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LEARNERS' COLLABORATIVE PRACTICAL INVESTIGATION ON ACCELERATION DUE TO GRAVITY: A COMPARISON OF THE EFFECT ON THEIR UNDERSTANDING USING AN ONLINE LEARNING ENVIRONMENT AS OPPOSED TO FACE-TO-FACE INTERACTION.

Nicolette Angjelika Aidan Glanville

A research report submitted to the Faculty of Science, University of the Witwatersrand, in partial fulfillment of the requirements for the degree of Master of Science.

Johannesburg, 2011

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DECLARATION

I declare that this research report is my own, unaided work. It is being submitted for the Degree of Master of Science in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

Nicolette Angjelika Aidan Glanville

_____

_____day of _____2011

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ABSTRACT

Moodle, an online course management system, has been introduced into the school where this study was conducted. One of the features on Moodle is a forum that allows groups to chat online, enabling online collaborative group work. Learners used the forum to design a practical investigation to study the effects of various factors on the acceleration of a falling body and analyse the results in order to draw a conclusion. Consequently, this study compares the effects on learners' participation within a group and learners' understanding of acceleration due to gravity using an online learning environment as opposed to face-to-face interaction. The study also investigates learners' perceptions of the use of activities in Moodle as effective learning tools. Alternative conceptions regarding acceleration due to gravity are common and persistent. It was hoped that a peer group collaborative practical investigation may help challenge these alternative conceptions. Time in class for collaborative learning is limited due to a full curriculum and learners have extensive extramural commitments in the afternoons that limit collaborative opportunities. However, our learners have access to the Internet and are familiar with online social networking.

Items in the pre-test and post-test were based on the Force and Motion Conceptual Evaluation devised by Thornton and Sokoloff (1998). Contrary to their findings that showed a disappointingly small *improvement* in the scores after traditional teaching, test scores for learners in this study *dropped* after completing the practical investigation. Another post-test administered seven weeks later showed that many learners had reverted back to previous alternative conceptions. It is possible that the frameworks learners use to solve textbook problems are replaced with intuitive conceptions when faced with real life application of the laws in their practical investigation.

With regard to the collaborative group work, the findings suggest that while there were far fewer off-task comments on the online forum, less challenging of alternative conceptions occurred, with participants often re-stating the correct conception without engaging with the other participants. The face-to-face contained lively debates and the use of good analogies but there were also cases

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where the voice of reason was drowned-out by more insistent alternative conceptions.

Some learners found the discussion on the forum disjointed and difficult to follow. Aspects of the forum can be changed to minimize these problems in future. Most learners enjoyed the self-marking tests and questionnaires. Overall, neither the collaborative discussions on either the Moodle forum or face-to face, nor the practical investigation helped to challenge alternative conceptions.

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CHAPTER 1 - INTRODUCTION

1.1 Introduction

Acceleration due to gravity is a topic that is taught in grade 11 and provides necessary prerequisite knowledge for Grade 12 Mechanics. Gravity is a topic that is known to have persistent, alternative conceptions (Watts, 1982; Baldy, 2007). Many learners subscribe to the notion that the greater the mass of an object, the greater the speed (Gunstone & White, 1981; Barr, Zinn, Goldmuntz & Sneider, 1994; Weller, 1995). Another common alternative conception is that motion -implies- force (Palmer & Flanagan, 1997).

I have used a practical investigation of the factors that affect the acceleration of falling objects to address this alternative conception for years and my experience in the classroom has mirrored the alternative conceptions described in the literature. The planning, execution, data gathering and interpretation of results is completed by learners as a group and each member writes up his report individually. In previous years, the design of the practical and the data collection have been completed in class in groups and the interpretation of the results was left for the learners to complete after school. My experience has been that the results are often variable and despite subsequent teaching of Newton's universal law of gravitation, and showing that the acceleration due to gravity, g, is independent of the mass of the object, many learners remain unconvinced that the mass of the object has no effect on the acceleration with which it falls. Baldy (2007) reports similar findings.

In the past the overall standard of the practical reports was disappointing in that many learners had not related the practical to theory. The group work was mainly evident in the team work required to collect the data and the lack of structured group work may be an area of weakness that could be remedied. Learners often complete collaborative practical investigations as quickly as they can and so the intended benefit of the collaboration is lost. According to Johnson

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and Johnson (1999) collaborative learning can result in critical thinking, deeper level learning, shared understanding and long term retention of the learned material. I expect that if greater emphasis is placed on the collaboration between group members to complete a practical investigation, more meaningful learning will occur.

While I value face-to-face collaborative work, I am wary of using too much teaching time for group work. The learners I teach are busy and have little time for homework, projects or group work out of school hours as a result of school activities.

A possible solution to the learners' difficulty with meeting face-to-face for collaborative group work after school is the use of an online learning environment. Moodle has recently been set up at the school and is in use at many schools in Johannesburg..

Could we do group work on the internet? How does it compare with face-to-face group work? How do learners feel about doing other activities that might be better suited to the internet? The next section of the chapter is devoted to the context of the study to provide the reader with greater insight into the study.

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1.2 Background: the institution and Moodle

The school to which I refer is both the site of research and my full-time employment and while quite typical of a small niche of private boys-only schools is certainly not representative of schools in South Africa as a whole.

When the school first opened its doors seventy years ago, it was situated on the outskirts of Johannesburg in a farming area. The closest tarred road was a couple of kilometers away. As is common in many cities, the original central business district (CBD) degenerated and a new CBD sprang up two kilometres from the school. The residential area around the school is affluent with large houses on large stands being the most typical. The school accommodates learners from 4-18 years and many of our learners attend the same school throughout this period. The

school provides full bursaries to 3.7% of learners in the 13-18 year age group and 5.4% are awarded scholarships or bursaries between 50% and 95% of the fees. Some of these boys experience a very different home life compared to their affluent class mates.

Extra-curricular activities are strongly promoted at the school with a particular focus on sport. Private education is quite competitive and sporting prowess seems to be an important draw card in attracting learners to a boys' school. The school is relatively small with 540 learners in grades 8 to 12. The top achieving learners are expected to play sport at a competitive level so sports' practices are held every afternoon with the exception of Tuesdays which is earmarked for Advanced Programme Mathematics and extra lessons in many of the academic subjects. Swimming and pre-season hockey training are held at 6 o'clock in the morning. Learners are actively encouraged to support the various outreach projects initiated by the school and are required to complete at least 10 hours of community service each year. Those hoping to be accepted to study medicine need to complete considerably more. The school also offers a wide range of cultural activities. The major school production's rehearsals are held until 9 o'clock at night four evenings a week. Public speaking, debating, chess, jazz band, marimba band and choir also engage in competitions between schools and make demands on learners' time. Due to the busy extra-curricular programme at the school, it is unrealistic to expect learners to engage in face-to-face collaboration after school.

The school has an information technology (IT) department and the use of computers and technology in classrooms is encouraged and the support of teachers to this end is given priority. The mathematics classrooms and science laboratories are situated on the same floor to enable easy access to a mobile trolley containing thirty Apple Mac laptops that are battery operated and have wireless connection to the school network and internet. The science department works closely with the information technology department in the school. The departments often set joint projects for learners in Grade 8 where both departments will assess their own components of the task. This degree of collaboration extends to the staff. Often

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the Science staff will try out a new IT product or technology before the rest of the school. The science department was one of the first to use and promote Moodle

Moodle (the acronym for Modular Operator Oriented Dynamic Learning Environment) is an open source software package that is used to produce internet-based courses and web-sites. There are 49 834 registered Moodle sites operating in 212 countries with 40 092 834 users, 1 119 111 of whom are teachers (Moodle Statistics, n.d.). Moodle is a course management system that learners can access via the internet using their school network username and password. Teachers can load notes, assignments, past papers and self-marking tests for a specific subject and grade. In addition, instead of blackboards or whiteboards, many teachers use electronic interactive whiteboards. Any images and writing on the electronic board that occurred during the lesson can be saved for future use and can also be loaded onto Moodle. Via the internet, learners can select their grade and subject and view, download or print any of the notes or past papers, complete the online self-marking tests or upload their assignments. An email is automatically sent to the teacher once an assignment is uploaded by a learner. Once the teacher has graded the assignment, an email is sent to the learner with the link to their mark and feedback for the assignment. I have already made use of Moodle to give learners access to past examination papers and memoranda from the school Moodle site and to upload their research reports and draft PowerPoint presentations. I have posted feedback on the draft and the learners have made the suggested improvements and uploaded their final projects.

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1.3 Rationale for the study

Our school has followed the trend of many private schools and acquired Moodle, a course management system that provides an online learning environment.

One of the features of Moodle is a *forum*. A forum in Moodle can be limited so that only group members in a specific group can view and edit the content. This allows for collaborative work of group members via the internet. I believed that the learners would be able to access Moodle via the internet after school hours and

a forum on Moodle may be a good platform for collaborative work and provide an alternative to traditional group work between learners. My hope was that learners may be more conscious of their contributions and challenge each other's alternative conceptions when working together via the internet where there is a record of each learner's participation in writing.

The alternative conceptions that learners exhibit, particularly in the area of force and motion, have been a source of continued interest and concern for me over the years. Guided by the literature, I have become more acutely aware of alternative conceptions and modified my teaching strategies accordingly. I have administered the Force and Motion Conceptual Evaluation devised by Thornton & Sokoloff, (1998) to my grade 11 learners for the last three years. Our partnership with a disdavantaged school that completes the practical component of the portfolio at our school highlighted some of the conceptual difficulties. The learners were required to complete the practical used in this study. The belief that the object with the heavier mass will drop faster proved particularly resistant to change. The practical was introduced into the grade 11 course at *our* school in the hope that it would illucidate some of the alternative conceptions and improve our teaching. The use of the practical has been refined each year. It can be expected that if alternative conceptions regarding gravitational force and acceleration due to gravity are challenged, other alternative conceptions regarding force and motion may also be remediated.

My learners are "digital natives" in that they have grown up surrounded by and using technology and can be considered "all "native speakers" of the digital language of computers, video games and the Internet" (Prensky, 2001, p. 1). Most learners connect regularly to the internet and subscribe to an internet-based social network site such as Facebook or MySpace. In order to gauge familiarity with internet-based social network sites, I discovered that 33% of the learners spend less than 15 minutes on average per day, 42% between 15 minutes and an hour and 10% more than an hour on sites such as Facebook, MySpace or Twitter while 15% do not subscribe to those sites. (Appendix N)

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The trend of social network sites being used for *online to offline* interactions, as in an online dating site, has changed to *offline to online* with social network sites often being used to continue or consolidate interactions between acquaintances that met offline (Ellison, Steinfield & Lampe, 2007). This type of interaction is familiar to most learners and thus should provide a comfortable milieu in which to engage in collaboration online.

Since Moodle is web-based it is important that learners have access to the internet. The characteristics of the learners at school that indicate that an online learning environment may promote collaborative learning are detailed below:

Many learners at school have their own personal computers, laptops, PDA's or cell phones that link to the internet. I determined that 77% of the learners in this study have their own computer with access to the internet and 96% have cell phones that connect to the internet. The library and the computer centre are open after school and provide internet access so learners who do not have internet access at home can make use of the school facilities. 10% of learners said they used the school computers in the library to complete school work very often and 15% used them quite often.

To accommodate Moodle requires a change in mindset and extra and different preparation. Before making this commitment, as head of Physical Sciences at the school I want to know whether this is an educationally sound way of teaching in my context and the ways in which it will be beneficial to my teaching. Many of the features available on Moodle, e.g. self-marking tests and access to past exam papers and memos, appear to provide unquestioned benefits. The benefit of the use of Moodle as a platform for collaborative group work does not seem assured as group work is traditionally carried out face-to-face.

If we are to adopt this technology more fully into our teaching it will have far-reaching implications and pose new problems: Do we put laptops or notebooks on the stationery list so all learners need to have one? Do we expect all staff to use the online learning environment and to what extent? Or do we just support and encourage teachers who want to use it? We have disadvantaged learners who

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receive a bursary and live in disadvantaged areas – do we supply them with laptops or notebooks which may compromise their safety or should we improve the access to the internet at school?

Much research has been carried out in separate studies, on the topics of collaborative learning, alternative conceptions in science and the comparison of the use of an online learning environment and face-to-face interactions. Often these studies are done outside the classroom environment under very controlled conditions in order to obtain quantifiable results. The information gleaned from this research is useful in guiding my choices in the preparation of teaching and explaining the outcomes. It seemed, however, that the most effective method to establish if Moodle would be accepted and useful to my learners in this context was to conduct action research *in situ*.

1.4 Aim of the study

The principal aim of the research is to investigate the use of an online learning environment for a collaborative practical investigation using acceleration due to gravity as the content for the investigation.

A secondary aim of the research is to inform school policy regarding the appropriate use of computers and Moodle and the internet, in teaching at the school in the future.

1.5 Research Questions

The present study was designed to answer the research questions detailed below:

1.5.1 What are the effects of the use of an online learning environment for a collaborative practical investigation on acceleration due to gravity:

a) on the learners' understanding?

b) on learners participation within a group?

1.5.2 What are learners' perceptions of the use of activities in Moodle as effective learning tools?

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1.6 Sequence of the research report

The rest of this report is structured in four chapters as follows:

Chapter two reviews the relevant literature on the theoretical frameworks that underpin collaborative learning, the use of online learning environments and the alternative conceptions associated with acceleration due to gravity.

The third chapter details the research methodology and design. It maps out the research instruments used, the process of the data collection and adherence to ethical norms. Attempts to address validity and reliability are discussed in conjunction with the selection of the sample.

Chapter four presents the analysis of the data in response to the research questions and describes some unexpected outcomes of the study.

The fifth chapter attempts to clarify answers to the research questions while highlighting questions that have arisen from this study that require further research.

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CHAPTER 2 – LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Introduction

In this chapter, the theoretical framework that underpins the study will be explored. This is followed by a review of the literature on the integrated and separate studies on the use of Moodle or similar course management systems, the effects of collaborative learning and the extensive body of knowledge that has interrogated the alternative conceptions associated with acceleration of falling bodies which provides the foundation and context of the study.

2.2 Theoretical Framework

Ferguson (2007) points out that theoretical frameworks influence the methods used and the research questions asked by researchers. Caliendo (1996) emphasizes the dependence of scholarly work on theory. He maintains that the benefit of articulating a theoretical framework is that the underpinning theories and the inherent assumptions in the study are clearly communicated to the reader and the link between the theory and the research design, model and data analysis becomes apparent. Abd-El-Khalick and Akerson (2006, p. 188) describe the most sophisticated end of the continuum of theoretical frameworks as "intricate developments of hypothesized links among different theories into a complex web of ideas to help guide research studies." In this study the use of collaborative learning is the focal point posed by the primary research question while challenging alternative conceptions and the use of computers and technology to communicate are ancillary topics. To achieve coherence in this study, it is necessary to investigate how these three topics relate in terms of the theoretical framework.

In order to present a coherent theoretical framework that encompasses collaborative learning and Moodle it is useful to interrogate the premise of the design of the course management system. Moodle is distinguished from other

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online course management systems in that the underlying philosophy inherent in its design is social *constructionism* (Dougiamas, 1998). Social *constructionism*, often described by the catch phrase "learning-as-making" (Papert, 1991), is distinguishable from social *constructivism* even though the two terms are often used interchangeably. To fully appreciate social constructionism, it is useful to briefly consider its development from constructivism. Watts and Bentley (1991) describe constructivism as a theory that emphasizes that individuals create their own conceptions of reality based on their own perceptions of sensory data. From the *cognitive* constructivist perspective the mind of the individual is focused on as the site of learning (Piaget, 1964). Vygotsky (1978) extended constructivism to include the role that social interaction plays in the development of higher mental functions. The use of semiotic tools and the development that occurs as a result of the assistance of more capable others are the hallmarks of Vygotsky's socio-cultural constructivism (Wertsch, 1979).

Gergen (1999) writing from the discipline of psychology, highlights the commonality of emphasizing that what is considered "real" is a human construction found in both social constructivism and social constructionism. Gergen pinpoints the fundamental contrast: for social constructivists "the head" determines how the world is constructed whereas for social constructionists our view of reality is a product of social relationships (p. 237).

The term *social constructionism*, as described by Gergen (1999), is used by Dougiamas and Papert in the context of computer programming by learners in education. Seymour Papert describes social *constructionism* as the extension of social *constructivism* - "the building of knowledge structures" to include the "conscious construction by the learner of a public entity" (Papert, 1991, p.1). Papert (1991) highlights the distinction between *constructionism* and *instructionism* in the use of computer technology. He envisions the use of computers in education not as another medium of teaching but as a flexible tool to be used to encourage thinking and creativity in the production of knowledge. He proposes a radical reform of education that can be facilitated by computers when used to create a tangible product either individually or as a collaborative

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effort of learners (Papert, 1980). Dougiamas (1998) cites a wiki as an example of a constructionist knowledge structure that is collaboratively written and edited by learners that can be accessed by others on the internet or within a course and thus serves as a public entity that is constructed by the learner.

Collaborative learning shares many features with the design and use of Moodle. According to Pierre Dillenbourg, cited in Vesisenaho, Valtonen, Kukkonen, Havu-Nuutinen, Hartikainen and Karkkainen (2010), the theoretical basis for collaborative learning is evident in both socio-cultural and socio-constructivist approaches to learning. The active participation of learners and the interaction with others is common to both. Piaget (1932) negated the effect of adult interaction with children due to inequalities of power and status but regarded peer interaction as significant in promoting progress (Littleton & Hakkinen, 1999). Piaget (1985) highlighted conceptual conflict as a pre-requisite for equilibration and noted that group-generated conflict was particularly beneficial and helped to develop logic. Howe, Tolmie, Anderson and Mackenzie (1992) reported that conceptual change occurred most readily during collaborative tasks when there was internal conflict and re-equilibration.

Littleton and Hakkinen (1999) describe a series of studies in the 1970s and 1980s by Doise, Mugny and Perret-Clermont that focused on whether the *individual* would make progress in understanding as a result of the socio-cognitive conflict in a group activity. Their study distinguished between the progress of the group as a whole and the progress of the individual and compared whether an individual's understanding would be enhanced as a result of the group interaction as opposed to the individiual working alone.

Duran, Dugan and Weffer (1998) characterize the socio-cultural Vygotskian approach to instruction as one in which the learner action is initiated by the teacher defining important cultural activity and explaining its purpose and execution. In the subsequent phase, the teacher's role is to guide activity and support student practice. The foregrounding of the authority of the cultural tools is an important aspect in empowering learners to carry out the activity. In this context the cultural tool refers to mastery of the social language of the disciplinary

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community. This can refer to the use of information and communication technologies (ICT) and specifically the use of a forum as an online chat facility.

The scientific community could also be regarded as a disciplinary community in the context of this study. Learners are required to use the semiotic tools of scientists in the "specific genre of scientific languages … such as the scientific method and report writing" (Duran, Dugan, & Weffer, 1998, p. 314). In the practical investigation, learners are required to design a practical, identify variables and agree on an aim and hypothesis. Having collected the data, the learners meet to analyse the data together and discuss their findings. Here the social language refers to the joint understanding and language used in science. There is also a dimension of *situated learning* as learners are trying to use a process that scientists would use (Lave, 1996). This could be considered as a cognitive apprenticeship as they are introduced to a *community of practice* (Brown, Collins & Duguid, 1989). It could be argued that in many cases the use of ICT could also be considered part of the semiotic tools of the scientific community: there are many scientific papers published where the authors work at separate universities and have never met in person but have collaborated to complete and publish a journal article by communication via email and other media.

The area of alternative conceptions can also be viewed from a constructivist perspective. Smith, Di Sessa and Roschelle (1993) criticise the use of the term "misconception". They assert that the idea of a misconception contradicts one of the main tenets of constructivism: that learning begins with the prior knowledge and conceptions of the learner. In the next section, work that has been done that relates to this study is reviewed.

2.3 Literature review

A preliminary step in the design of a research study is to determine the scope of the existing work in the field linked to the research questions. This is often an iterative process as the literature will often help to refine or redirect the focus of

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the research questions. Through the literature, the researcher is alerted to useful theoretical frameworks, informed of a range of data collection and analysis methods, made aware of avenues of further research and directed to additional literature. The purpose of a literature review in a research report is to demonstrate the results of this iterative process and provide the reader with a concise, insightful overview of the current situation (Burton, Brundrett & Jones, 2008).

The literature review describes current thinking and research in the use of ICT in and its value in promoting collaborative learning. Moodle and various studies pertaining to the use of Moodle are described. The other topic of relevance to this study that is reviewed is the alternative conceptions associated with force and motion in general and then more specifically at gravitational force and acceleration due to gravity.

2.3.1 ICT, Moodle and Collaborative Learning

The use of information and communication technologies (ICT) has increased considerably over the past decade. The learners I teach are "digital natives" and have grown up surrounded by cell phones, personal computers and laptops (Prensky, 2001). Many learners have cell phones that connect to the internet and remain in constant contact with their social networks via Facebook, Mxit and Twitter. Parents are so dependent on communicating with their children via cell phones that when teachers confiscate cell phones for unsanctioned use in class, parents supply their children with a replacement for the period that the phone is withheld. Most children have perfected the art of negotiation with their parents via short messaging service (sms) and many children report that the outcome is more successful than face-to-face negotiations.

ICT has also made its presence felt in the classroom. Vesisenaho, Valtonen, Kukkonen, Havu-Nuutinen, Hartikainen and Karkkainen (2010) describe the extending of traditional teaching with the use of social software with various everyday technologies such as cellphones and mini-laptops as blended learning. The traditional teaching refers to face-to-face teaching while the use of everyday technologies implies the use of a *course management system* such as Moodle

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that facilitates the access of additional materials and learning assignments online. Moodle as has been described earlier is a *course management system* with very wide appeal that has generated much interest in terms of its usefulness in education. In the period from 2003 till 2007 in Taiwan alone, there were 23 studies in which Moodle was the research topic in either of Masters or PhD theses (Liao & Chen, 2010). There are various modules in Moodle, e.g. a wiki and a forum, that facilitate interaction between users and promote collaborative learning. Liao and Chen (2010) reported that the content and quality of assignments had improved as a result of learners working together on chat rooms and forums on Moodle. Computer supported collaborative learning (CSCL) is an extensive field and is discussed in the next section.

Pierre Dillenbourg, coordinator of a multidisciplinary group of scholars representing cognitive psychology, educational science and artificial intelligence admitted that the group could not agree on any definition of collaborative learning due to the range of different meanings and contexts with which the term is associated (Dillenbourg, 1999). The working definition of the term used in this study that Dillenbourg uses often is:

> "… a coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem" (Roschelle & Teasley, 1995, p. 70)

A great deal of interest has been shown in Computer Supported Collaborative Learning (CSCL) and it has been the topic of much research (Littleton & Hakkinen, 1999). Various attempts have been made to assess the quality of the collaboration (Meier, Spada, & Rummel, 2007). The ability to communicate effectively is one of the key requirements for successful collaboration. The *task-media fit hypothesis* developed by McGrath and Hollingshead (1993), cited by Mennecke, Valacich and Wheeler (2000) proposed that some group tasks are better suited to a lean medium of communication while others require a rich medium. Computer systems, audio systems, video systems and face-to-face communications are ranked from lean to rich in terms of the medium of communication. If the medium is richer than the task requires, the medium may

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serve as a hindrance while conversely if the medium is too lean the required communication will not be effective. Four categories of tasks are described: the generation of ideas and plans, the choice of a correct answer, the choice of a preferred answer and the negotiation of a conflict of interests (Mennecke, Valacich & Wheeler, 2000, p. 510). The first category requires the leanest medium while the last will need the richest medium. Face-to-face discussions are considered the richest medium.

In a comparative study of the effects of face-to-face versus chat communication on the performance in a collaborative inquiry modelling task, Sins, Savelsbergh, van Joolingen and van Hout-Wolters (2011) concluded that their findings were contrary to the *task-media fit hypothesis* in that the chat communicators outperformed their face-to-face counterparts. This was surprising as the collaborative inquiry modelling task required negotiation which according to the *task-media fit hypothesis* requires the richest medium. They accounted for the discrepancy based on the fact that they were working with dyads which eliminated the confusion that can arise from trying to keep track of the conversation on chat. Another contributing factor was that the participants in their study were very familiar with using chat as a mode of communication. In analysing the interaction between dyads, Sins, *et al.* (2011) distinguish between *surface* and *deep reasoning*, describing *surface reasoning* as involving unelaborated processes where students do not refer to knowledge. Substantiation is an aspect of reasoning that particularly distinguishes *deep reasoning* from *surface reasoning* and relates to referring to experiential knowledge, physics or mathematics knowledge and components of the model used in the study. They noted that the particpants communicating via chat had far fewer communication episodes but far more instances of *deep reasoning* than participants working face-to-face. Sins, *et al.* (2011) ascribe this difference to the fact that chat participants have more time to process incoming messages and can thus interpret complex instructions more easily and revise messages so that the message they send is likely to be more precise and contain clearer instructions. This compression occurs as participants adapt to chat communication. They caution that the task instructions should

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include *how* the goals should be attained by participants in addition to *what* must be done to achieve the goals.

2.3.2 Alternative conceptions related to acceleration due to gravity

Learners tend to develop intuitive ideas about natural phenomena (Palmer, 2001) and gravity is a phenomenon that learners encounter from very early in their lives and so they have many preconceived ideas or notions about it that they bring to class (Watts, 1982). The development of these conceptions has been shown to relate to the age of the learner (Barr, Zinn, Goldmuntz & Sneider, 1994). Watts (1982) maintains that learners construct "conceptual frameworks" based on their own experiences which they use to make sense of their world but these frameworks are not consistently applied in all contexts. Galili (2001) asserts that besides space and time, the concepts of weight, force and mass comprise the most fundamental ideas in physics and consequently affect physics knowledge. All three of these notions affect learners' understanding of gravitational force and thus acceleration due to gravity.

Mildenhall and Williams (2001) classify the mental models used by learners to solve the questions given in their study as *intuitive*, as it is based on everyday experience, and *academic*, based on formal tuition. The *intuitive* model is regarded as Aristotelian. The main features of the Aristotelian model are that force causes motion, the greater the force the greater the motion (speed not acceleration) and that the applied force is in the direction of motion. They contend that in some learners both mental models coexist and are drawn on depending on the context.

Palmer and Flanagan (1997) used a refutational text that was learner-centred to challenge the notion that "motion-imples-force" and achieved conceptual change in 35% of a year 6 group and 44% of a year 10 group. Thornton and Sokoloff (1998) devised a research-based multiple-choice assessment that has been administered extensively to map learners' conceptual understanding of Newton's Laws of Motion. Their findings indicate that only a small percentage of learners accept a Newtonian framework despite thorough traditional teaching. Thornton and Sokoloff (1998) maintain that unless learners recognise that the force and

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acceleration are acting downwards throughout the trajectory of an object thrown upwards and falling down again, they cannot be considered to be applying Newton's Laws. Alternative conceptions surrounding *gravity* abound and are particularly persistent (Baldy, 2007). A common alternative conception is that the mass of an object affects its acceleration due to gravity and that the greater the mass of an object the faster it will fall to the ground (Gunstone & White, 1981; Barr, Zinn, Goldmuntz & Sneider, 1994; Weller, 1995). Weller's study (1995) compared the nature and extent of alternative conceptions held by learners considered as strong or weak by their teachers and learners who had completed their physics course with learners still engaged in the course. His results show that many learners exhibited a "quickness-of-fall-depends-on-mass conception" (Weller, 1995, p. 280) irrespective of their ranking in class.

For a conceptual framework to be replaced by a new framework the new theory must be understandable, plausible and effective for solving problems (Posner, Strike, Hewson, & Gertzog, 1982). As Baldy (2007) points out the Newtonian theory of gravity, describing bodies interacting at a distance, does not fulfil these criteria from a learner's point of view as they do not experience bodies moving towards each other and matter's force of attraction is difficult to believe. Cognitive conflict can arise when the existing conceptual framework proves inadequate to explain an event and often triggers conceptual change (Baldy, 2007). Howe, Tolmie, Anderson and Mackenzie (1992) showed that peer conflict is effective in causing conceptual change. Mildenhall and Williams (2001) contend that when two mental models coexist, dialogue in the classroom may provide the best opportunity to confront the models and expose the conditions in which they arise.

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2.4 Conclusion

There are many studies that have used computer supported collaborative learning in an attempt to effect conceptual change in the teaching of physics e.g. Roschelle and Teasley (1995) and Howe, Tolmie, Anderson and Mackenzie (1992). An understanding of the theoretical framework and the current literature provide the basis for the choice of methods and the design of the study.

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CHAPTER 3 - METHODOLOGY AND RESEARCH DESIGN

3.1 Introduction

This chapter starts by explaining why the research approach in this study can be described as action research and attempts to justify the use of a pragmatic paradigm that makes use of a mixed methods approach to data collection and analysis. The practical investigation and the report that learners are required to submit based on the practical investigation are central to the study and the detailed description precedes the choice and design of the instruments and the data collection.

3.2 Research Design

The purpose of a research design is to "situate researchers in the empirical world" and to provide guidelines that link theoretical paradigms to strategies of inquiry and empirical data collection methods (Denzin & Lincoln, 2000, p. 20).

3.2.1 Research paradigm

An important feature to consider inherent in the design is the research paradigm which is described as the perspective from which the research is performed (Burton, Brundrett & Jones, 2008). Guba (1990, p. 17) defines a paradigm as a "basic set of beliefs that guide action." These beliefs encompass axiology, epistemology, ontology and methodology. Thus one's view of what constitutes ethical behavior (axiology), how knowledge is generated and the relationship between inquirer and the known (epistemology), the nature of reality (ontology) and the best process for gaining knowledge about reality (methodology) affect the questions that a researcher asks and the means used to answer those questions (Denzin & Lincoln, 2000; Morgan, 2007) .

Although the list of paradigms described by Denzin and Lincoln (2000) has been extended to include postpositivism and participatory action frameworks, the traditional contrasting paradigms are positivism and constructivism. Positivism

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is synonymous with an objective and inductive approach to research that uses quantitative methods while constructivism is associated with qualitative methods, deductive reasoning and a subjective view of reality (Morgan, 2007). Johnson and Onwuegbuzie (2004, p. 17) present mixed methods research as the third paradigm and define it as "the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study." Proponents of pragmatism describe pragmatism as the philosophical partner to mixed methods research and assert that "research approaches should be mixed in ways that offer the best opportunities for answering important research questions" (Johnson & Onwuegbuzie, 2004, p. 16). Researchers operating from a pragmatist paradigm and mixed methods research, use methods and thus instruments that fall traditionally into either the qualitative approach or the quantitative approach. The choice of methods or combination of methods will be determined by whether they are appropriate for answering the research questions (Morgan, 2007). My research made use of both quantitative and qualitative methods as I believe the combination of methods is appropriate for answering the research questions (Johnson & Onwuegbuzie, 2004).

3.2.2 General research approach

Gall, Gall and Borg (2007) describe solving a problem or achieving a goal in current practice as the purpose of action research. Burton, Brundrett and Jones (2008) compare action research to a series of lessons where the subsequent lesson is modified based on the outcome of the previous lesson. They refer to the cyclical aspect of the approach which requires the analysis of the data in terms of the literature and relevant framework from one cycle being used to inform the next cycle with the ultimate goal of achieving a desired outcome. Action research is typically used by practitioners in their own or very similar context with the intention of solving a problem, answering a question or improving their practice.

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This study represents the first formal cycle of action research. As described earlier in section 1.3, there have been ongoing attempts to improve the effectiveness of the practical in order to challenge the alternative conceptions that were identified. Freebody (2003) distinguishes action research from ethnographic or case study methodologies on the following basis: it is deliberate; intended to solve a particular problem; owned and conducted by the educational practitioner; comprised of cycles or spirals of research; and aimed at improving educational practice in an immediate and localised situation. The *findings* of this study are analysed with a view to refining and improving the collaborative group work of the learners in completing the practical and the improved use of Moodle and ICT in promoting collaboration amongst the learners in the following year. The *reflection* on the study allows the researcher to refine the questions asked and methods used to improve the second cycle of the action research.

3.3 The learners' practical investigation

The practical investigation is described in detail as it is central to the choice of instruments and timing of data collection. The task sheet shown in Appendix A was distributed to science teachers in Gauteng as a resource that could be used as the Grade 12 Physics practical investigation for the Portfolio.

The task requires learners to design a practical investigation to determine the influence of various factors on the gravitational acceleration of objects under free fall near the surface of the earth. Learners are provided with a list of apparatus that can be used and a detailed marking rubric to guide them. The marking rubric is given in Appendix B. The design of the practical investigation requires learners to write an aim and a hypothesis, identify the independent, dependent and fixed variables for each factor and detail the method to be employed. This preparation is completed in groups before the data collection which is carried out during the science lesson at school. The groups need to meet again to discuss their results and findings. Group members are expected to have the same design, data and findings but each learner is required to submit his own report on the practical investigation.

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In the practical, learners record the time taken for different objects that are dropped from the balcony to reach the ground. The height of the balcony and the time taken are used to calculate the acceleration of the object using the equation $\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$, where **Δx** is the height of the balcony, $\mathbf{v_i}$ is the initial velocity of the object, equal to zero because the object is dropped, **a** is the acceleration of the object and **Δt** is the time taken for the object to hit the ground after being released. Using the mass (m) of the object, the net force acting on the object is calculated, $F_{net} = ma$. The gravitational force, $F_{gravity}$, acting on the object is the product of the mass measured in kilograms and acceleration due to gravity which is taken to be a constant value of 9.8 $m.s^{-2}$ on earth. The equation, $\mathbf{F_{net} = F_{gravity} - F_{air\ friction}}$, enables the calculation of the force of air friction acting on the various objects so that a comparison can be made.

The highest balcony that can be used at the school is 9.1m above the ground. Consequently the time taken for the object to drop is very small so inaccurate timing results in a substantial percentage error and the results are far from accurate. The calculated value for the acceleration of the object often exceeds the acceleration due to gravity.

3.4 Instruments

A pre-test was employed to establish the learners' prior knowledge and a post-test to assess the effect of the teaching strategy. There are questions in the pre-test and post-test that test conceptual understanding as opposed to low-level knowledge. The details of these tests follow. The transcripts of the face-to-face interaction and the log of the Moodle forum entries capture the learners' participation within a group. The questionnaire interrogated the learners' frequency of internet usage and perceptions of the use of a forum for group work. A question in the examination weeks later checked the long term effects of the intervention.

Tests

Tests are measuring devices that lend objectivity to our observations with regard to the outcomes of instruction (Dreckmeyer & Fraser, 1991).

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A pre-test was used to establish the learners' prior knowledge and conceptual understanding of acceleration due to gravity and a post-test to assess the effect of the different modes of collaboration on their understanding. The pre-test comprises multiple-choice items from the bank of questions in the Force and Motion Conceptual Evaluation designed by Thornton and Sokoloff (1998). Many of the questions target common alternative conceptions held by learners and distinguish between horizontal forces and the force due to gravity and differing contexts. Palmer (2001) shows that learners' alternative conceptions are often inconsistent and context-dependent. In addition there is an open response item regarding their understanding of acceleration due to gravity. The test is shown in Appendix F.

The post-test also consists of some multiple-choice items that are commonly found in school assessments and others that target conceptual understanding more specifically. The post-test is given in Appendix H. The difficulty in uncovering alternative conceptions is that learners can often answer the question correctly even though their reasoning is flawed. An item consisted of two diagrams of a scenario depicting the force of gravity. The learners were required to write a response to the scenario. Learners completed the post-test within a week of completing the data collection part of the practical.

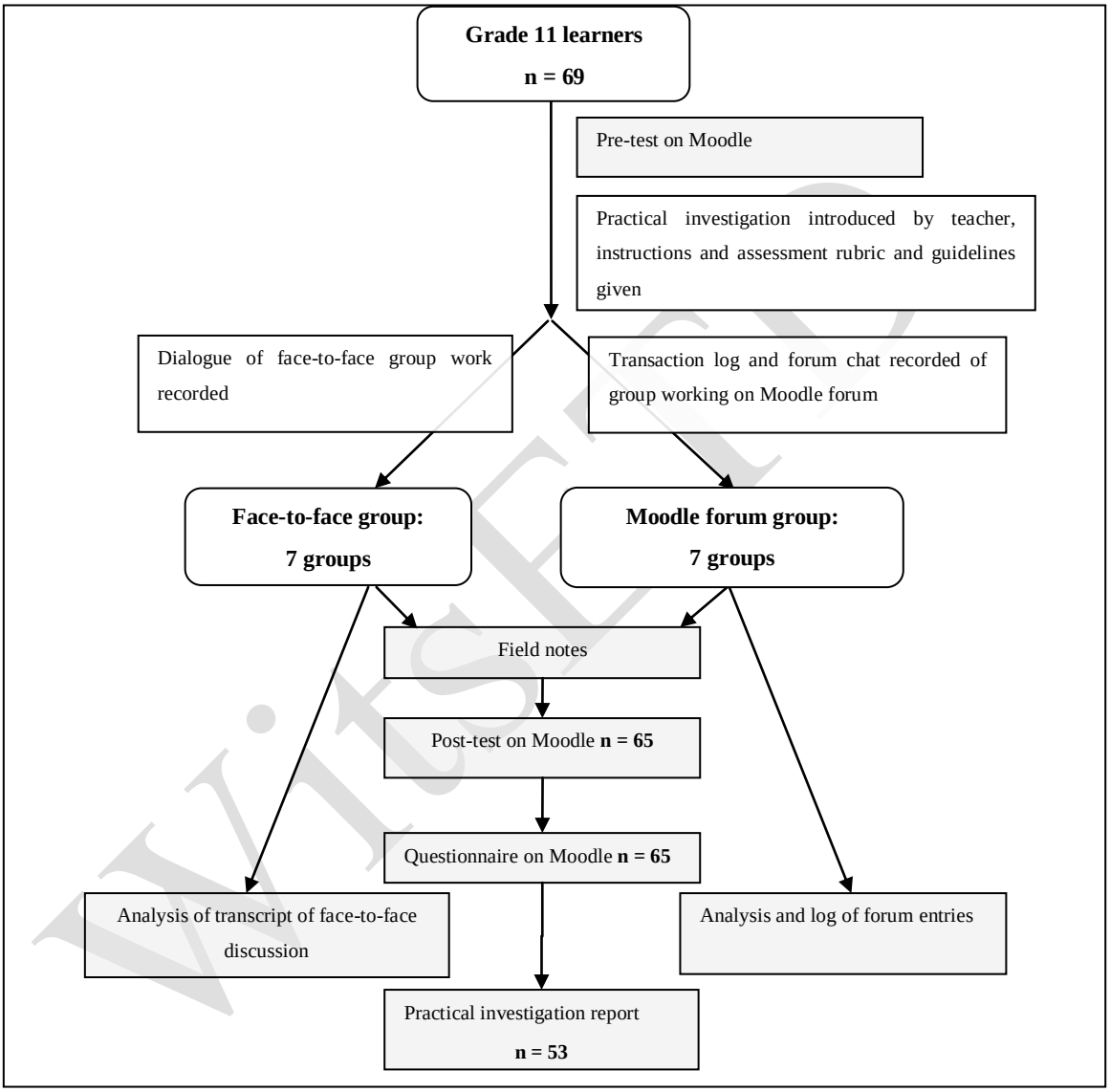
A question was included in the mid-year examination to test learners understanding shown in Appendix M. This second test was administered to investigate the long-term effects of the learning. The examination was written near the start of the following term and assessed learners on half a year's work. Often learners' alternative conceptions are quite persistent and they may revert back to them after some time has elapsed. The question required learners to identify variables, calculate the acceleration due to gravity and justify the trend in acceleration they expect with regard to varying mass of objects.

Moodle provides a platform for self-marking tests that can be customized and administered online. The self-marking aspect is a considerable advantage for the researcher. The test can comprise true/false, match the column, multiple choice and select the answer from a list on a drop-down box items. Open-ended questions

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were also accommodated but are not self-marking and needed to be graded by a teacher. As in any test, careful consideration of the wording of the items was necessary to illicit the required response.

Figure 3-1: Detailed summary of planned data collection



Questionnaire

Gall, Gall and Borg (2007) describe questionnaires as a set of questions that ask the same questions of all respondents though some questions may be different for sub-groups, and require written responses. Questionnaires can share many of the basic features of an interview but are more suitable for larger populations and are

free from interviewer bias that may be a concern in interviews (Burton, Brundrett & Jones, 2008).

The aim of the questionnaire was to gather data with regards to the accessibility, frequency and extent of use of the internet and social network sites and learners' perceptions regarding the use of a forum to facilitate group work. Some of the pertinent questions taken from an instrument used by Ellison *et al.* (2007) were included to assess Facebook usage.

The questionnaires were administered using the questionnaire module in Moodle. The participants completed the questionnaire during class time on the computers in the computer centre or the laptops in the mobile computer laboratory. Questionnaires are exceptionally quick to administer to a large group of people and analyze. Collecting data from learners during class time is particularly effective as one can expect a 100% completion as opposed to postal or emailed questionnaires that have a very low rate of return (Neuman, 1994). Learners comprising the sample being tested are accustomed to completing written responses to questions during school hours and are more likely to comply than other groups of respondents. I could have collected the same data by using an interview sheet but this would take far longer. While allowing less freedom of response, closed-ended questions enhance the consistency of respondents' answers and although more difficult to construct are easier and faster to tabulate and are more popular with respondents (Fraenkel & Wallen, 1990).

The drawbacks to this method is that one can be limited by the number of available computers and the time to hand out a pencil and a piece of paper is invariably shorter than opening the questionnaire on Moodle and less can go wrong with the pen-and-paper method. Another concern is that using a technologically advanced method of collecting data about how learners feel about using technology in learning may beg the question and bias the results.

The questionnaire contains both closed questions in the form of statements that the respondent ranked on a Likert scale (Opie, 2004), and some open-ended questions. The advantage of the Likert scale is that the data can be analysed

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quantitatively with ease. The open-ended questions added the depth that is lacking in the closed questions (Appendix N).

Audio recording of group work

An audio recording of learners' discussions during group work is an example of observational research. Opie (2004) distinguishes observational research from everyday observations on the basis of the planned and systematic collection data.

The aim of recording the group discussions during the planning and interpretation of results phases of the practical carried out by the learners, was to establish whether alternative conceptions come to the fore during the group discussion and whether other learners in the group attempt to correct or challenge the alternative conceptions.

This provided data that is largely anecdotal in nature but may shed light on the gains or shortcomings of using a forum instead. A short-coming of audio recordings is that non-verbal activity is not captured and the learners may, consciously or unconsciously, react differently in the group because their discussion is being recorded and thus the recording may not give an accurate picture of the face-to-face collaboration (Opie, 2004). This can pose a problem when the learners record their own discussions as they could rehearse their group work prior to recording.

The intention was that all groups within the face-to-face group would record their group discussions during the planning, and interpretation of results stages of the practical investigation. Specific instances that typify how learners challenge the alternative conceptions of group members were highlighted as evidence of collaboration.

Log of Moodle use and forum pages

Moodle keeps a log of the time that a learner opens a new page in Moodle so one can trace the time and duration of learners' involvement in the collaborative group work even if they merely observe but don't contribute. Moodle also retains a copy of the forum page each time it is edited allowing a sequential record of

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participants' contributions resulting in a "transcript" of the contributions of the learners to the discussion.

The aim of keeping a log of the group discussions during the planning and interpretation of results phases of the practical carried out by the learners is to establish the duration and extent of the involvement of the learners. The forum pages revealed whether alternative conceptions came to the fore during the group discussion and whether other learners in the group attempted to correct or challenge the alternative conceptions.

It is an advantage that the Moodle discussion is in the form of a transcript as the learners type their responses to each other. Learners regularly communicate in a similar format on Facebook and other social network sites using a very informal style. Learners may have felt obliged to use a more formal register because I was analyzing it and this may have inhibited their communication and present a disadvantage.

3.5 Validity and Reliability

Rigour refers to the validity and reliability of the research. Opie (2004, p. 68) uses Wellington's definition: "Validity refers to the degree to which a method, a test or a research tool actually measures what it is supposed to measure". Bell's definition of reliability: "the extent to which a test or procedure produces similar results under constant conditions on all occasions" is quoted in Opie (2004, p. 66). Many authors, e.g. Golafshani (2003) and Denzin and Lincoln (2000), maintain that the terms *validity* and *reliability* are more appropriate for quantitative research but *trustworthiness, rigour* and *quality* are more relevant in qualitative studies. This is achieved largely by attempting to eliminate bias. In this study, piloting of the instruments was a way of ensuring their validity and reliability; details of how the piloting of the instruments was conducted follow.

Piloting the instruments

In order to ensure the validity of the questionnaire it should be piloted and refined before data collection for the purposes of the research. The purpose of piloting is

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to test how long the questionnaire takes to administer, and uncover any ambiguities in either the instructions on how to complete the questionnaire or the actual questions or statements contained in it, detect any omissions or objections and collect feedback on the attractiveness of the layout (Opie, 2004). Sapsford and Jupp (1996) are quoted in Opie (2004) in relation to the choice of the pilot group. The authors maintain that while the pilot sample should be representative of the variety of individuals that the main study will cover, the correct proportions of the different categories of individuals is unnecessary. Some of the questions are designed to check the internal consistency of the test. The questionnaire was administered to learners during class time a week after the teaching intervention occurs but before the post-test is written. This time frame has been chosen partly out of convenience but also to ensure that learners have had time to reflect on the teaching and have a better overview.

The pilot of the self-marking test, questionnaire and forum occurred in the week before the pre-test. My pilot instruments were administered to the learners involved in the study even though a pilot should not be piloted on the sample it is eventually intended for. I made this unusual choice based on the fact that I wanted the learners to be familiar with these modules prior to the data collection. The content of the pilot test, forum and questionnaire was thus different to the final instruments. All of these instruments are internet-based Moodle applications and thus more complicated than the administration of a pen and paper test or questionnaire. The purpose of the pilot was to gauge the time taken for learners to access the module, learners' understanding of the instructions and format of the items. Piloting also provided an example of the reporting of results generated by the module. An information technology staff member was on hand at each of the pilot sessions to help with username and password problems and other technical hitches. The items and results of the pilot questionnaire are given in Appendix M.

3.6 Actual data collection

The task sheet and rubric for the practical investigation given to the learners is shown in Appendix A and Appendix B.

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Ethical considerations

A considerable amount of planning and preparation was required prior to the actual data collection. Ethical considerations regarding application for ethical clearance, access to the institution and participants are detailed below.

The teaching interventions and data collection stages of the research project only commenced after ethical clearance for the project had been received from the Wits Human Research Ethics Committee (Non-Medical).

There is always a concern when two groups are exposed to different interventions that the one group will be disadvantaged compared to the other. While there was no plan to reverse the interventions, the practical investigation was only one of the methods used to teach the topic so all learners should have had an equal opportunity to learn the work.

Access to the learning institution

As is common in action research I chose to conduct my study at the school at which I'm employed. The school is a private independent Catholic school so permission from the Gauteng Department of Education was not required but permission from the Principal had to be obtained first before data collection could be conducted. The school management actively promotes further studies in education and provides financial assistance for staff to study. Consequently, the management is also supportive of the execution of research studies at school. A copy of the letter of permission from the school principal is shown in Appendix C. The principal was also given the participant letter for his information (Appendix D).

Access to the learners

The learners were chosen based on convenience as they are all the Grade 11 Physical Science learners, divided into three classes and I was able to teach all these learners during the intervention and data collection period. I normally teach one of the classes and my colleague teaches the other two. During class I described the nature of the research, guaranteed the learners' anonymity and attempted to ensure that they were fully informed prior to starting the data

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collection. Learners were also given the participant information letter to read (Appendix D) .The participants in the study were required to sign a consent form (Appendix E). Parental consent was not required as they are older than the stipulated age of 14. Ethics clearance granted by the Ethics Committee in Education of the Faculty of Humanities is shown in Appendix F.

Once the practical investigation and the study had been explained to them, learners were given the choice of working in a forum chat group or a face-to-face group. Some learners chose to work in a face-to-face group because it was difficult for them to access the internet at home. In many cases learners who chose to work on the Moodle forum, did so because they were busy and couldn't find a common time to meet face-to-face. Learners then formed groups of 3 or 4 members within each of those divisions. Seven groups were formed to participate in face-to-face collaboration and the learners who opted to collaborate by using the *forum* module on Moodle to chat also formed seven groups while the four learners who chose not to participate in the study worked together. I set up the *forum* groups on Moodle so that only the group members could see or post information to the *forum*. I was a member of all the groups so that I could initiate the forum discussion and view and analyse individual group discussions afterwards.

Pre-test

Despite piloting as already explained, there was a flaw in the administration of the pretest for one of the classes. I set up the self-marking test incorrectly so learners could see their score for each page and so some, through trial and error, selected different answers until they scored full marks. The problem was remedied before the next class took the test.

Moodle forum design discussion

Learners were required to access Moodle via the internet and use the *forum* module on Moodle. I had already posted the instructions on Moodle for group members to respond to. Of the seven groups who chose to work on Moodle, only five posted responses and in one of those groups only two of the four group members contributed. Based on the date and time that Moodle includes in the log

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of the forum discussion, it is clear that one of the groups worked from eleven o'clock until midnight. One group found communicating via the forum tedious and stilted and asked to be allowed to change to working as an audio recording group but agreed to continue on Moodle. One learner who wasn't able to access the internet at home joined the forum discussion via his cell phone. Learners could choose to record their face-to-face group discussion of the design of the experiment using their cell phones and had access to microphones and the school laptops. They were only constrained to use the lecture theatre or laboratory as a venue if the laptops were used. The laptops can be used in a Windows or Mac operating system. Some groups were not satisfied with the quality of the sound recording on the laptops and waited to use the microphone on the desktop in my laboratory. Learners walked through venues while discussions were being recorded and some joking and background noise is evident on the recordings.

Field notes during practical investigation

Field notes were not planned as part of the intended instruments for data collection. I didn't have any particular criteria for selecting observations so my notes during the sessions, a single one-hour session per class, were based on connections that struck me at the time.

Some of my findings were unexpected: while I hadn't intended there to be groups that had not prepared for the practical investigation there were a couple of groups that did not meet in either face-to-face groups or the forum on Moodle. From the field notes taken on the day of the practical investigation, it was clear that the groups who had not prepared together did not seem to have even read the task sheet. One learner was overheard to say: "So, what is this prac actually about? What do we have to do?" Members from another group that hadn't met, threw various objects and timed them from both balconies but were disappointed in their interpretation of results discussion that they hadn't measured the most appropriate objects due to lack of adequate planning. The inability to neither meet nor bring appropriate objects seems to be symptomatic of inadequate planning skills. It is clear that many learners from both the face-to-face and forum groups came better prepared for the practical and brought different objects to drop e.g. a medicine ball

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and a larger than usual tennis ball. Others brought a builder's tape measure to record the height of the balconies and plastic film or aluminium foil to cover the balls to alter their surface covering. The requirement to discuss the practical seemed to improve the engagement of the learners in the activity.

Moodle forum interpretation of results discussion

Compared to the Moodle forum design discussion, there were fewer groups and fewer members in the groups. Some learners only posted their results but did not engage in any discussion.

Audio recording of interpretation of results discussion

Some groups had planned to complete the recording after school on the Friday afternoon even though it was a school celebration day that included Mass in the morning and a mini-fete and inter-house soccer matches for the rest of the school day. It wasn't surprising then that some of the learners who planned to meet that afternoon didn't arrive. Some learners had already left on sports tours so some groups were left incomplete. Where there was only one member from a particular group, the individual joined another group for the purposes of the discussion.

Post-tests

Learners completed a Moodle self-marking post-test shown in Appendix H within a week of completing the data collection part of the practical. Some learners were away at a sport's tournament so fewer learners completed the test.

The question that was included in the grade 11 mid-year examination to test learners' understanding is shown in Appendix M. The learners had not received feedback on the pre-test, post-test or practical investigation write-up prior to writing the examination. The 2010 academic year was unusual as a result of the FIFA World Cup Soccer tournament being hosted by South Africa. All schools in South Africa were required to close in June to accommodate the soccer matches. Instead of the mid-year examination being written at the end of a long second term it was written two weeks after the learners had returned from a month of holiday spent watching soccer. The result is that the learners' answers to the examination questions are likely to reflect their deeply held alternative

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conceptions due to lack of revision. The question was worth 15 marks out of a total of 134 marks for a three hour physical science examination.

Questionnaire

The questionnaire was administered after the post-test. The learners in one class used laptops in the laboratory and the other class went to the computer centre to access the questionnaire on Moodle. The second question was badly worded as it contained two statements, "I don't have my own computer but I do have access to a computer with internet access at home some of the time" and some learners pointed out that it was illogical as soon as they started.

Practical investigation write-up

The practical investigation write-up was due to be handed in on the 8th of June. The learners who were away were allowed to hand in later. Learners also had the choice of submitting their report on Moodle via the Internet. Table 3-1 provides a summary of the dates and details of the data collection.

Table 3-1: Data collection details

Instrument	Date (2010)	Participation	No. of learners	Data
Pre-test on Moodle	31st May	Individual	n = 67	Multiple choice
Audio/forum log of design of practical investigation discussion	1st June	Group	5 Audio groups 5 Moodle groups	Audio recordings Moodle transcripts
Observation of practical investigation	2nd June	Individual/group		Field notes
Audio/forum log of results of practical investigation discussion	7,8th June	Group	6 Audio groups 5 Moodle groups	Audio recordings Moodle transcripts
Post-test on Moodle	8th June	Individual	n = 62	Multiple choice and open response
Questionnaire	8th June	Individual	n = 52	Choice, Likert and open response
Post-test examination question	27th July	Individual	n = 69	Open response: identification of variables, calculation of g, justification of g independent of m using a physics equation
Practical investigation report	9th June	Individual	n = 53	Full experiment write-up

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3.7 Critique on data collection methods

The period chosen for data collection was not ideal as the founder's day and the sports tours disrupted the continuity of the group discussions and decreased the overall number of participants.

The learners were allowed to select their own groups to collaborate with and to choose whether they communicated via the Moodle forum or face-to-face. Groups who chose to meet face-to-face could have based their choice on difficulty in accessing Moodle via the internet from home. This selection of comparison groups could have skewed the results in that learners who chose not to use the forum may have found it less suitable as a medium for communication than learners who may be better acquainted with ICT.

In some cases I heard learners planning what they would say in the recorded version of their group discussion and so the recording does not necessarily reflect a spontaneous response.

3.8 Conclusion

This chapter presented the theory underpinning the research approach and method. The background with regards to the practical investigative task and the design and choice of the instruments followed and culminated in the description of the actual data collection. This background is necessary so that the results presented in the following chapter can be understood in context.

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CHAPTER 4 – ANALYSIS OF RESULTS AND FINDINGS

4.1 Introduction

This chapter describes the criteria used to select the appropriate data, the strategies used to analyse the data and the findings based on the data.

As an introduction to the data and findings of the study, it is helpful to restate the purpose of the study and the relative hierarchy of ideas: the research questions interrogate whether an online forum on Moodle provides a useful tool to facilitate collaborative group work in order to maximize the engagement in a practical investigation intended to challenge alternative conceptions regarding acceleration due to gravity.

4.2 Data analysis strategy

Burton *et al.* (2008) caution that not all the data that was collected needs to be used to answer the research questions. There are various ways that data can be presented and analysed. In this report the data presentation and analysis have been combined to address each research question individually. Burton *et al.* (2008) describe this as the holistic approach to data presentation and analysis. Some of the items in the pre-test, post-test and questionnaire lent themselves to quantitative analysis while some of the open-ended items and transcripts and logs of collaborative work were more qualitative in nature. In keeping with the pragmatic paradigm, a combination of the relevant quantitative and qualitative data that pertains to each question is drawn on to answer that question.

4.3 Analysis of Research Data

The data lends itself to both descriptive and inferential analyses. The self-marking tests on Moodle were used to collect the data for the pre-test and post-test. The module reports the individual learner's total mark and score for each question. An item analysis of the test provides the number and percentage of learners that chose

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the correct answer as well as each distracter. The open-ended questions in the questionnaire were analyzed using open-coding in an attempt to quantify those responses too, and used to corroborate the answers given in the closed questions or to highlight a specific aspect. The questionnaire is shown in Appendix N. Having skimmed all the forum chats, excerpts that show the most debate around alternative conceptions were analyzed in more detail. The dialogue was characterized based on whether and how participants challenged each other if they disagreed. This mirrored the choice of transcripts of the face-to-face discussions selected. In the next section, the results are presented in relation to each research question.

4.4 Results

Each research question is addressed separately.

Research question 1.5.1 a

What are the effects of the use of an online learning environment for a collaborative practical investigation on the acceleration due to gravity on the learners' understanding?

The original intention of comparing the scores of the pre-test and post-test of the forum Moodle group with those of the face-to-face groups was thwarted by the large group of learners who did not participate in the face-to-face or forum discussions. A comparison of the pre-test scores of the whole cohort compared to their post-test scores has been used instead. A tabulated summary of the results of the pre-test and post-test are shown in Appendix I.

Both instruments were based on the complete Force and Motion Conceptual Evaluation (FCME) designed by Thornton and Sokoloff (1998) and modified for the purpose of this study. Very similar questions were included in the pre-test and the post-test. The three questions I have chosen to compare relate to an object being thrown up into the air and falling back down. The questions differ in that the learner has to choose from a description of forces, acceleration or force diagrams to describe the motion. Thornton and Sokoloff (1998) only consider the

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questions to have been answered from a Newtonian point of view if all three questions indicate a constant downward force. In the question in the pre-test shown below in Figure 4-1, the statement A, "the force is down and constant" is the correct answer to all three of the questions. 48% of learners selected the correct statement, for the first question that described the coin moving upward after its release, 42% chose A for the second question, 'the coin is at its highest point' and 51% were successful in the last question related to the coin moving downward.

Figure 4-1: Coin question from the pre-test

Questions 3.1-3.3 refer to a coin which is tossed straight up into the air. After it is released it moves upward, reaches its highest point then falls back down again. Use one of the following choices (**A** through **G**) to indicate the force acting on the coin for each of the cases described below. Answer **J** if you think none are correct. Ignore any affects of air friction.

A: the force is **down** and constant.

B: the force is **down** and increasing.

C: the force is **down** and decreasing.

D: the force is **zero**.

E: the force is **up** and constant.

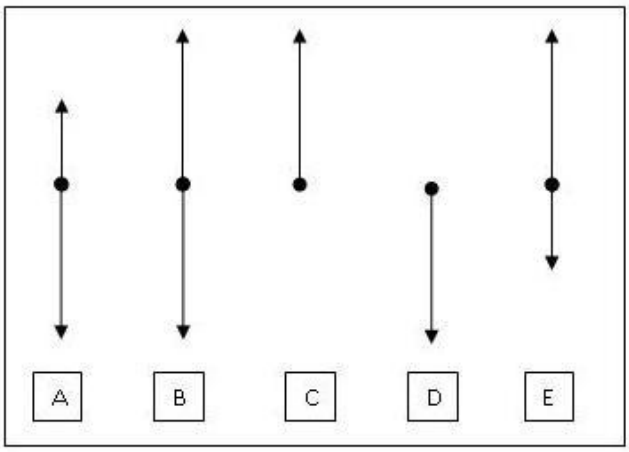
F: the force is **up** and increasing.

G: the force is **up** and decreasing.

3.1 The coin is moving upward after it is released.
3.2 The coin is at its highest point.
3.3 The coin is moving downward.

Analysis of the data of the individual learners' responses showed that only 37% selected all three correctly, so only this group could be considered to be using Newtonian physics. The percentage of incorrect answers chosen highlights some typical alternative conceptions. The most popular incorrect response (36%) to the first question was that the force was up and increasing, 46% of learners held the view that the force was zero at the top of the coin's trajectory while 43% chose B, "the force is down and decreasing" to describe the coin moving downward. In each case the response chosen, related to the velocity and direction of the object suggesting that learners overlooked the relationship between force and acceleration.

Figure 4-2: The Stone question from the post-test.



The following three questions refer to a stone that is shot straight up by a catapult. After it is released the stone moves upward, reaches its highest point and falls back down again. Assume that air friction is so small it can be ignored.

Match the correct force diagram with the scenario given. If none of the answers seem correct, choose F.

The stone is moving upward after it is released.
The stone is at its highest point.
The stone is moving downwards.

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The post-test contained a very similar question shown in Figure 4-2. Instead of a coin being tossed the object was a stone shot up by a catapult and the answers were force diagrams as opposed to statements about forces. The post-test was completed after the data collection and results discussion of the practical investigation eight days after the pre-test. The results were alarmingly different. The correct answer for the three questions was D, a single arrow down, representing gravitational force. Only 5% chose the correct force diagram for the stone moving upwards. The two popular incorrect choices were E (48%) and C (44%). Both these answers show the confusion between the direction of motion of the stone with the force acting on it. The selection of E shows some

acknowledgement of a gravitational force. Only 16% correctly identified the force acting on the stone at its highest point while an overwhelming majority selected B which shows two forces equal in magnitude but opposite in direction. The learners are regarding the stone as stationary at the top of its trajectory and showing a net force of zero. 69% selected the correct answer for the third question but it is likely that it was selected because it indicates the direction of the motion rather than because the force has been correctly identified. The most common error (23%) was to choose A that has a long force vector down and a shorter one up. It is possible that learners were thinking of air friction although the question asked that it be ignored. Only one learner (1.6%) correctly chose all three answers.

Figure 4-3: The Coin toss question from the post-test.

The following questions refer to a coin which is tossed straight up into the air. After it is released it moves upward, reaches its highest point then falls back down again. Use one of the following choices (**A** through **G**) to indicate the acceleration acting on the coin for each of the cases described below. Answer **J** if you think none are correct. Ignore any affects of air friction. Take up to be the positive direction.

A : the acceleration is in the positive direction and constant.

B : the acceleration is in the positive direction and increasing.

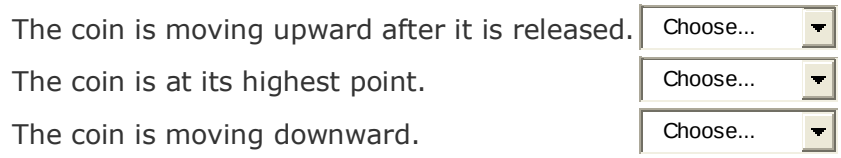
C : the acceleration is in the positive direction and decreasing.

D : the acceleration is zero.

E : the acceleration is in the negative direction and constant.

F : the acceleration is in the negative direction and increasing.

G : the acceleration is in the negative direction and decreasing.



The third question in the post-test shown corresponds to questions 27 - 29 of the FCME and is very similar to the third question in the pre-test but asks about

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acceleration instead of forces. The two questions also differ in terms of the language used in the answers. Thornton and Sokoloff (1998) describe the statements as “natural language” whereas the post-test answers are more vector orientated: “the force is down and constant” as opposed to “the acceleration is in the negative direction and constant.” 6% of learners correctly identified the acceleration of the coin as it moved upwards while 66% described the acceleration as decreasing in the positive direction. This points once again to a confusion between acceleration and velocity. Only 1.6% (1 learner) recognised that the acceleration of a coin at its highest point is in the negative direction and constant while nearly without fail (94%) stated that the acceleration is zero. 74% chose the incorrect answer of acclerating in the negative direction and increasing as opposed to the 21% who understood that the acceleration is constant.

It is not clear whether the notable drop in learners using Newtonian physics from the pre-test to the post-test is linked to the more conceptually difficult wording of the post-test questions or whether during the week of performing the practical investigation learners became muddled. The questions in the tests excluded air friction whereas the practical investigation required calculation of the force of air friction. The summary of the results for the three questions is shown in Table 4-1 below.

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Table 4-1: Summary of the results of the three questions compared

Pre-test n = 67						
Question	Origin	Description		Correct	All 3 correct	Incorrect
Coin toss	FMCE	vertical forces, natural language	3.1	48% (A)	37%	G (36%)
			3.2	42% (A)		D (46%)
			3.3	51% (A)		B (43%)
Post-test n = 62						
Question	Origin	Description		Correct	All 3 correct	Incorrect
Stone	modified FMCE	vertical forces, force diagram	1.1	5% (D)	2%	E (48%), C (44%)
			1.2	16% (D)		B (61%)
			1.3	69% (D)		A (23%)
Coin toss	FMCE	vertical forces, vector language	3.1	6% (E)	2%	C (66%), B (10%)
			3.2	2% (E)		D (94%)
			3.3	21% (E)		F (74%)

The alternative conception that mass affects the acceleration due to gravity is ubiquitous and was used as one of the criteria to measure learners' understanding. The data from the pre-test and the mid-year examination were compared. Assessment of the same concept was phrased differently in the pre-test and post-test which was given as a question in the mid-year examination. Question 4 of the pre-test with the expected responses to the statements is shown in Figure 4-4 The question was designed to assess learners' understanding of the effect of mass on the acceleration of falling objects. The four sub-questions checked if learners recognized the relationship between force, acceleration, velocity and time.

Figure 4-4: Question 4 of the pre-test

Questions 4.1- 4.4 refer to two objects that have the same size and shape but differ in mass. Object A has double the mass of object B. The objects are dropped off the balcony at the same time.

4.1 Object A will experience the same gravitational force (weight) as object B.	False
4.2 The acceleration of Object A will be the same as object B.	True
4.3 Object A will reach the ground before object B.	False
4.4 Object A will have the same velocity just before reaching the ground as object B.	True

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Table 4-2: Results of question 4 of the pre-test

Question	4.1	4.2	4.3	4.4	All 4 correct
% learners correct (n = 67)	73	66	67	72	52

The variation between the sub-questions indicates that some learners have muddled the relationship between force, acceleration, velocity and the time of the drop. Only 52% of learners chose all four of the correct answers to the question.

The results of the post-test in the mid-year examination (Appendix M) showed that of the 70 learners who wrote the examination only 30% stated that the mass of the object being dropped does not affect its acceleration. 49% stated that the heavier object would experience a greater acceleration while the remaining 21% omitted the question or wrote contradictory statements. One learner wrote," You would expect an object with a heavier mass to fall at a greater speed because Newton Two states that acceleration is inversely proportional to the mass of the object". Another learner explained, "The object with the greatest mass will fall the fastest but all three objects will accelerate towards the ground at the same rate". This unexpected result appears to indicate that the practical investigation and the associated collaborative group work had the undesired effect of *reducing* the learners' understanding of the concept. The examinations were held at an unusual time in the academic calendar as a result of the FIFA soccer tournament hosted in South Africa in June, 2010. Instead of the term culminating in examinations, the 3rd term started with only two weeks of school before the examinations were written and in many cases the revision of previous work was overlooked by learners. It is likely that learners relied on their "common sense" everyday answers due to lack of adequate revision. This is relevant as it is plausible that this result is evidence that alternative conceptions are often context-dependant and the alternative conception is commonly suppressed

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during direct teaching but resurfaces in time. In other words, the answer reflects what the learner has actually continued to believe as opposed to what he has learned. A practical flaw in the choices I selected for the pre-test on Moodle resulted in the results of the online forum group being indistinguishable from those of the face-to-face groups. I was able to distinguish between the groups in the examination question. Of the 20 learners who clearly stated that the mass does not affect the acceleration of an object in free fall, 8 of them had participated in the online forum Moodle discussions, 8 learners had met for face-to-face discussions, 4 had not discussed either the design or the results. These results are summarized in Table 4-3.

Table 4-3: Results of a question from the mid-year examination

Learners who stated that the acceleration of a body in free fall is independent of its mass.	Online forum on Moodle	Face-to face	No discussions
Number of learners	n = 8	n = 8	n = 4
% learners	40%	31%	25%

Since most learners had regressed in their understanding of this concept based on the pre-test results, the use of the online forum discussion cannot be claimed as a predictor of success. It could be argued though that some form of collaboration is better than none as 35% of learners who collaborated understood as opposed to only 25% of the learners who had not met.

The ability to present examples, analogies and a justified argument are far richer indicators of conceptual understanding. Instances of these are discussed within the context of the following research question related to collaborative learning.

Research question 1.5.1 b

What are the effects of the use of an online learning environment for a collaborative practical investigation on the acceleration due to gravity on learners' *participation within a group*? There are many ways of assessing the extent to which learners participate in a group or the value associated with their participation. The aspect that I have chosen as a measure of their effective

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participation is the nature of the mediation of cognitive conflict (Ploetzner, Dillenbourg, Preier, & Traum, 1999).

I read the text generated by the learners on the forum on Moodle. The Moodle report provides a list of the groups that were set up and the number of replies posted. In order to compare the participation of the groups, I added group members that participated, the duration of the group's online interaction and noteworthy features of their collaboration. This tabulated summary is shown below:

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Table 4-4: Summary of Moodle forum discussions

Key: M represents Moodle group number, L represents learner

	Design experiment				Interpretation of results			
Group number	**Members**	**Group replies**	**Duration**	**Comments**	**Members**	**Group replies**	**Duration**	**Comments**
M1	L1, L2,L3 & L4	23	6:46-7:15pm	L1 corrected someone without any justification 2 hypotheses incorrect	L1, L2 & L3, L4 excused	43	7:33-8:13 pm	L2 wrote lyrics! They refer to emails they sent each other with the results. Excellent collaboration.
M2	L5, L6,L7 & L8	9	5:11 pm 6:59-8:33 pm	Some good debate over choice of objects but L5 just restates the hypothesis correctly without referring to L7's at all	L5 & L6	3	5:24; 6:23pm 3:48 pm the following day	Separate postings – no conversation
M3	L9 & L13	12	8:31-9:09pm	Many errors in hypotheses but no correcting	L9, L10 & L11, L12 excused	20	8:56-10:12pm	Use of mxit to compensate for no computer. Took results but only chose pairs of data during write-up. Blatant variable error – not challenged.
M4	L14, L15 & L16	10	1:42-2:26pm	Fair amount of discussion but no challenging of incorrect hypotheses	L14, L15,L16 & L17	9	9:49-11:30 pm	L14 posted results but not part of discussion – textbook discussion but no real dialogue or challenging
M5	L18, L19,L20 & L21	38	9:55-10:49pm	A fair amount of discussion and getting back on track but some incorrect hypotheses	L18, L19 & L20 away at sport's tournament, L21 joined A7	0		
M6	L22, L23,L24 & L25	0				0		
M7	L26, L27,L28 & L29	0				0		All absent on day of prac except L26

I highlighted the dialogue that illustrated an alternative conception and noted whether another learner challenged the alternative conception or merely restated the corrected statement. Some of the excerpts of the forum discussions are shown in Appendix J.

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A striking distinction between the online forum discussions and the face-to-face discussions was that there was a considerable amount of teasing, joking and off-task interactions that comprised much of the time used while the banter on the online forum was limited. In many cases in the face-to-face interactions, group members all spoke at once when there were disagreements and many valid points made by less assertive members were overlooked indicating a poor collaborative style. The most marked difference between the two modes of communication seemed evident when learners did not agree and often related to alternative conceptions.

There were instances where the response to alternative conceptions can be described as:

- Ignored - in that it was neither accepted nor rejected
- Accepted, where the group agreed and the alternative conception was confirmed

In cases where alternative conceptions were the focus of debate, the interactions can be characterized as:

- Successfully challenged – an example of a learner muddling speed and acceleration is given below.
- Unsuccessfully challenged – an example shown below is taken from transcripts of the audio recording.
- Corrected without challenging

I used these categories as a guide to assess the quality of the discussions. In the text that follows, I have given illustrative examples of these categories.

Ignored - in that it was neither accepted nor rejected

In the example given below that comes from a Moodle forum discussion the learner proposed an incorrect hypothesis for the effect of mass on acceleration but is not challenged or confirmed by his group members.

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Excerpt from Moodle forum discussion

Re: Design Experiment

by Learner 3 - Tuesday, 1 June 2010, 02:03 PM

So our hypothesis would be that for the experiment ,where we change the height that we are dropping the objects from, would be the the greater height the object is dropped from, the greater acceleration the object will have. Then the acceleration where we change the object we are dropping over the balcony would have an hypothesis of, the greater the mass of the object the greater the acceleration of the object. Then for the experiment where we change the surface area of the objects, the hypothesis would be, the smaller the surface area of the object, the greater the acceleration of the object will be. Then lastly the experiment where we change the surface covering of the object, the hypothesis would be that the object with a smooth surface covering will have a greater acceleration than an object with a rough surface covering.

Successfully challenged – an example of a learner muddling speed and acceleration is given below.

The following excerpt has been transcribed from the design of the experiment by group 4 from 4:23 -5:23 of the audio recording.

L1: Basically, acceleration increases over height.

L2: No, we're proving that acceleration doesn't change because gravity is acceleration.

L1: Well, of course acceleration must change!

L3: No, it doesn't.

L2: No, we're testing if acceleration will change with mass.

L1: What are we testing then? Terminal velocity is achieved with height not mass.

L4: But we're not dropping it from 50 000 feet.

L1: Surely the difference in height affects the speed of the object?

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L2: The *speed* not the *acceleration*.

L3: Does gravity change?

L1: Ja, ok, there we go. Sorry, guys.

Unsuccessfully challenged – an example shown below is taken from transcripts of the audio recording.

This excerpt is transcribed from the design of the experiment by group 4, 8:54 - 9:30 of the recording.

L1: We need a hypothesis. The change in mass will affect the acceleration.

L2: But how?

L1: The heavier, the quicker or greater the acceleration.

L3: I think you're wrong – it doesn't accelerate.

L1: It must.

L3: An object accelerates due to gravity and gravitational acceleration is the same.

L1: Wait, but hold on…

L4: But surely the whole theory is that the objects will hit the ground at the same time?

L3: But force is equal to mass times gravity, so the mass of the objects …

L2: Hypotheses can be wrong though – the greater the mass, the greater the acceleration.

L4: That's retarded! Nothing affects it – it's like a law!

Corrected without challenging –Appendix K shows an example from a forum chat.

This excerpt is taken from the second Moodle forum group. The text highlighted in grey indicates when Learner 5 states the hypothesis and

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Learner 6 re-states the hypothesis correctly without challenging Learner 1.

Re: Design Experiment - by **Learner 5**- Tuesday, 1 June 2010, 07:19 PM

The more wait an object has, the faster the object will fall towards the ground because the force of attraction is greater than lighter objects.
Objects with large surface areas will fall to the ground slower than objects with a less surface areas. This is so because there is less air friction on objects with smaller surface areas.

Re: Design Experiment - by **Learner 6** - Tuesday, 1 June 2010, 07:30 PM

For the mass experiment we use a golf ball and ping pong ball (which are the same size) and have covered them in tape, so they have the same surface covering.

They are both exactly the same execpt for the mass. This will keep the variables the same.

For the surface area experiment we use the polystirene cubes and balls

For the height test we use a tennis ball

For the covering test we use a normal tennis ball and then a tennis ball covered in tape.

Re: Design Experiment - by **Learner 6**- Tuesday, 1 June 2010, 07:37 PM

Hypothesis

Mass test - Objects will have the same acceleration regardless of mass

Surface area - the larger the surface area the slower the acceleration becomes

Coverings - the smoother the covering the faster the acceleration becomes

Height - The object will accelerate at the same rate

The different categories of responses in the face of potential cognitive conflict provided a measure of the level of reasoning and interaction. The face-to-face

discussions had far more instances of successful and unsuccessful challenges and learners often used examples or rich analogies to persuade their peers. The forum discussions tended to present more examples of learners ignoring incorrect statements or simply re-stating the correct statement without engaging with the other learner. I expect that there is less likelihood of conceptual change in the latter.

Research question 1.5.2

In order to answer the third research question: what are the effects of the use of an online learning environment for a collaborative practical investigation on the acceleration due to gravity on learners' perception of the use of activities in Moodle as effective learning tools, I used data drawn from a questionnaire that the learners completed in Moodle shortly after the completion of the practical. All learners had completed the pre-test and post-test in Moodle and the learners in the one comparison group had used a forum on Moodle to design the practical and to discuss the results in preparation for the write-up while the other group recorded their face-to-face discussions to design and analyse the results of the practical. The statements were designed to distinguish between using Moodle for the purpose of the forum chat and the completion of class tests.

The results of the relevant Likert scale questions on the questionnaire are summarized in the table below. The full questionnaire with all the results as generated by Moodle is given in Appendix N.

Questions 10 – 14 were completed only by the learners who were in the forum chat comparison group and question 17 was exclusively answered by the face-to-face interaction group. A surprisingly large percentage of the learners (89%) in the face-to-face interaction group reported their perceived advantage in understanding the practical investigation as a result of their taped discussions. All the other questions were answered by both groups.

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Table 4-5: Results of the closed questionnaire responses

No.	Statement	n	Strongly disagree (%)	Disagree (%)	Agree (%)	Strongly agree (%)	Sum of agree & strongly agree (%)
9	I enjoyed completing the diagnostic test on the computer.	52	10	31	44	15	59
10	I would prefer other class tests to be completed on computer too.	52	12	25	37	27	64
11	I battled to use Moodle for communicating with my group members	23	26	18	39	18	57
12	I do not think using a wiki on Moodle is appropriate for group work.	23	13	22	48	17	65
13	I would like to use this approach for the planning and writing up of future science projects.	23	12	38	26	24	50
14	Our group battled to find a time to access the forum at the same time.	23	4	22	39	35	74
17	I felt that the discussion we taped helped me to understand the practical better.	19	5	5	47	42	89
18	This questionnaire was quick and easy to complete.	52	6	10	48	37	85

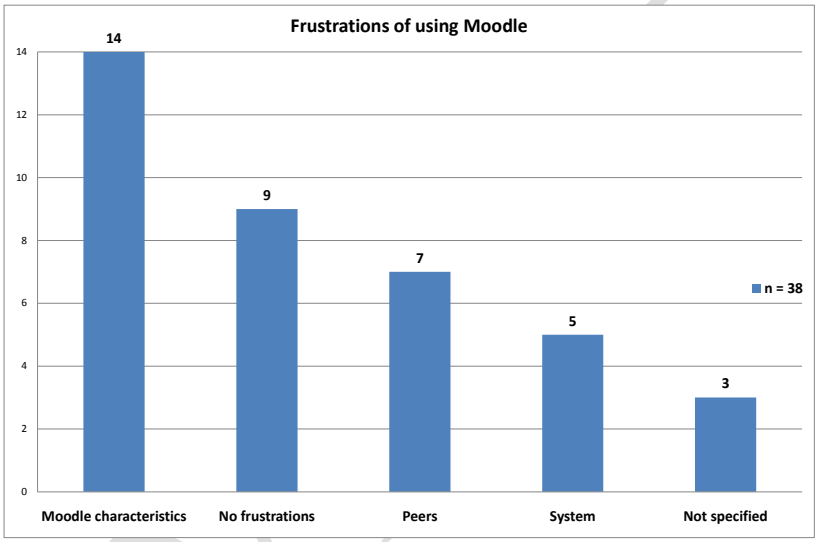
I can't tell from the results whether some learners had formed an unfavourable view based on their experience of using the forum chat which influenced their response to using the other facilities on Moodle.

From the results of the questionnaire it can be deduced that learners were in favour of using Moodle to complete class tests and enjoyed completing the diagnostic test on the computer. The learners in the forum chat comparison group were ambivalent about Moodle's use to plan and write up future practicals and did not find a forum appropriate for group work. Only a minority struggled to use Moodle to communicate with their group members but found the scheduling of a common time for group members to meet online more problematic.

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The free response items on the questionnaire were broad in nature and asked learners what they enjoyed about using Moodle and the aspects of using Moodle that they found frustrating. The responses to the question were grouped into broad categories of comments from learners feeling frustrated with their interaction with Moodle, their interaction with their peers and with the overall "system". Other categories were comments from those who did not find it all frustrating and some learners whose responses weren't specific. The results are shown in Figure 4-5 below. Thirty-six learners completed this question and between them made 38 comments. Some learners made comments that related to different topics so there were more comments than learners.

Figure 4-5: Chart presenting the frustrations of using Moodle

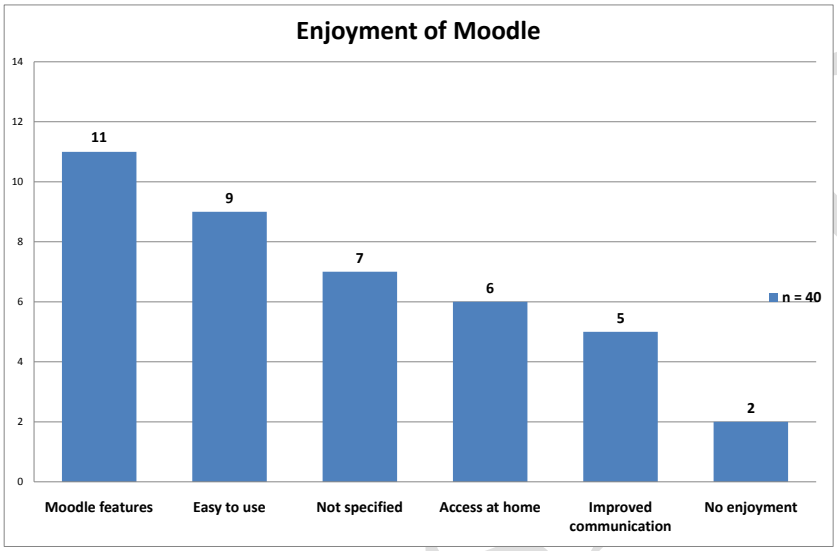


Most of the frustration related to the characteristics of Moodle was experienced as a result of the need to refresh screens on the forum that lead to disjointed conversations that were out of sequence so learners weren't sure which response matched the original comment. The responses of the learners are shown in the results of the Questionnaire in Appendix N.

The analysis of the data reflecting the most enjoyable aspect of using Moodle is shown in Figure 4-6. Thirty-two learners generated forty comments. The **Moodle**

features that learners referred to that contributed to their enjoyment included accessing resources from the teacher like past papers and tests for revision, completing self-marking tests, submitting assignments and communicating with group members. An interesting observation made by a learner regarding the **improved communication** was that it could cut out the disagreements found in most group discussions.

Figure 4-6: Chart presenting the enjoyment of using Moodle



In comparing the responses to both questions one must be wary of doubling up the data – e.g. the 9 learners who reported that Moodle was easy to use could be the **same** learners who were not frustrated by Moodle while it is noteworthy that only two learners did not enjoy using Moodle.

Both the Likert scale and free-response items suggest that learners see some of the activities in Moodle as useful learning tools. Learners refer to self-marking tests, uploading assignments, accessing past exam papers and other resources. The criticisms of the use of the forum chat were largely technical in that the pages didn't automatically reload and it wasn't clear which response matched the previous one. Another concern expressed by learners was that they weren't

sure how it worked and whether members of other groups could also see their responses.

4.5 Conclusion

The relevant data were presented and the findings discussed in this chapter in response to the individual research questions. An integral part of the cycles of action research is to reflect on the data and draw conclusions that inform the subsequent planning of the following phase. This will be the topic of the next chapter.

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CHAPTER 5 - CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter provides an overview of the study against which the conclusions drawn can be assessed. The findings and conclusions relate to the research questions. The recommendations that arise from the conclusions are discussed and avenues for future research described. The chapter and report ends with a reflection on the study.

5.2 Overview of the study

There are many alternative conceptions associated with force, weight and acceleration due to gravity. It was hoped that a practical application of the theory would challenge the alternative conceptions so learners carried out a practical investigation to establish the factors that affect the acceleration of objects when dropped off a balcony. In previous years, the practical investigation did not appear to help and the alternative conceptions persisted. Often learners rushed practical investigations and insufficient thought and reflection was given during the data collection and analysis.

The purpose of the study was to establish whether the forum on Moodle would provide a suitable platform for learners to engage in collaborative group work online compared to face-to-face collaboration of groups.

5.3 Summary of findings and conclusion

Each research question is re-stated so the relevance of the specific findings and conclusions can be shown.

Research question 1.5.1 a

- What are the effects of the use of an online learning environment for a collaborative practical investigation on the acceleration due to gravity on the learners' understanding?

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Some of the items in the pre-test and post-test were based on or came directly from the Force and Motion Conceptual Evaluation (FCME) designed by Thornton and Sokoloff (1998). They present the results of some of the questions that had been answered by 240 learners who had enrolled in one of various physics lectures in Oregon before and after traditional teaching of Newton's Laws. On the coin tossing question which featured in the pre-test in this study, barely over 10% of the Oregon learners answered all three questions correctly. All three questions had to be answered correctly if learners could be assumed to be using Newton's Laws. This figure remained low after traditional teaching and increased to just over 20%. 37% of the learners in my study answered the questions correctly before the practical investigation. Far from an anticipated improvement in this figure, it dropped to 1.6% in the post-test. The fourth question in the pre-test addressed the effect of mass on acceleration and the associated relationships between weight, velocity and time using a True/False question. 52% of learners chose all four of the correct responses. Seven weeks later only 30% of learners predicted that the mass would not affect the acceleration. There is more than one plausible explanation for these results. It would appear that learners' initial apparent understanding of gravity is tenuous and transitory. This is borne out in the literature. Watts (1982) maintains that learners construct "conceptual frameworks" based on their own experiences which they use to make sense of their world but these frameworks are not consistently applied in all contexts. It is likely that the frameworks learners use to solve textbook problems are abandoned when they are confronted with a real application of the laws that they encountered in the practical investigation. It could be argued that learners should not complete the practical investigation if it muddles them and causes pre-Newtonian structures to be used to answer questions. However, this would imply that learners can learn Newton's Laws but not apply them in a real everyday problem which would be counterproductive.

The unusual timing of the holidays and the examinations also has relevance. Learners would normally have received feedback on their work and would have written tests on this section with the examination posing as a formative and summative assessment. The continued feedback and studying would have

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confirmed their new Newtonian framework and diminished the status of any prior alternative conceptions. Baldy (2007) confirms that alternative conceptions surrounding gravity are common and persistent. Last year, the month long school holiday was instituted at that time due to South Africa hosting the FIFA Soccer World Cup. Besides disrupting the usual academic buildup to examinations, a carnival atmosphere reigned in South Africa and many learners would have attended games or watched them on television which would have reduced the time they would have spent preparing for the examinations. Numerous schools who chose to write their examinations after the Soccer World Cup said their results were poorer than previous years.

Some of the data discussed in the next section with regard to the group participation is also relevant to learners' understanding as the use of analogies and logical arguments demonstrates conceptual understanding. In many cases this is linked to the identification of variables and the design of an experiment instead of acceleration due to gravity.

The final conclusion is that there is no evidence to suggest that the practical investigation itself or the forum discussion of the design or results were effective in challenging the alternative conceptions of learners regarding acceleration due to gravity. This study has been useful in that it has highlighted the extent to which alternative conceptions persist and showed that in this particular study practical work was not as successful in challenging alternative conceptions as hoped.

Research question 1.5.1 b

- What are the effects of the use of an online learning environment for a collaborative practical investigation on the acceleration due to gravity on learners' *participation within a group*?

The 89% positive response from learners who taped their face-to-face discussions that the discussion helped them to understand the practical better, confirm that learners feel as though they're learning more when they've discussed the topic. The face-to-face discussions had a level of richness in terms of the analogies and

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logical argument that learners used to convince their group members that was lacking in the online forum discussions. The discussions also contained far more responses than the forum although a considerable amount of those responses were not task-related. Sins, Savelsbergh, van Joolingen and van Hout-Wolters (2011) maintained that learners using a medium of communication like a forum had time to consider and structure their point carefully so the quality of the responses is better than in the face-to-face discussions and thus fewer are required. Sins *et al.* (2011) referred to McGrath and Hollingshead (1993) to describe the task- media fit hypothesis that suggests that if the task requires a level of depth and richness of communication, the media chosen must be able to support that level of communication. The forum seemed adequate as a way to plan the investigation and communicate results on a superficial level. The criterion I applied to test whether the online forum could facilitate effective participation of learners in collaborative group work was if learners could challenge the alternative conceptions held by their peers. Fewer cases of successful challenging occurred in the forum groups than in the face-to-face groups. It was more common for learners using the forum to ignore the faulty reasoning or restate the correct reasoning without any justification. I had not alerted learners to the need to debate the contentious aspects. Since the forum is a less spontaneous medium and responses are given more thought and require more effort, it is possible that if learners were told it was necessary they would comply. It is also likely that the degree of sophistication required exceeds that provided by an online forum.

Research question 1.5.2

- What are the effects of the use of an online learning environment for a collaborative practical investigation on the acceleration due to gravity on learners' perception of the use of activities in Moodle as effective learning tools?

Based on their responses in the open and closed responses it would appear that learners preferred to write class tests on Moodle and enjoyed the uploading of their assignments, self-marking tests and remote access to past exam papers and resources from teachers but were ambivalent about its use to communicate with

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group members in a forum. The main reservations about the use of the forum was the difficulty in setting a common time to meet online and the refreshing of the forum screen during the online chat which led to disjointed conversations. Some of the criticisms related to not knowing where to find the module or whether other groups could see the conversations are easy to avoid for subsequent groups by explaining the procedure better first. Proponents of the forum found it easy to use and enjoyed being able to communicate remotely.

Limitations of the Study

The study can be considered limited in two aspects. In terms of the design and the data collection, there were flaws that limited the usefulness of the data. These included the selection of the Moodle forum groups and face-to-face groups by the learners themselves and the unfortunate weeks chosen for data collection that coincided with sports tours and non-academic days that limited the participation of the learners.

Another inherent problem is that the practical investigation executed by the learners is flawed and the results are very variable and can confuse learners. This results from any small error in timing having a significant effect on the acceleration due to the relatively short height the object is dropped.

Our school is very similar to many advantaged private schools in South Africa in terms of learners who have access to computers and the internet at home in addition to a strong focus on the use of information technology in the classroom. This is certainly not the case for the majority of schools in South Africa. Consequently, this study cannot be generalized to the majority of South African schools.

5.4 Recommendations

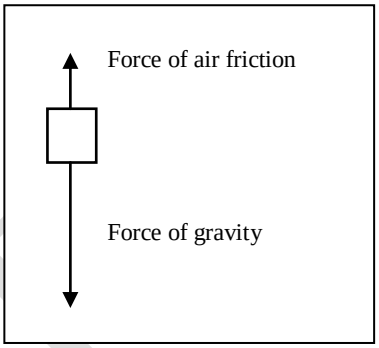
The purpose of action research is to reflect on practice to inform and improve subsequent practice. This study shows the first cycle of the action research process. The recommendations arising from the study thus inform the design of the second cycle of the process and can be considered the crux of the study.

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Recommendations for each of the different aspects of the research questions are described below:

5.4.1 Alternative conceptions related to acceleration due to gravity

Figure 5-1: Force diagram



Often the terms that are used in the task sheet for the practical and used by the teachers while teaching are not technically correct and do not differentiate between different forces. I am guilty of muddling terms concerning the acceleration due to gravity in this report. The task sheet requires learners to "determine gravitational acceleration of various objects under free fall near the surface of the earth. Design, plan and carry out an investigation to determine the influence of different masses, different surface areas and coverings and different heights of release." One of the criteria used to assess data interpretation on the detailed marking rubric given on the task sheet is to calculate the frictional force acting upwards in both cases. Another criterion refers to "comparing the net force acting downward to what you'd expect it to be for a free falling body i.e. $F_g = m \times 9.8 m.s^{-2}$".

Since acceleration due to gravity is taken as a constant value of 9.8 $m.s^{-2}$ it is confusing and invalid to ask learners to calculate and compare the acceleration due to gravity for different objects as it is the net force that would differ as a result of the force of air friction varying for objects of different shapes and size. In the next cycle of research I will reword the task sheet so that the terms are correct and used consistently. It will also be necessary to highlight the difference between the net force and weight when teaching the topic and explaining the task

5.4.2 ICT and Moodle

Many of the concerns around the use of the forum can be easily avoided. Learners did a dummy run on the diagnostic test and questionnaire but very few

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tried out the forum. Learners need to be familiarised with how it works and the structure and security better explained. Using dyads would mean that scheduling a suitable time to meet online would be easier and would also negate the confusion of sequencing in group discussions. While limiting the number of useful contributors it would also decrease the poor participation of some members in a larger group.

5.5 Future Research

There are a couple of research avenues that arise from this study. The obvious route is to repeat the study, taking heed of the recommendations in the planning and implementation of the next cycle of action research. This could focus on finding ways of making the online collaboration more effective.

Another focus is to explore the other modules in Moodle to enhance learning and free up time in class to use for face-to-face collaboration in groups.

The study could also be extended to learners in schools in less privileged circumstances. A sizeable percentage of learners attending disadvantaged schools in impoverished areas have cell phones and many are able to access the internet and thus Moodle. An extension of this study could include the effect of providing support materials to learners via Moodle that is better suited to cell phones than personal computers.

5.6 Reflection on the Study

As a result of this study I have learned far more about the different modules available in Moodle. I used many of the features of Moodle for the first time in preparing for the data collection and can see enormous benefits in the use of self-marking tests, questionnaires and the forum that are applicable to my teaching and many other teachers at our school. I also inadvertently made some inappropriate choices in setting some of the self-marking tests and have learned how to avoid those errors too.

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While I was aware of the alternative conceptions associated with weight, force, acceleration and mass, as a result of reading more deeply and analyzing learners' responses I have become far more attuned to possible pitfalls in the teaching of the topic. I have a greater awareness of the language that I use in worksheets and in teaching and how inconsistent or incorrect use of terms may cause learners to hold alternative conceptions.

While much of my study is qualitative I am confident that the conclusions I have drawn are valid. I have a clear sense of how to progress on my next cycle of action research. On reflection, I will be in a better position to ask more searching and focused questions and design instruments that will deliver more relevant data in the second stage of this cycle. In this study I asked learners to design the experiment and discuss their results in order to reach a conclusion. I would specify what criteria I was using to investigate learner collaboration and design the task and instruments accordingly. Sins *et al*. (2011) recommend that learners are told *how* to achieve the goals of the task in addition to *what* to achieve. In the second cycle of research I would give them more direction regarding their collaboration. I would provide them with scripts or phrases e.g. "I propose that … because …", I disagree with … because…" and "I would modify … because…" may help focus learners' discussions and promote deep reasoning.

Although this study represents only the first cycle of action research, I trust that teachers in a similar context may find the findings in this study informative.

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APPENDICES

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Appendix A: Task sheet for practical investigation

GRADE 11: PORTFOLIO

KNOWLEDGE AREA: MECHANICS

TOPIC: VERTICAL PROJECTILE MOTION

LO's and AS's: L01 AS1; L01 AS2; L01 AS3; L01 AS4; L02 AS1; L02 AS2.

Name:

Class:

Date:

Names of group members:

Teacher's Name:

SECTION B:

One of the most common examples of uniformly accelerated motion is that of an object allowed to fall freely near the Earth's surface. That a falling object is accelerating may not be obvious at first. And beware of thinking, as was widely believed until the time of Galileo, that heavier objects fall faster than lighter objects and that the speed of fall is proportional to the mass of the object.

Our goal in this investigation is to determine gravitational acceleration of various objects under free fall near the surface of the Earth. Design, plan and carry out an investigation to determine the influence of different masses, different surface areas and coverings, and different heights of release.

Our goal in this investigation is to determine gravitational acceleration of various objects under free fall near the surface of the Earth. Design, plan and carry out an investigation to determine the influence of different masses, different surface areas and coverings, and different heights of release.

Write a .scientific report about the practical investigation including all data and calculations.

List of available equipment:

Stop watches
String
Metre rules
Tape measure
Tennis balls
Polystyrene balls of same volume as tennis balls Cricket balls
Golf balls
Polystyrene cubes similar mass as the polystyrene balls.
Triple beam balances (mass scale).

Appendix B: Marking rubric for practical investigation

Skills	0	1	2	3	4
State problem statement and formulate hypothesis	Not attempted	• Either aim or hypothesis stated but not related to the investigation	• Either aim or hypothesis clearly stated and linked to investigation • Not all applicable variables mentioned • Mention all variables and mass	• Both aim and hypothesis clearly stated • All necessary variables mentioned – surface covering, shape, surface area, height • Relationship between the variables clearly outlined	•
Design and plan	Not attempted	• Experimental method and procedure not valid •	• Method is valid but difficult to implement • Not all the necessary apparatus are mentioned • Safety precautions are not considered • Some impractical implications (e.g. experiments conducted too close to the ground, windy environment)	• Method is valid, viable • All required apparatus mentioned • Safety precautions noted • Method and procedure could be reproduced • Objects must fall from rest • Windless environment • Sufficient height above ground	• creative, valid and implementable • the procedure is viable(equipment, time management etc.) • method and procedure could be reproduced • safety procedure adhered to • objects must fall from rest • windless environment • sufficient height above ground
Conduct investigation	Not attempted	• cannot follow instructions/ procedure independently • safety of others not considered • little or no recording of findings • does not realize the need to control variables	• follows instructions/ procedure with difficulty • some difficulties in using apparatus • minimal participation in group work • uses apparatus correctly with due regard for safety of others • records findings correctly • need help in controlling all variables	• follows instructions accurately and independently • contributes positively to group work • follows all safety procedures • uses apparatus correctly with due regard for safety of others • records findings correctly • can control all variables independently	• follows instructions/procedure accurately and independently • participates actively in group activities • follows all safety procedures with due regard for safety of others • uses and manipulates apparatus appropriately and when necessary • controls all variables effectively • records findings correctly • repeats investigation for precision
Data collection,	• Not attempted	• data collected is wrong/ inaccurate • Method of collection inappropriate	• insufficient data collected • Method of collection inappropriate • Data recorded in appropriate format (e.g. table with correct headings, units,	• Sufficient data collected • Method of collection appropriate • Data recorded logically, and in appropriate format (e.g. table with	• Sufficient relevant data collected through extremely accurate methods • Data recorded logically, with precision and in appropriate format (e.g. table with correct

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recording and presentation		• No attempt to record data in appropriate format	labels, etc.) but not in logical sequence	correct headings, units, labels, etc.) • Mass of each object not converted from g to kg • Measurement not recorded accurate where applicable to two significant figures	headings, units, labels, etc.) • Height found (accurate to within 0.05m) • Mass of each object found (in kg) • Times of the drops found (at least 3 for each object) • Average times found for each object • Measurement recorded accurate where applicable to two significant figures
Data manipulation	Not attempted	• Formulae incorrect	• Insufficient manipulation of data • Some correct calculations, formulae and equations • Uses correct formula and substitution to calculate acceleration of each object from data - $\Delta x = vi\Delta t + \frac{1}{2}a\Delta t2$	• Meaningful and purposeful manipulation of data (e.g. correct calculations, formulae or equations) • A variety	• Correct methods of interpretation and appropriate translations (e.g. table to line graph) • Most calculations, formulae and equations are correct • Uses a variety of methods to interpret results • Uses correct formula and substitution to calculate acceleration of each object from data - $\Delta x = vi\Delta t + \frac{1}{2}a\Delta t2$
Data interpretation	Not attempted	•	• Fnet not calculated • Doesn't calculate the frictional force acting upwards in both cases. •	• Uses correct formula and substitution to calculate net force acting downward on each object – Fnet = ma • Doesn't calculate the frictional force acting upwards in both cases. • Doesn't compare the net force acting downward to what you expect it to be for a free falling body i.e. Fg =mx9.8 m.s-2 •	• Uses correct formula and substitution to calculate net force acting downward on each object – Fnet = ma • Calculate the frictional force acting upwards in both cases. • Comparing the net force acting downward to what you expect it to be for a free falling body i.e. Fg =mx9.8 m.s-2 •
Conclusion	Not attempted	• Poor conclusion: does not link to aim or hypothesis or refer to upward frictional forces.	• Conclusion links to aim or hypothesis but does not refer to upward frictional forces.	• Interpret the calculations i.e. compare the upward frictional forces acting on each of the two bodies. Explanation attempted. Final conclusion links to aim or hypothesis.	• Interpret the calculations i.e. compare the upward frictional forces acting on each of the two bodies. Plausible explanation given. Final conclusion links to aim or hypothesis.

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Appendix C: Permission from research site

106 Pembroke Street

Sydenham

Johannesburg

2192

The Headmaster

Xxx

7th May 2010

Dear Mr Xxx

With the generous financial assistance of Xxx, I am currently registered for a M.Sc.(Science Education) degree at the University of the Witwatersrand. Part of the degree requirements is the completion of a research report. I would be grateful for your permission to conduct my research study at Xxx with the consenting Grade 11 Physical Science learners from Xxx . The Participant Information Sheet that will be given to the Grade 11 learners follows and details the purpose, nature and duration of the study. Kindly complete the permission slip that follows.

I hope that the results of my study will be beneficial to the Xxx community in answering a question relating to the extended use of Moodle as a teaching and learning tool.

Yours sincerely

Nicci Glanville

Permission from Research Site

I, _____

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as Headmaster of the independent private school, Xxx, grant Ms Glanville permission to conduct a research study at Xxx with consenting Grade 11 Physical Sciences learners.

I am confident that confidentiality and anonymity of the participants and the school will be ensured. Nicci Glanville and her research supervisor, Dr Samuel Oyoo are the only people who will have access to the raw data. Names of the participants or school will not be used in the report. Transcripts of the audiotape may be shared with fellow researchers at seminars or conferences. At the end of the study data is going to be kept in a safe and secure place for ten years. The end results will be reported to the Wits School of Education in the form of a research report for MSc (Science Education) and possible conference papers and publications.

Signature:

Date:

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Appendix D: Participant information sheet

Dear Grade 11 learner

I am currently registered for a M.Sc. (Science Education) degree at the University of the Witwatersrand. Part of the degree requirements is the completion of a research report. Details of the research follow:

Moodle, a course management system that learners can access via the internet was introduced at xxx towards the end of 2009. One of the features of Moodle is a forum, where pre-designated groups can communicate on-line. The aim of my study is to establish whether traditional group work on projects can be facilitated using a forum on the Xxx Moodle and whether this group work will be more beneficial than traditional group work.

I invite you to take part in this study. Participation is voluntary and learners will not be disadvantaged if they don't take part in the study. Learners who participate in the study are free to withdraw from the study at any point without any negative consequences. The data collection will take place from the 25th May – 8th June with some follow-up interviews scheduled for the third term.

For the past couple of years the Grade 11 science class has completed a practical to investigate some of the factors that affect the acceleration of a falling object. The practical investigation is prescribed by the Gauteng Department of Education for the Grade 12 Physical Science portfolio. All Grade 11 learners will complete a short diagnostic test prior to the practical and a test on the topic after the practical.

The practical investigation is carried out in groups and comprises the following: The initial phase consists of designing the practical investigation by identifying the independent, dependent and fixed variables, selecting the appropriate apparatus and describing the method. Feedback is given on the design before the practical investigation is carried out. The data collection phase of the practical investigation will take place during class time. The group will need to discuss the interpretation of the results and conclusion after the practical investigation has been completed. Each learner hands in their own write-up.

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Learners participating in the study will complete a questionnaire and may be asked to tape their group work discussions or submit the forum pages of their online discussion. Learners who choose not to participate will still complete the practical with the associated group work and the diagnostic and formative assessment but will not be required to complete the questionnaire, tape their group work discussions or submit their forum pages. The benefit to these and future groups of learners is that we can use Moodle more efficiently and provide more effective teaching.

Confidentiality and anonymity of the participants will be ensured. My research supervisor and I are the only people who will have access to the raw data. Names of the participants will not be used in the report. Transcripts of the audiotape may be shared with fellow researchers at seminars or conferences. At the end of the study data is going to be kept in a safe and secure place for ten years. The end results will be reported to the Wits School of Education in the form of a research report for MSc (science education) and possible conference papers and publications.

Ms Nicci Glanville (083 751 1947)

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Appendix E: Informed Consent Form

Informed Consent Form

I, _____

willingly agree to participate in the research undertaken by Ms N Glanville. I understand that I am free to withdraw from the study at any point. There will be no negative consequences if I do.

Signature:

Date:

Recording Consent Form

I, _____

willingly agree to be recorded on an audiotape as part of the research undertaken by Ms N Glanville. I understand that I am free to withdraw from the study at any point. There will be no negative consequences if I do.

Signature:

Date:

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Appendix F: Ethics Clearance

Wits School of Education

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STUDENT NUMBER: 0516741H
Protocol: 2010ECE48**C**

10 July 2010

Ms. Nicolette Glanville
106 Pembroke Street
Sydenham
2197

Dear Ms. Glanville

Application for Ethics Clearance: Master of Science

I have a pleasure in advising you that the Ethics Committee in Education of the Faculty of Humanities, acting on behalf of the Senate has agreed to approve your application for ethics clearance submitted for your proposal entitled:

Learners' collaborative practical investigation on acceleration due to gravity: a comparison of the effect of their understanding of using an online learning environment as opposed to face to face interaction

The Protocol Number above should be submitted to the Graduate Studies in Education Committee upon submission of your final research report.

Yours sincerely

Matsie Mabeta
Wits School of Education

Cc Supervisor: Dr. S Oyoo (via email)

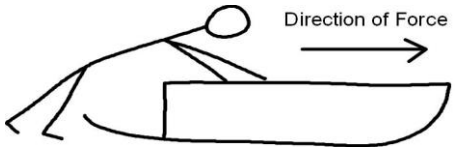
Appendix G: Pre-test

Question 1

Marks: 1

A sled on ice moves in the ways described in questions 1- 7 below. Friction is so small that it can be ignored. A person wearing spiked shoes standing on the ice can apply a force to the sled and push it along the ice. Choose one force (A through G) which would keep the sled moving as described in each statement below.

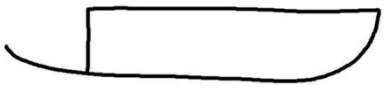
You may use a choice more than once or not at all but choose only one answer for each blank. If you think that none are correct, answer choice J.



A: the force is toward the right and is increasing in strength (magnitude)

B: the force is toward the right and is of constant strength (magnitude)

C: the force is toward the right and is decreasing in strength (magnitude)

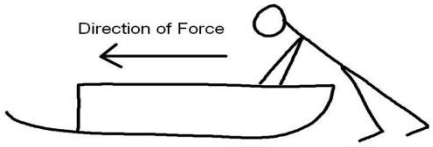


D: no applied force is needed.

E: the force is toward the left and is decreasing in strength (magnitude)

F: the force is toward the left and is of constant strength (magnitude)

G: the force is toward the left and is increasing in strength (magnitude)



1.1 Which force would keep the sled moving toward the right and speeding up at a steady rate (constant acceleration)? Choose...

1.2 Which force would keep the sled moving toward the right at a steady (constant) velocity? Choose...

1.3 The sled is moving toward the right. Which force would slow it down at a steady rate (constant acceleration)? Choose...

1.4 Which force would keep the sled moving toward the left and speeding up at a steady rate (constant acceleration)? Choose...

1.5 The sled was started from rest and pushed until it reached a steady (constant) velocity toward the right. Which force would keep the sled moving at this velocity? Choose...

1.6 The sled is slowing down at a steady rate and has acceleration to Choose...

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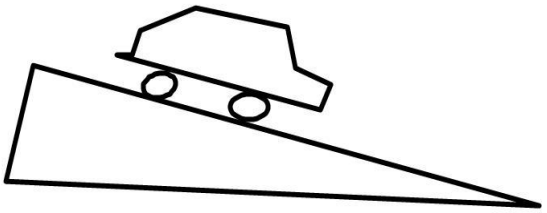
the right. Which force would account for this motion?

1.7 The sled is moving toward the left. Which force would slow it down at a steady rate? Choose...

Question 2

Marks: 1

2.1 - 2.3 refer to a toy car which is given a quick push so that it rolls up an inclined ramp. After it is released, it rolls up, reaches its highest point and rolls back down again. Friction is so small it can be ignored.



Use one of the following choices (**A** through **G**) to indicate the net force acting on the car for each of the cases described below. Answer choice **J** if you think that none is correct.

A : net **constant** force **down** ramp.

B : net **increasing** force **down** ramp.

C: net **decreasing** force **down** ramp.

D : net force **zero**.

E : net **constant** force **up** ramp.

F: net **increasing up** ramp.

G : net **decreasing up** ramp.

2.1 The car is moving up the ramp after it is released. Choose...

2.2 The car is at its highest point. Choose...

2.3. The car is moving down the ramp Choose...

Question 3

Marks: 1

Questions 3.1-3.3 refer to a coin which is tossed straight up into the air. After it is released it moves upward, reaches its highest point then falls back down again. Use one of the following choices (**A** through **G**) to indicate the force acting on the coin

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for each of the cases described below. Answer **J** if you think none are correct. Ignore any affects of air friction.

A: the force is **down** and constant.

B: the force is **down** and increasing.

C: the force is **down** and decreasing.

D: the force is **zero**.

E: the force is **up** and constant.

F: the force is **up** and increasing.

G: the force is **up** and decreasing.

3.1 The coin is moving upward after it is released. Choose...

3.2 The coin is at its highest point. Choose...

3.3 The coin is moving downward. Choose...

Question 4

Marks: 1

Questions 4.1- 4.4 refer to two objects that have the same size and shape but differ in mass. Object A has double the mass of object B. The objects are dropped off the balcony at the same time.

4.1 Object A will experience the same gravitational force (weight) as object B. Choose...

4.2 The acceleration of Object A will be the same as object B. Choose...

4.3 Object A will reach the ground before object B. Choose...

4.4 Object A will have the same velocity just before reaching the ground as object B. Choose...

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Appendix H: Post-test

Grade 11 - Physical Science

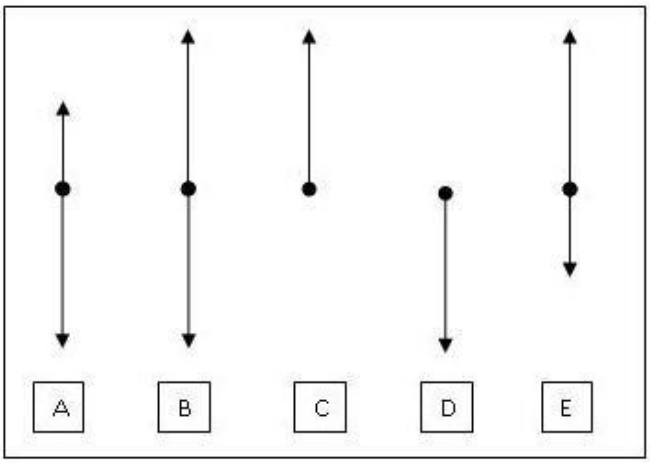
Forces test

Question 1

Marks: 3

The following three questions refer to a stone that is shot straight up by a catapult. After it is released the stone moves upward, reaches its highest point and falls back down again. Assume that air friction is so small it can be ignored.

Match the correct force diagram with the scenario given. If none of the answers seem correct, choose F.



The stone is moving upward after it is released. Choose...

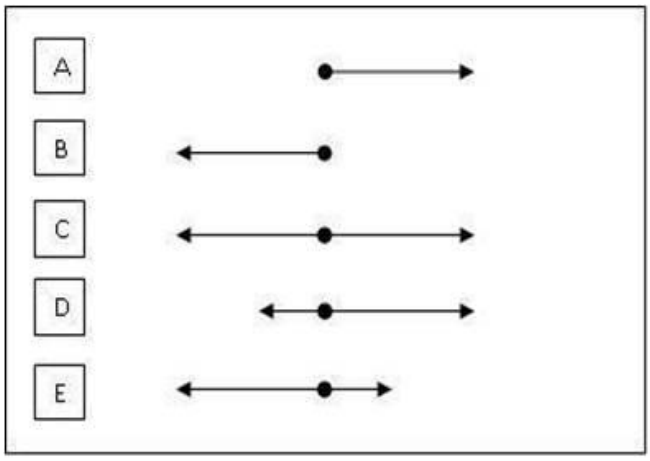
The stone is at its highest point. Choose...

The stone is moving downwards. Choose...

Question 2

Marks: 4

Choose the force diagram that correctly represents each of the following scenarios. Friction cannot be ignored.





The car is travelling at constant velocity. Choose...

The car accelerates from 10m/s to 16m/s. Choose...

The car brakes. Choose...

The car reverses. Choose...

Question 3

Marks: 3

The following questions refer to a coin which is tossed straight up into the air. After it is released it moves upward, reaches its highest point then falls back down again. Use one of the following choices (**A** through **G**) to indicate the acceleration acting on the coin for each of the cases described below. Answer **J** if you think none are correct. Ignore any affects of air friction. Take up to be the positive direction.

A : the acceleration is in the positive direction and constant.

B : the acceleration is in the positive direction and increasing.

C : the acceleration is in the positive direction and decreasing.

D : the acceleration is zero.

E : the acceleration is in the negative direction and constant.

F : the acceleration is in the negative direction and increasing.

G : the acceleration is in the negative direction and decreasing.

The coin is moving upward after it is released. Choose...

The coin is at its highest point. Choose...

The coin is moving downward. Choose...

WITHDRAWN

Question 4

Marks: 1

An 8kg box is lifted vertically from rest by an upwards force of 120N. The height through which the box is moved is 5m. The acceleration of the block is

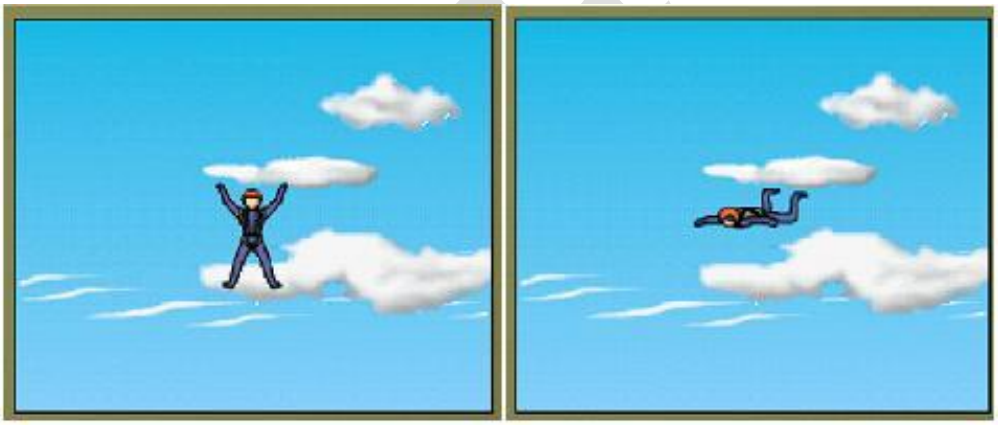
Choose one answer.

- A. 15 metres per second squared
- B. 10 metres per second squared
- C. 8 metres per second squared
- D. 5 metres per second squared

Question 5

Marks: 5

Describe the change in the forces acting on the skydiver as he changes from the position shown on the left to the position on the right. Explain how will this affect the acceleration of the skydiver?



Save without submitting | Submit all and finish

VETD

Summary of pre-test and post-test results

Pre-test n = 67						Post-test n = 62					
Question	Origin	Description		Correct	Incorrect	Question	Origin	Description		Correct	Incorrect
Force Sled	FMCE	horizontal forces, natural language	1.1	43%	A (52%)	Stone	modified FMCE	vertical forces, force diagram	1.1	5%	E (48%), C (44%)
			1.2	49%	B (45%)				1.2	16%	B (61%)
			1.3	51%	C (28%), G (9%)				1.3	69%	A (23%)
			1.4	43%	G (54%)						
			1.5	75%	B (13%)						
			1.6	21%	C (31%), A (9%), D (9%), E (9%), F (9%)						
			1.7	46%	E (30%), C (10%)						
Cart on ramp	FMCE	vertical forces, natural language	2.1	36%	G (30%), E (13%), F (12%)	Car on flat	Researcher	horizontal forces, force diagram	2.1	79%	A (13%)
			2.2	42%	D (43%)				2.2	84%	A (13%)
			2.3	57%	B (34%)				2.3	18%	E (53%), F (10%)
									2.4	47%	B (44%)
Coin toss	FMCE	vertical forces, natural language	3.1	48%	G (36%)	Coin toss	FMCE	vertical forces, vector language	3.1	6%	C (66%), B (10%)
			3.2	42%	D (46%)				3.2	2%	D (94%)
			3.3	51%	B (43%)				3.3	21%	F (74%)
Effect of mass	Researcher	vertical forces, True or False	4.1	73%		lift calculation	Researcher	vertical forces, values		23%	A (52%)
			4.2	66%							
			4.3	67%							
			4.4	72%							

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Appendix J: Summary of face-to-face audio recordings

	Design experiment			Interpretation of results		
Group number	**Members**	**Duration**	**Comments**	**Members**	**Duration**	**Comments**
A1	L1, L2,L3 & L4		Muddled about the use of a control	L1, L2 & L3. L4 excused	7:23	Used a control, good understanding of results but muddled by force of air-friction 5:45, improved design
A2				L5, L6,L7 & L8	7:17	Quite formal, appeared to have prepared in advance and read the results
A3						
A4	L9, L10, L11 & L12. L10 from A3 joined them.	17:42	Lots of joking around; successful challenge of speed vs acceleration 4:43-5:23 Unsuccessful challenge of effect of mass on acc 8:54-9:30	L9, L10,L11 & L12		Mainly just read the results, timing inaccurate
A5	L13, L14,L15 & L16	5:31	Hypotheses not discussed,			
A6	L17, L18,L19 & L20	5:10	Fair amount of messing around, successful challenge of mass affecting g 2:10, good discussion of fixed variables	L17, L18,L19 & L20	4:14	
A7	L21, L22,L23 & L24. L25 missing.	18:56	Good discussion of variables, good example of shape, successful challenge of independent vs dependent variables at 16:00	L21, L22,L23, L24 & L25. L17 from M5 joined them.	11:45	Mainly just read the results - Results were good, all acceleration values under 9.8m.s^{-2}. Learner comment 3:10 that the results of the friction were expected. Found that the greater mass had a greater acceleration based on data – accepted by the group. Good discussion on how to improve the expt.

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Appendix K: Excerpts from the Moodle Forum Log

This excerpt is taken from the second Moodle forum group. The highlighted text indicates when Learner 5 states the hypothesis and Learner 6 re-states the hypothesis correctly without challenging Learner 5.

Re: Design Experiment

By **Learner 5**- Tuesday, 1 June 2010, 07:19 PM

The Variables are fine; Although Brandon has brought up a great problem. Yes tennis balls can be used although tennis balls with different masses might be a challenge to find. We could use different sports balls which have different masses and surface areas. (soccer balls; cricket balls; hockey balls)
Hypothesis:
The more wait an object has, the faster the object will fall towards the ground because the force of attraction is greater than lighter objects.
Objects with large surface areas will fall to the ground slower than objects with a less surface areas. This is so because there is less air friction on objects with smaller surface areas.

For the mass experiment we use a golf ball and ping pong ball (which are the same size) and have covered them in tape, so they have the same surface covering. They are both exactly the same execpt for the mass. This will keep the variables the same.

For the surface area experiment we use the polystirene cubes and balls

For the height test we use a tennis ball

For the covering test we use a normal tennis ball and then a tennis ball covered in tape.

Re: Design Experiment

by **Learner 6** - Tuesday, 1 June 2010, 07:37 PM

Hypothesis

Mass test - Objects will have the same acceleration regardless of mass

Surface area - the larger the surface area the slower the acceleration becomes

Coverings - the smoother the covering the faster the acceleration becomes

Height - The object will accelerate at the same rate

Show parent | Edit | Split | Delete | Reply

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Appendix L: Pilot questionnaire

Grade 11 - Physical Science

You are logged in as Nicci Glanville (Logout)

View All Responses. All participants. View Default order Responses: 44

Test questionnaire

Please complete this questionnaire so I can test this aspect of Moodle.

1.

I am going on the sport's tour to Bloemfontein today.

Response	Average	Total
Yes	55%	24
No	45%	20
Total	100%	44/44

2.

I prefer physics to chemistry.

Response	Average	Total
Strongly disagree	11%	5
Disagree	23%	10
Agree	45%	20
Strongly Agree	20%	9
Total	100%	44/44

3. I spend the following amount of time watching television on average per day.

Response	Average	Total
not applicable	5%	2
less than 30 mins	27%	12
between 30 and 1.5 hours	59%	26
more than 1.5 hours	9%	4

Total	100%	44/44

4.

I found the format of the multiple choice test on Moodle easy to understand.

Response	Average	Total
Strongly disagree	9%	4
Disagree	7%	3
Agree	36%	16
Strongly Agree	48%	21
Total	100%	44/44

5. Which section of Grade 11 science have you found most challenging this term? How do you intend to improve on this section before the July exams?

#	Response
1	
1	acid and base. practice more examples and try understand the concept
2	Acid and Bases
1	acid and bases. i will study extra hard for the exams.
1	Acids and Bases Actually study for the exams this year
1	acids and bases i will study harder and go to extra science
1	Acids and Bases, need to learn what a conjugate base and acid is.
1	All areas i found equally challanging. Only a problem with iniatially grasping concepts. I will improve by studying far harder and doin many examples to cement my understanding
1	all chemistry was challenging. i will just work harder for the mid-year exams
1	balancing chemical equations. i will practice more of them
1	chemistory
1	Chemistry
1	Chemistry and Physics
1	Chemistry because there is a vast quantity of theoretical information to study. I will study more to improve my performance in this section.
1	Chemistry(acids and bases), studying more.
1	Chemistry, i intend to try do a lot of examples and extra science to help me understand better.

1	Chemistry, i will attempt to study ad understand the subject more
1	chemistry, i will practise it at home
1	CHemistry- that sucks
1	Chemistry-study harder
1	Chemistry. I am going to attend the extra science classes and study in my free time.
1	chemistry. i will relearn this section for the exams and ask for help where i need it
1	Chemsitry and Physics
1	concentration... forces... physics..... study more efficiently, do practise tests, extra science, when i can.
1	Forces
1	forces - i will try to study
1	I found the chemistry section most challenging, particularly on moles. I will ensure that i have adequate notes and will study adequately for the test.
1	I found the section on Acid's and Bases a very challenging section this term and I tend to improve on this section by going to extra science lessons with the respective teacher on a Monday afternoon.
1	I have found acids and bases , as well as titration a little bit difficult. I plan on attending cosolidation lessons as well as practising more of the challenging, theoretical work during the holidays.
1	I thought that physics was very hard.. all the the avogodos number and room temprature and all that was hard. Long and had I plan to study.. a lot.
1	kjhkjhkjhkjhkjhkjhkjh
1	Mechanics: By practising examples in the book and in past tests that we have done and studying our text book thoroughly.
1	newton foeces. umderstand it and follow the laws properly, listen to the teacher and eat omega 3 and 6 fish oils.
1	Newtons 3 laws-going to extra science
1	Newtons Laws of Physics
1	Preparation of salts, i intend to study it more and try and complete the tests that i struggled with
1	Stoichiometric calculations, I shall study.
1	The part with titrations involving acids and bases. basically everything that was in the test out of 40
1	The physics concepts - since only small sections are being completed at a time. All the formula only work once all are known. I plan to take extra lessons if needed and focus primarily on Physics whilst studying
1	The Titrations section and aspects around it such as Conjugate bases etc. I plan on putting more time into my studies.
1	Tight rations, and concentrations
1	Titrations and physics. I plan on doing summaries of the information and formulas in a way which I find easier to understand.

1	Titrations. More practice makes one luckier.

6.

This questionnaire was quick and easy to complete.

Response	Average	Total
Disagree	9%	4
Agree	45%	20
Strongly Agree	45%	20
Total	100%	44/44

Moodle Docs for this page

You are logged in as Nicci Glanville (Logout)
GR11-PHY

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Appendix M: Post-test- question in mid-year examination

Question 8

James has completed the section on projectile motion. He is still not convinced that all objects will fall at an acceleration of 9,8 $m.s^{-2}$. He sets out to confirm this value. He chooses 3 objects of different masses. He drops these objects of known masses from the balcony of the school hall which is 2 m high. He records the time of each drop in the following table:

Objects	**Drop 1 -** **Time in seconds**	**Drop 2-** **Time in seconds**	**Drop 3-** **Time in seconds**
Mass 1	0,4	0,5	0,6
Mass 2	0,5	0,5	0,6
Mass 3	0,6	0,6	0,7

8.1 Write a suitable hypothesis for James's investigation. (3)

8.2 What are James's fixed variables? (1)

8.3 What was his dependent variable? (1)

8.4 His table of results is incomplete. He should have added an extra column. Write down a possible heading for this column. (1)

8.5 Use the table to calculate 'g' for mass 3 (3)

8.6 Analyse your answer and then make a recommendation on how he could improve and make **sure** of his results. (2)

8.7 Explain the trend that you would expect to see between the time of the drop and different masses. Now make use of the appropriate physics equation to justify your answer(s). (4)[15]

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Appendix N: Results of questionnaire

Grade 11 - Physical Science

Test questionnaire

The aim of this questionnaire is to evaluate the use of Moodle as an effective teaching and learning tool. The questionnaire is not aimed at evaluating you. There are no right or wrong answers. I would be grateful if you could answer the questions as accurately as possible.

1. I have my own computer with internet access at home.

Response	Average	Total
Yes	77%	40
No	23%	12
Total	100%	52/52

2. I don't have my own computer but I do have access to a computer with internet access at home some of the time.

Response	Average	Total
Yes	37%	19
No	63%	33
Total	100%	52/52

3. My cell phone can connect to the internet.

Response	Average	Total
Yes		50

	96%	
No	4%	2
Total	100%	52/52

4. I use the computers in the library or computer centre to complete school work.

Response	Average	Total
Never	12%	6
Hardly ever	63%	33
Quite often	15%	8
Very often	10%	5
Total	100%	52/52

5. The library and/or computer centre provides a good working environment.

Response	Average	Total
Strongly disagree	10%	5
Disagree	19%	10
Agree	63%	33
Strongly Agree	8%	4
Total	100%	52/52

7. I spend the following amount of time on Facebook, Myspace etc, on average per day.

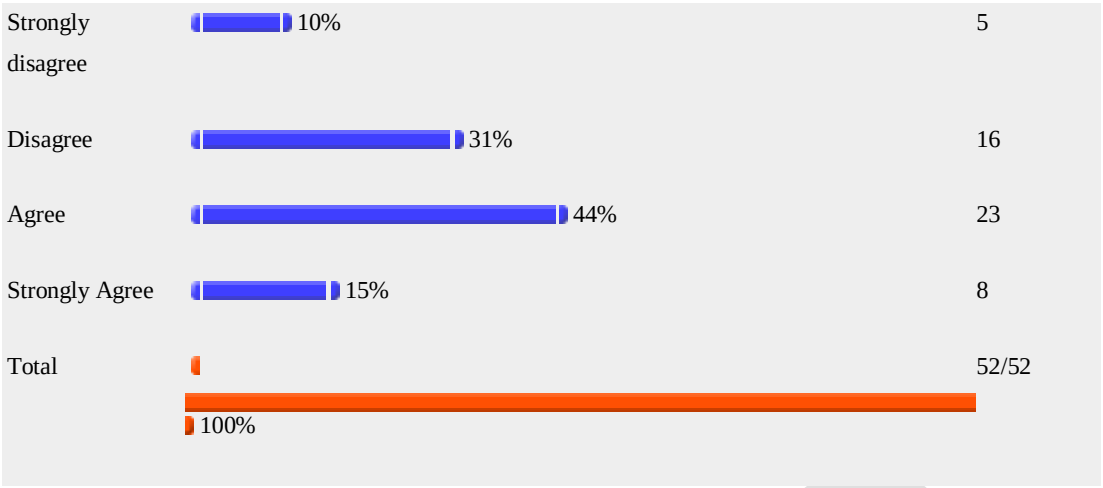
Response	Average	Total
not applicable	15%	8
less than 15 mins	33%	17
between 15 and 60 mins	42%	22
more than 60 mins	10%	5
Total	100%	52/52

8. I spend the following time on the internet on school-related research on average per day.

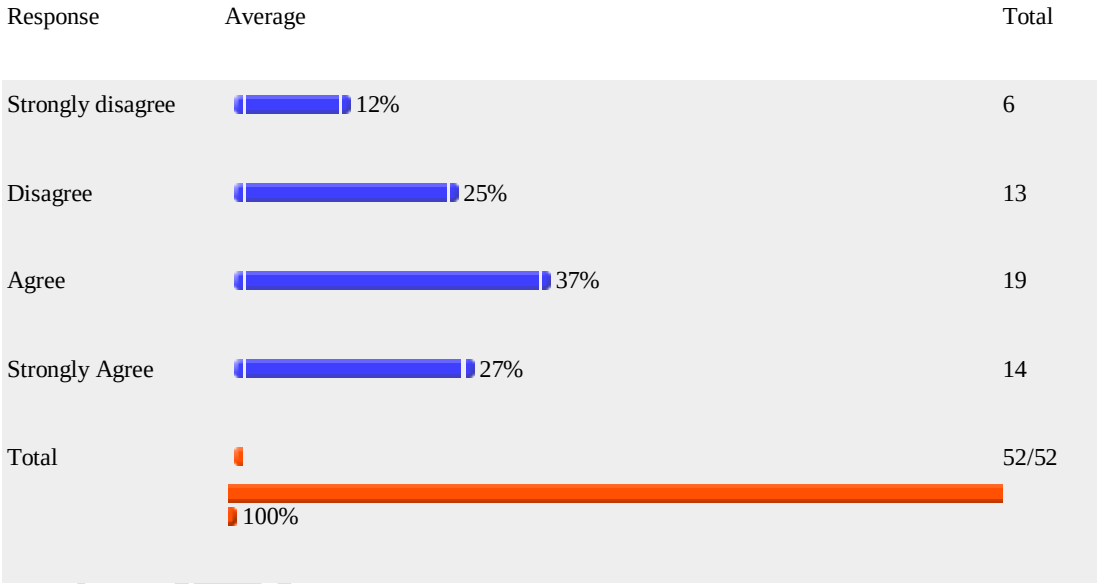
Response	Average	Total
not applicable	23%	12
lessan 15 mins	38%	20
15-60 mins	38%	20
Total	100%	52/52

9. I enjoyed completing the diagnostic test on the computer.

Response	Average	Total

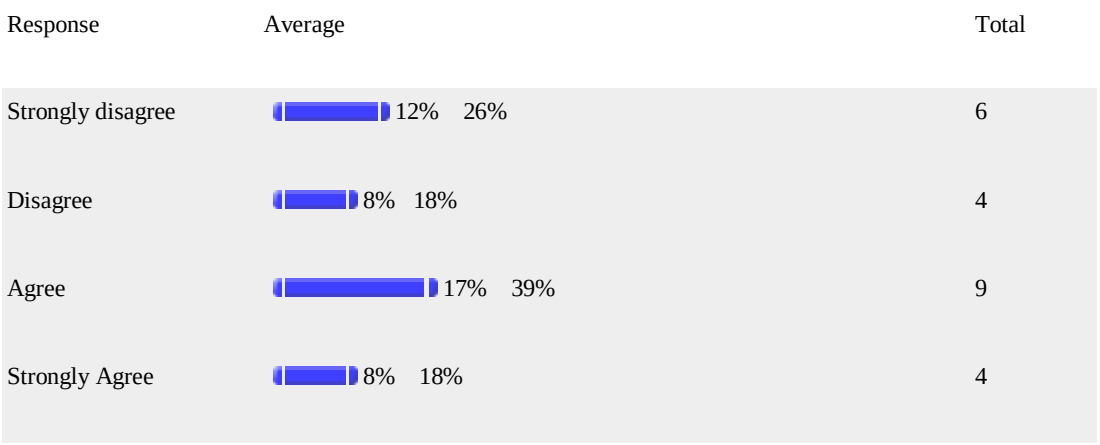


10. I would prefer other class tests to be completed on computer too.



Please answer 11 - 14 if you were part of the Moodle forum discussions.

11. I battled to use moodle for communicating with my group members.



Total	44%	100%	23/52

12. I do not think using a forum on Moodle is appropriate for group work.

Response	Average	Total
Strongly disagree	6% (13%)	3
Disagree	10% (22%)	5
Agree	21% (48%)	11
Strongly Agree	8% (17%)	4
Total	44% (100%)	23/52

13. I would like to use this approach for the planning and writing up of future science projects.

Response	Average	Total
Strongly disagree	6% (12%)	3
Disagree	19% (38%)	10
Agree	13% (26%)	7
Strongly Agree	12% (24%)	6
Total	50% (100%)	26/52

14. Our group battled to find a time to access the forum at the same time.

Response	Average	Total
Strongly disagree	2% (4%)	1

Disagree	10% (22%)	5
Agree	17% (39%)	9
Strongly Agree	15% (35%)	8
Total	44% (100%)	23/52

15. What aspect of Moodle did you find most frustrating?

#	Response
1	The first time I attempted to do group work online , it appeared to be ineffective.
1	a bit un easily readiable ish (if you know what i mean)
1	cant answer some questions with honest opinions but rather have to select an answer i might not 100% agree with.
1	communicating with group members
1	Difficult to organise to be free at the same time.
1	Finding out where to go, to complicating.
1	Hard to find what we've been told to look for.
1	Hard to fully understand what was expected. Unsure of implications after sending a message(who would see it? Just the teacher or everyone on moodle?)
1	I did not enjoy Moodle because it takes a long time to communicate what could be said in a few second verbally. It is often difficult to express yourself and it doesn't have the dynamic flow usually found in a convosation. it is also difficult to find where we are supposed to write
1	i don't know because i don't use it often enough to make a judgment
1	I don't like using MAC pc and its hard to nagative through the pages
1	Many people were trying to talk at the same time and it was a disjointed discussion

1	moodle frustrated me because when you are talking on a forum to other group members, you always having to refresh the page to see what the group members have said.... on the personal chat box it sais that the page refreshes every 60 secs so that you can read what people have said to you... but y doesnt the forum have that automatic refresh???
1	N/A
2	none
1	None at all i did not encounter any problems with the system.
1	none of it
1	none of it. it all works nice and smoothly. maybe just finding the work or test u are required to complete.
1	not much
2	Nothing
1	Nothing really, only the fact that it has to be done on computer. I prefer the idea of working on paper
1	Slight confusion on how to use it.
1	That our group members could never find a time to go on at the same time
1	The access of forums and the way forums work. It would be easier to have a forum that is more or less similar to a chatroom
1	The continous loading of the page after every person has replied and the constant struggle for communication between group members
1	The difficulty of typing.
1	The fact that i had to reload the page whenever I wanted to see a reply.
1	the indenting of the individual posts dependant on which answer you replied to.
1	The instant messenger is primitive.

1	The layout of Moodle could be more user friendly.
1	the part that we dont always know if work is on it and whether or not a teacher has got it
1	We wer unsure of how to use it to talk to one another
1	We were unabe to communicate effectivly and be online at the same time due to other activities

16. What did you enjoy most about Moodle?

#	Response
1	a place in order to communicate to oter members of the school in the comfort of our home without the other member having to come over.
1	Access to homework and practise
1	alomost everything
1	Didnt use it
1	easy access to past papers
1	Easy to use.
1	easy to use. most of the tests are multiple choice
1	having the discussions on moodle chat.
1	i didnt do it
1	i don't know i don't use it often enough to make a judgment
1	I enjoyed the fact that it is easy to locate school work and activities. The speed at which tests can be completed is much faster than putting pen to paper.
1	it easily cuts out the arguing found in most group discussions
1	It is different
1	it is easy to use oce you understand where to go

1	It was quick and easy to use and gave you your results often straight after completing a test.
1	It's very effective
1	It's virtual and easy to use once i have found what I am looking for.
1	its easy to use and access and i can talk to mates
1	Its effective as a learning tool, as well as allowing you to have a small amunt of personality in it.
1	N/A
1	not much.
1	Nothing
1	simple and easy to understand and do tests. its the best!!!!!!!
1	that we could use it out of school hours
1	The efficiency of Moodle to communicate with other group members
1	the quick access to the required page
1	The self-marking of the tests, can access it at home
1	The teacher can upload data and past exam where we can refer to
1	The way work can be uploaded to submit assignments.
1	to be able to get work that teacherss have posted.. and to be able to submit work from my home diretly to a teachers moodle thingy.
1	We can do work in the comfort of our own home
1	work can be doen at home or anywhere.

Please answer this question if you taped your discussions.

17. I felt that the discussion we taped helped me to understand the practical better.

Response	Average	Total

Strongly disagree	2% (5%)	1
Disagree	2% (5%)	1
Agree	17% (47%)	9
Strongly Agree	15% (42%)	8
Total	37% (100%)	19/52

18. This questionnaire was quick and easy to complete.

Response	Average	Total
Strongly disagree	6%	3
Disagree	10%	5
Agree	48%	25
Strongly Agree	37%	19
Total	100%	52/52

Moodle Docs for this page

You are logged in as Nicci Glanville (Logout)

GR11-PHY