at all					moderate					completely

B. If you answered other than 0 (not at all) to question IA, **in what way(s) did you change your studying** when you studied the **chapter on pumps** because of the studying tactics feedback you received?

C. **Why** did the studying tactics feedback lead you to change or not to change your **approach to studying the chapter on pumps**?

II. In Section II, we would like to know if the **Studying Tactics Feedback** you received at the beginning of this session had an affect on your **approach to taking the test on pumps.**

A. **How much** did the studying tactics feedback you received influence your **approach to taking the test** on pumps?

0	1	2	3	4	5	6	7	8	9	10
not at all					moderate					completely

B. If you answered other than 0 (not at all) to question IIA, **in what way(s) did you change your approach to taking the test** because of the studying tactics feedback you received?

C. **Why** did the studying tactics feedback lead you to change or not to change your **approach to taking the test**?

III. For the question after the test, "How much effort did you put into studying the chapter on lightning?" in session 1, you rated your effort as ____/10. For the question, "How much effort did you put into studying the chapter on pumps? in session 2, you rated your effort as ____/10. (0=no effort, 10=complete effort)

Why did you rate your effort the same or differently for studying these two chapters?

IV. For the question after the test, "How much effort did you put into answering the questions above on lightning?" in session 1, you rated your effort as ____/10. For the question, "How much effort did you put into answering the questions on pumps? in session 2, you rated your effort as ____/10. (0=no effort, 10=complete effort)

Why did you rate your effort the same or differently for answering the questions for these two chapters?

Appendix P

Consent Form

SIMON FRASER UNIVERSITY

You may make $65 by participating in a study!

This study investigates your views on studying and how you study. If you complete both sessions, you will receive $15 *and* you may win one of four $50 prizes awarded by random draw. Your odds of winning a $50 prize depend on the total number of participants which will not exceed 150.

Session #1 will take about 1 hour. You will answer a questionnaire about your views of studying. Then, you will be taught how to use a simple computer environment, called *PrepMate*, to study a short chapter and then complete questions related to the material you studied. *PrepMate* will record your studying activities, such as what you highlight and notes you make.

Session #2 will take place 1 day after Session #1 and will take about 1 hour. You will receive a second chapter to study using *PrepMate* and complete questions similar to the ones in Session 1. Session 2 will end with a brief interview.

This research has been examined and approved by the SFU Ethics Review Committee. Your participation is completely voluntary. All information gathered for research will be labeled by a random code so that you are entirely anonymous. If you decide at any time that you don't want to continue participating, all information about you will be erased from the research files.

If you want to participate in this research, sign below to indicate that you understand the voluntary nature of participating. If you want a report on this project after it is completed, provide an address (below) to which we can mail it. If at any time you have questions about this project, please see one of us (telephone and address are at the bottom of this letter). If you have questions or concerns that you prefer to discuss with someone else, contact Dr. Phil Winne, Professor of Education and Psychology, supervisor of our research, telephone 291-4858 or Dr. Robin Barrow, Dean of the Faculty of Education, 291-3148.

Thank you. Your participation is greatly appreciated.

Stephanie Chu and Dianne Jamieson

Return this signed form to Dianne Jamieson or Stephanie Chu to schedule sessions.

Signature ______________________________

Name (print) ______________________________

Phone or E-mail (the best way to contact you) ______________________________

Address ______________________________

Appendix Q

Further Investigation of Group Differences

A MANOVA indicated no multivariate differences between the condition groups in this study although univariate tests indicated a difference in achievement scores. As a result, further analyses were performed. In the next step, an ANCOVA examined the score in session 1 by treatment group with the following variables as covariates: high-order and low-order tactics use, general science and weather knowledge, and effort. After removing variance in the achievement score in session 1 that was shared by the other five variables, results suggested that there was still a difference in the residual of the score across treatment conditions; $F(5,82)=4.58$, $p=.001$. Results remained unclear on whether differences were due to random factors or to the semi-random assignment.

To further explore this apparent difference, a logistic regression was performed to assess prediction of group membership in the two groups based on the six measures as predictors: grade, high-order tactic use, low-order tactic use, general science knowledge, prior knowledge about weather, and effort. The test indicated that the model was statistically reliable, $x^2(6, N=83)=13.94$, $p=.03$. However, the percent of correctly classified membership in the two groups was not impressive at only 65%.

In conclusion, several analyses were performed to investigate whether statistically significantly different achievement scores between groups in session 1 were due to semi-random sampling. Results remain unclear.