IDENTIFYING GRADE TWELVE LEARNERS' PROBLEM SOLVING STRATEGIES IN GRAVITATIONAL ACCELERATION PROBLEMS

A

RESEARCH REPORT

Submitted by

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ABSTRACT

The purpose of this research was to identify grade 12 learners' present problem-solving strategies, factors that hinder or promote these learners' mastery of problem-solving strategies in physics. The research used 54 learners and four different research methods, namely documents review, questionnaire, interviews, and observations.

A multiple choice questionnaire was used to find out learners' understanding of the concept "gravitational acceleration" and factors hindering acquisition. Learners were asked to choose the correct option from a multiple choice questionnaire, and to provide a reason for that option. After analyzing data from the questionnaire, four learners were purposefully sampled for interviews and were continuously observed.

The results of this study indicate that Grade 12 learners begin their problem-solving by identifying the problem followed by listing given information and go on to search and manipulate the equation until they find the solution.

The results also indicate that these learners do not have a clear understanding of the concept 'gravitational acceleration'. The following factors hinder the mastery of problem-solving: (a) not understanding concept and principles of physics, (b) learners' lack of mathematical skills, (c) the learners' application of algorithms in problems that are conceptual and (d) learners' lack of appropriate knowledge for solving a problem, for example, lack of prior knowledge or content knowledge.

DECLARATION

I declare that this dissertation, titled

IDENTIFYING GRADE 12 LEARNERS' PROBLEM SOLVING STRATEGIES IN GRAVITATIONAL ACCELERATION PROBLEMS

Is my own work and that all sources that I have used or quoted have been indicated and acknowledged by means of complete reference.

It is being submitted for the degree of Master of Science at the University of the Witwaterand, Johannesburg. It has not been submitted before for any degree or examination at any other university.

…………………………….
Mahlatshwayo Judith Mokhele

DEDICATION

I dedicate this dissertation to my mother Phillipa, my two sons Mbusi and Ntaote and my niece Busi for their support, encouragement and patience.

ACKNOWLEDGEMENTS

I would like to thank the two grade 12 classes for allowing me to work with them, and a special thanks to the four learners who agreed to be interviewed. I would also like to thank the principal and my Head of Department for allowing me to use the grade 12 classes. I would also like to thank my supervisors Dr. M. Chakane and Dr. F. J. Mundalamo who were so supportive, patient and very encouraging. My family, thank you very much, my mother who took care of my boys when I was doing the research, my sons Mbusi and Ntaote who were also very supportive and used to fetch me at the bus stop after lectures and my niece Busi who was always there to help.

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LIST OF ABBREVIATIONS AND ACRONYMS

a	acceleration
d	distance
$m.s^{-2}$	meters per second squared
$m.s^{-1}$	meters per second
s	seconds (not to be confused with: s = displacement)
t	time
u	initial velocity
v	final velocity
UK	United Kingdom
SA	South Africa

CHAPTER ONE
INTRODUCTION

1.1. Overview

The level of problem-solving strategies amongst learners in science education is unsatisfactory (Shin, Jonassen, and McGee (2001). In the study by Dahsah and Coll (2007) Grade 10 and 11 learners resorted to the use of algorithm ostensibly without understanding the underlying science concepts. In another study conducted by (Harlen, Palacio and Russel (1984) in the United Kingdom (UK), 11 to 15 year-old students displayed a poor understanding of scientific concept and low-order process skills to perform cognitive tasks in science.

There are a number of reasons attached to this unsatisfactory level of problem-solving strategies amongst learners. Bodner (1991) argued that there is a gap between learners' conceptual understanding and algorithmic problem-solving. This gap makes it difficult for learners to translate and apply their conceptual understanding to solve both familiar and unfamiliar problems from different contexts. This therefore, suggests a need for educators to help learners bridge this gap. Once this gap is closed, learners can comfortably solve problems (Bodner, 1991). This fact was shown by the study conducted by Thomson and Stewart (2002). They showed how geneticists successfully solved problems by using their conceptual knowledge and problem-solving strategies.

According to Reid and Yang (2002), problem-solving in most educational settings involves the presentation and solution of a well-defined textbook problem that does not resemble ill-defined problems encountered in everyday real life. Reid and Yang (2002) asserted that problem-solving happens in every field of human enquiry and form of knowledge. Problem-solving does not only end in the classroom but it goes beyond classroom settings. Educators and schools need to provide opportunities for learners to solve both well and ill-defined problems and use science to solve crucial everyday problems (Reid and Yang, 2002).

In South Africa (SA), the National Department of Education's (NDoE) Revised National Curriculum Statement Policy (RNCS)'s first critical outcome envisage learners who are able to identify, solve problems and make decisions using critical and creative thinking (NDoE, 2002). SA needs skilled citizens who can identify, solve problems and make decisions using critical and creative thinking.

There is a need for educators to help learners acquire problem-solving strategies. However, to help learners master these strategies, there is a need to first identify their present problem-solving strategies (i.e. whether their conceptual understanding match algorithmic understanding), second to identify factors that hinder or promote acquisition of correct problem-solving strategies especially in physics, and thirdly initiate strategies that can be used to help learners acquire correct problem-solving strategies.

1.2. Research Problem

The problem for my study was therefore this persistent unsatisfactory level of problem-solving strategies amongst learners. Learners experience problems in solving classroom science problems in general, and gravitational acceleration problems, in particular. They either have little or no correct strategies to solve problems related to gravitational acceleration (Reif, 1995; van Heuvelen, 1991).

1.3. Research Purpose

The purpose of this research was therefore to identify Grade 12 learners' problem-solving strategies in gravitational acceleration and factors that hinder or promote their mastery of problem-solving strategies in gravitational acceleration.

1.4. Research Questions

I operationalized the above purpose of the study into the following two questions:

i) What are the problem-solving strategies a grade 12 learner uses when solving problems involving gravitational acceleration?

ii) How do these problem-solving strategies hinder or promote mastery of appropriate problem-solving strategies in gravitational acceleration?

1.5. Research Context

The study was conducted within the context of a Physical Science subject taught in a high school where I teach. The school is in a township in Boksburg and is one of the well equipped. There are three well-equipped laboratories, hall, computer center and technology center. Although the school is well equipped, students are from the disadvantaged communities. They live in shacks and some walk long distances to school without food. They are all English second language speakers and are taught by a qualified teacher, who has a diploma in chemistry and physics.

Grades 10, 11 and 12 classes have supervised study periods after school from Monday to Thursday.

Before conducting this study, I reviewed both theoretical and empirical literature for possible answers to my questions above. In the next chapter, I discuss what I found from literature.

CHAPTER TWO:
LITERATURE REVIEW

2.1. Introduction

In this section, I critically discuss some of the theoretical and empirical debates and findings around problem-solving, problem-solving strategies, gravitational acceleration, students' difficulties and factors that promote or hinder acquisition of problem-solving strategies.

2.2. Problem-Solving

Different authors define problem-solving in different ways. Shin et al. (2001: 7) indicate that there are two types of problems: well-structured and ill-structured problems. Well-structured problems have the following characteristics:

1. are well-defined problems with a known solution
2. present all elements of the problem
3. possess correct, convergent answer
4. engage application of a limited number of rules and principles that are organized in a predictive and prescriptive arrangement with well-defined constrained parameter.

On the other hand, ill-structured problems:

1. Are less definable and fail to present the elements of the problem
2. Possess multiple solutions or sometimes no solutions at all
3. Offer no general rules or principles for describing or predicting most of the cases
4. Represent uncertainty about which concepts, rules, and principles are necessary for the solution or how they are organized.

Pfeiffer (1994) states that problem-solving means creating a change to bring actual conditions closer to desired conditions. Wheatley (1984) defines problem-solving as what you do when you do not know what to do. Gagne and Mayer (1997) argue that problem-solving is a thinking process by which the learner discovers a combination of previously learned rules that she can apply to solve a novel problem. Perez and Torregros (1983) see problem-solving as a scientific investigative task. Ausubel, Novak, and Hanesian (1978) defined problem-solving as a form of meaningful discovery learning, but not completely autonomous discovery.

In this study, a problem is defined as a well-structured problem and problem-solving means a thinking process by which a learner discovers a combination of previously learned rules and applies them to solve problems in gravitational acceleration, and thus going through a process of meaningful discovery learning (Gagne and Mayer, 1997)

2.3. Problem-Solving Strategies

There are a number of different problem-solving models that are found in the literature (Woods, 1989). However, most problem-solving models that are found in the literature describe a process for solving well-defined problems (Shin et al, 2001). Pfeiffer (1994) gives nine steps to follow when solving well-defined problems. According to Pfeiffer, you have to: define the problem, decide on a method of attack for the problem, generate alternative test for reality, choose an alternative, plan for action, implement the plan, and evaluate the problem.

According to Reid and Yang (2002); and Reif (1995) the above models are required when the problem is solved but they do not make a claim that the learner can solve any given problem.

2.4. Gravitational Acceleration Problems

The acceleration produced by the gravitational force is called acceleration due to gravity or gravitational acceleration (g). The experimental value of g is approximately 9,8m/s^2. It is independent of the mass of the body, i.e., all bodies fall towards the center of the earth with the same acceleration in the absence of air friction. As the height above the surface of the earth increases, g decreases. The gravitational acceleration is dependant on the radius of the earth. The value of g is smaller at places such as at the equator where the radius of the earth is large and g is larger at places such as at the poles where the radius of the earth is smaller (Govender & Pillay, 1999: 91).

2.5. Students' Difficulties in Solving Problems

The concept "gravitational acceleration" is too abstract for learners (Huddle & Pillay, 1996). As a result this abstract nature of the topic results in learners' misconceptions about falling bodies, gravity and gravitational acceleration, which in turn leads to a lack of problem-solving strategies (Huddle & Pillay, 1996). Some of the misconceptions learners have are:

- Heavier objects fall faster than light ones
- Acceleration is the same as velocity
- The acceleration of a falling object depends upon its mass
- Gravity only acts on things when they are falling (McDermott, 1984).

The other problem is the language that is used when teaching this topic. Some words have meanings in science that are totally different from their familiar meaning (Bulman, 1986) and learners fail to link these words to their everyday experiences (e.g. the word "force'). Halloun and Hestenes (1985) indicate that in everyday life the term 'force' is used in a chaotic variety of contexts e.g. police force, economic force, and force of argument. This according to Halloun and Hestenes (1985) causes learners to use "force" loosely for variety of different concepts.

2.6. Factors that Promote or Hinder Problem-Solving Strategies

Research reveals that the lack of appropriate knowledge will hinder problem-solving ability. Shin et al. (2001) and Reif (1995) argue that domain knowledge (domain knowledge includes declarative knowledge, procedural knowledge, strategic knowledge and conceptual knowledge) is a primary requisite in both well-structured and ill-structured problems. The study conducted by Shin et al. (2001) showed that students who successfully solved both well-structured problems and ill-structured problems had well-integrated domain knowledge.

According to Anderson (1980), problem-solving in science is based on an understanding of concepts and rules that inter-relate them. That is, only a meaningful understanding of concepts and clear conceptual connections between them can lead to desired behaviour in problem-solving (Ausubel et al., 1978).

According to Shuell (1990), novice problem solvers lack problem-solving skills not because of the lack of the ability to solve but because they lack prior knowledge of the specific content area. Shuell continues to indicate that prior problem-solving experience is important in determining successful problem-solving. This shows the importance of prior knowledge in problem-solving. The observations that students make or the problems they attempt to solve cannot be separated from their previously gained intellectual skills (Osborne & Freyberg, 1985).

Bodner (1991) argued that there is a gap between learners' conceptual understanding and algorithmic problem-solving. According to Reid and Yang (2002) teaching that tends to focus on correct numerical answers might cause this gap. A basic need in science education is for the educators to acquire the knowledge that would guide them in better educating learners to think (Larkin & Rainard, 1984). Reid and Yang (2002) argue that if teachers want learners to be problem solvers, it is important to help them understand appropriate knowledge and avoid developing this knowledge in a rote fashion.

2.7. Conceptual Framework

This study is embedded within the conceptual framework of problem-solving strategies espoused by Reif (1995). According to Reif (1995), there are three major steps of systematic problem-solving strategy. These steps are initial problem analysis, construction of solution and checking the solution. The following is Reif's problem-solving model.

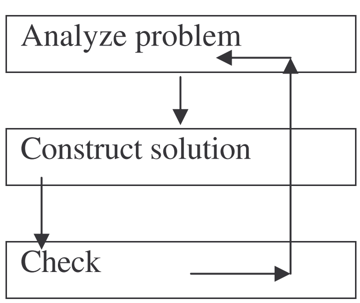

Figure 2.1: Major steps of a systematic problem-solving strategy

2.7.1. Initial problem analysis

The purpose of the initial problem analysis is to bring the problem into a form facilitating its subsequent solution. At this stage the problem solver must first clearly specify the problem by describing the situation (with the aid of diagrams and useful symbols) and by summarizing the problem goals. Furthermore, the problem solver must re-describe the situation in terms of physics concepts. This involves reading of question with understanding enabling the problem solver to extract the relevant information and visualize the situation. According to Reif (1981, 1995) deficiencies in an initial problem analysis are fatal.

2.7.2. Construction of a solution

An effective strategy for constructing the solution of a problem is to "divide and conquer," i.e., to decompose the search for a solution into simpler sub-processes (see figure 2.2). The problem solver assesses the status of the problem at any stage by ascertaining what information is known and the obstacles hindering a solution. The problem solver then identifies available options of sub-problems likely to overcome the obstacles and select a useful option.

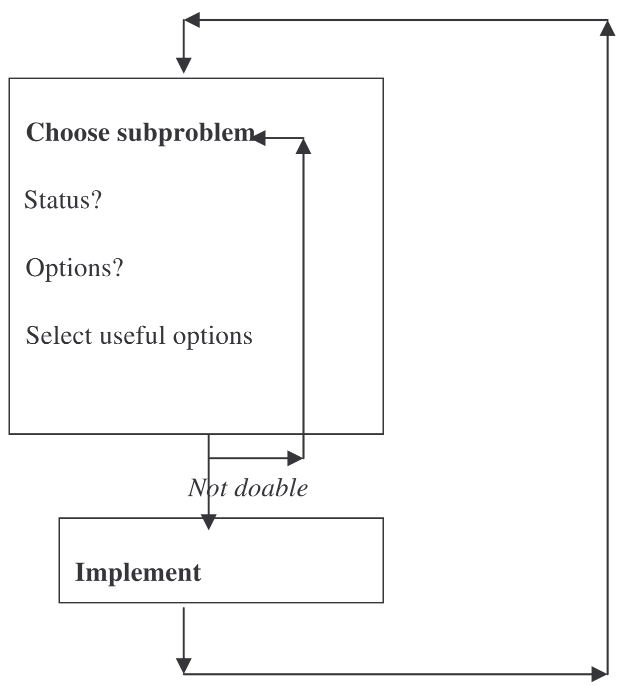

Figure 2.2: Construction of a problem solution by recursive into sub-problem

According to Reif (1995) effective knowledge organization is of crucial importance when constructing solution.

2.7.3. Checking solutions

According to Reif (1995), it is very important to check any solution to assess whether it is correct and satisfactory - and to revise it appropriately if any deficiencies are detected. The following can be used as a check-list for assessing any problem.

a) *Goals attained?* (Has all information needed been found?)

b) *Well specified?* (Are answers expressed in terms of known quantities? Are units specified? Are both magnitudes and directions of vectors specified?)

(c) Self-consistent? (Are units in equations consistent? Are signs or directions on both sides of equations consistent?)

d) *Consistent with other information?* (Are values sensible? Are answers consistent with special cases or with expected functional dependence? Are answers consistent with those obtained by another solution method?)

e) *Optimal?* (Are answers and solution as clear and simple as possible? Are answers in general algebraic form?)

The above problem-solving model provides a systematic approach that encourages learners to examine a problem before blindly calculating and to check their answers afterwards. Furthermore the steps in this method are essential to deal with more complicated problems.

2.8. Conclusion

Most studies reviewed paid attention to the problem-solving methods of college, university and lower grade learners (Herron & Greenbowe, 1986; Reid & Young, 2002; Harlen et al., 1984). Less attention is paid specifically to the problem-solving strategies of Grade 12 learners in the classroom. Most studies are about how learners solve chemistry problems and not physics ones. Finally, most of these research studies looked at students who were English first language speakers.

In the next chapter, I describe how the research was designed, the participants, instruments, and indicate how data was collected and analyzed.

CHAPTER THREE:
METHODOLOGY AND RESEARCH DESIGN

3.1. Introduction

In this section I describe in detail the design I used in my study. First I describe the methodology or the overall strategy I used. Secondly, I discuss how I developed and piloted my instruments. Thirdly I provide a full description of my participants. Fourthly, I describe how the data was collected, and analyzed. In conclusion, I critically reflect on the achievements and challenges of this design.

3.2. Methodology

To answer the research questions I used a case study methodology. Case study can be viewed as an in-depth study of interaction of a single instance in an enclosed system (Opie, 2004). In this study, Grade 12 class constitutes a single instance in an enclosed system and is studied in detail. It focuses on a real situation, with real people in an environment that is familiar to the researcher (Opie, 2004). Its aim is to provide a picture of certain features of social behaviour or activity in a particular setting and the factors influencing that situation.

A case in this study was my grade 12 classroom. Each learner in this classroom became the focus for my study. I used my classroom as a case because this allowed me enough time and energy to closely study each learner’s skills when solving problems. It also allowed me intimate interaction with each learner. To answer a question on how a learner solves problems, which requires a study of process, one needs close intimate observation of each learner. The strength of the use of case study was that it provided me in-depth information about one particular learner in contrast to a survey, which normally covers a huge number of learners beyond just one classroom.

3.3. Methods

Data was collected using: structured questionnaire, interviews, and observations. Learner’s prior physics workbooks, exam answer sheets and marks’ schedules were reviewed in an attempt to identify their difficulties in solving physics tasks. I used the questionnaire to find out learners' understanding of the concept "gravitational acceleration". Learners were asked to choose the correct option from a multiple-choice questionnaire, and to provide a reason for that option (see Appendix A). After analyzing data from the questionnaire, I purposefully sampled four learners for interviews based on their performance in the questionnaire (see Appendix B).

The aim of the interview was to encourage the problem solver to say aloud what they think and to do so with greater richness and spontaneity (Opie, 2004). When the interviews took place a problem solver (learner) verbalized all her thoughts when solving a problem, read and solved the problem aloud i.e. talked and justified all the steps she took up to the answer whilst the researcher listened carefully and kept the problem solver talking without affecting the natural thinking processes. I used learner's verbalized thought to find out whether learners read and understood the question, and how learners selected a problem-solving skill. Interviews allowed me to ask more questions, to assess learner's abilities before and after instruction.

Learners were told that the problem they are solving was not for marks, but to find the problem-solving strategies they use when solving problems. Learners were also told that they could take as long time as they wish to solve the problem and they can ask any question if they seek clarity. Also I requested to tape their conversations and they agreed. After transcribing the conversation transcripts, I gave each learner a chance to proof read his or her transcript to remove what they disliked and confirm the correctness of the transcript. In a way, this provided evidence for the validity of my interview data.

3.4. Participants

The participants were 54 Grade 12 learners, 25 boys and 29 girls. All of them passed their Grade 11 without being condoned (not one of them got less than 40% in Grade 11). They all completed the questionnaire. After analyzing the questionnaire, I purposefully selected four learners for the interviews and observations.

These four learners were selected according to their performance in the multiple-choice questionnaire. The selection criteria were as follows: a learner who scored 80-100%, a learner who scored 60-79%, a learner who scored 40-50, and a learner who scored 40%.

3.5 Ethics

I asked for the permission before conducting the study. I wrote letters for permission to the Gauteng Department of Education (GDE), the school principal and School Governing Body (SGB) and to the parents of the learners who took part in the research (see Appendix G for the letters). A consent form was also given, completed and signed by all the learners who volunteered to take part in the study (see Appendix H).

3.6. Data

I collected both quantitative and qualitative data. Quantitative data is constituted by multiple-choice responses, and qualitative one by open-ended section of the questionnaire, interviews and observations.

3.6.1 Collection

It took me one month to collect the data. I started by reviewing learners' workbook (class work and home work books), half yearly exam scripts and the schedules. Data collection took place in the afternoon during learners' study period to allow the year program to continue as planned. They took 30 minutes to complete the questionnaire and one hour for the interview. A minute was taken to describe the purpose of the research, confidentiality, consent, and the need to tape the conversations during interviews. Learners were allowed to open their books if they wanted to refer.

3.6.2 Analysis

To analyze the data, I used Reif's (1995) model. According to Reif, there are three major steps of systematic problem-solving strategy. These steps are initial problem analysis, construction of solution and checking the solution. In this study, I analyzed the data by firstly looking at whether the learners mastered the initial problem analysis, secondly, whether they mastered construction of solution and finally the checking of solution.

3.6.2.1 Analysis of the Questionnaire

Learner's responses were represented in a tabular form (see appendix F), options counted and converted into a percentage (see Table 4.1) and the information from the table was used to plot the graphs (see Figures 4.1 to 4.5).

3.6.2.2 Analysis of the Interviews

Four learners who were selected according to performance in the questionnaire were interviewed. To analyze the collected data I used the problem-solving model described by Reif (1995). I read each transcript three times assigning different colours to statements I found to be similar and dissimilar to Reif's problem-solving model.

3.7. Conclusion

In conclusion, even though to a large extent the design provided objective, valid and reliable data and findings, there were limitations. The documents review did not provide much information on learners' problem-solving skills and factors that hinder their learning. However, in spite of these challenges, the findings reported in the next chapter should be useful not only to practicing educators, but to other researchers.

CHAPTER FOUR
FINDINGS

4.1. Introduction

In this chapter, I present research findings and answer research questions. First, I provide and discuss the different problem-solving strategies Grade 12's use in solving gravitational acceleration problems. Secondly, I provide and discuss factors that hinder or promote the mastery of problem-solving amongst these learners. Thirdly, I discuss some of the limitations and significances of my work. In conclusion, I suggest areas for further research in gravitational acceleration problem-solving.

4.2. Grade 12 Learners' Problem-Solving Strategies in Gravitational Acceleration Problems

The four learners I interviewed displayed different problem-solving strategies to solve the four gravitational acceleration problems in the interview guide. The following are the problem-solving strategies of four learners who were interviewed.

4.2.1. Problem-Solving Strategies of Learner 1

Learner 1 knew what acceleration is but was not sure of what gravitational acceleration is. For example, he said:

> Firstly we know that acceleration is the rate at which velocity changes, and velocity is the rate at which displacement changes. This means that where there is acceleration, obviously, there is an increase in velocity. In my own words I can say gravitational acceleration is an increase in the rate at which velocity changes towards or away from the earth [Learner 1, Transcript L1]

Learner 1 read the question in parts and noted all the information directly provided by the question, understood the question, identified the problem and even listed all the given information to help solve the problem. The quote below provides evidence for all these skills in Learner 1:

Ok here they are looking for the time that took the ball to reach the ground if it is dropped from the height of two meters above the ground. From this statement I am already having my displacement of which is 2m and my gravitational acceleration, which is $10 m/s^2$ [Learner 1, Transcript L1]

Learner 1 was also able to choose the correct equation for question 2(a) and 2(b), he substituted correctly and he got the correct answer. When probed further, learner 1 said the following:

So the equation that I'm going to use is $s = ut + 1/2gt^2$". Now I'm going to substitute:

$s = ut + \frac{1}{2} gt^2$

$2 = 0 \times t + \frac{1}{2} (10) t^2$

$2/5 = 5t^2/5$

$t = 0.63s$

and,

$v = u + gt$

$v = 0 + 10 \times 0.63$

$v = 6.3 m/s$

My velocity is therefore 6.3 m/s

Although, Learner 1 was able to get correct answer for question 2(a) and 2(b), he lacked proper analysis of the problem mentioned by Reif (1995). Learner 1 did not translate words into diagram when he was identifying the problem, he also did not describe the physics behind his explanation. This learner's strategy of solving this question was similar to the findings of Heller and Heller (1995), and van Heuvelen, (1991). Their research revealed that learners begin to solve the problem by plunging into the algebraic and numerical solution. They search randomly for and inappropriately use an equation they associate with the given features until they get the answer. They rarely use their conceptual knowledge of physics to qualitatively analyze the problem situation.

When learner 1 was answering question 3 there was evidence of the lack of proper interpretation of scientific concepts. When the researcher asked him about initial velocity the learner said if there is nothing said about initial velocity, then it is equal to zero.

> Learner 1: The question says how high will the projectile go, so they want the displacement. Okay having my data i.e. my initial velocity = 0 final velocity = 20m/s
> Researcher: Why is your initial velocity equal zero?
> Learner 1: Nothing is said about initial velocity so it is equal to zero.
> Researcher: To you if nothing is said about initial velocity is it taken as zero?
> Learner 1: That's correct.

According to Reif (1995) proper interpretation of scientific concept is not an easy task. Many learners have a problem with interpretation of scientific concept.

4.2.2. Problem-Solving Strategies of Learner 2

Unlike Learner 1, Learner 2 confused gravitational acceleration with force. This is evident in the discussion between the researcher and Learner 2 below:

> Learner 2: Gravitational acceleration, what I think is a force that the earth pulls us with
> Researcher: Is force and acceleration one and the same thing?
> Learner 2: No, force is a pull or a push, and gravitational acceleration pulls, yes I can refer it as force
> Researcher: What is acceleration? And what is force?
> Learner 2: Acceleration is change of speed and gravitational acceleration is like Weight (Transcript L2)

However, Learner 2 read question 2 with understanding. She used key words to identify the problem. For example, she said: "the key word from the question is how long. So this question needs time" (Transcript L2). She was also able to list all the given information from the question. She wrote the following as given information: "g = 10, s = 2m, and t = ?, v = ? u = 0 (because the ball starts from rest)" (Transcript L2).

Just like learner 1, Learner 2 lacked initial planning, she did not describe the motion of the ball but only listed the information and chose the equation. She was able to choose the correct equation using the given information. She substituted the equation correctly and got the correct answer. The correctness of her calculation, shown below, revealed some of her mathematical skills. Speaking aloud she said:

> Firstly I need to check the question i.e. what does it need from me. Secondly I look for the equation. And thirdly I substitute as follows:
>
> $s = ut + ½ gt^2$
> $2 = 0 \text{ x } t + ½ (10) t^2$
> $2/5 = 5t^2/5$
> $t = 0.63s$
>
> Now I have time, gravitational acceleration and distance and the second question is looking for velocity:
>
> $v^2 = u^2 + 2gs$
> $= 0 + 2 \text{ x } 10 \text{ x } 2$
> $= 40$
> $v = 6,3m/s$

When learner 2 was solving question 3(a) she tried to describe the motion of the ball using familiar situation but that was not evident in question 2. The quote below illustrates this finding:

> So here the problem is like a person on the ground throwing the ball vertically upward, while throwing the ball hmm. The question is I am required to find the height because the key word is how high. That means they are looking for the certain distance. Okay I'm required to find "s" using distance. When the ball is

projected vertically upward that means my “g” is going to be negative (Leaner 2, Transcript L2 p.)

: $v^2 = u^2 + 2gs$

$0 = (20m/s^1)^2 + 2(-10) s$

$0 = 400 + (-20) s,$

$s = 20m$

When learner 2 was trying to solve question 3(c) she was a little bit confused (see below):

$s = ut + 1/2gt^2$, s = 20, t = ? g =10

$20 = 20t + 1/2(10) t^2$

$5t^2 + 20t - 20 = 0$

$t^2 + 4t - 4 = 0$

$(t + 2)(t + 2) = 0$

Learner 2: This is not correct

Researcher: What is the problem with answering question 3(c)?

Learner 2: In question 3 you have to be exactly sure with the initial velocity and the last question finding time. I thought the time used to throw the ball is the same time the ball came down. I’m now confused (Learner 2 Transcript L2)

This confusion according to Reif (1995) and Singh (2002) is caused by lack of proper analysis of the problem and lack of construction of the solution.

4.2.3. Problem-Solving Strategies of Learner 3

Whereas Learner 2 confused gravitational acceleration with force, Learner 3 confused it with the speed. Learner 3 said that “I think gravitational acceleration is the speed that the earth pulls us with” (Transcript L3). But she read the question with understanding, was able to list all information given and also identified the problem as evidenced by the quote below:

> The initial velocity is zero and I have "g", which is the gravitational acceleration, and "g" is always constant at $10m/s^2$ and then I'm asked to calculate time. So I must make time the subject of the formula in order to calculate it [Learner 3, Transcript L3].

However, there was no evidence for pictorial representation, and she did not translate words into a sketch, qualitative analysis was not evident, and did not describe the motion of the ball but simply read the question and went straight to look for the equation. She in fact used the textbook to look for equations and was able to choose the correct equation for question 2(a) and said "the equation that we are going to use is $s = ut + 1/2gt^2$" [Learner 3, Transcript L3].

Learner 3 lacked mathematical skills. She chose the correct equation but was not able to make "time" the subject of the formula (see the quote below):

> Okay now I have made "t" the subject of the formula and now I'm substituting the values in my equation [as follows]:

$$s = ut + 1/2gt^2$$

$$t = \frac{u + 1/2g}{2}$$

$$t = \frac{0 + ½(10)}{2}$$

$$t = 2{,}5\ s$$

> (Learner 3, Trancript L3)

And finally, she did not check the logic of the steps she undertook nor check the correctness of mathematics or her answer.

4.2.4. Problem-Solving Strategies of Learner 4

Learner 4 knew about Newton who discovered the concept of falling bodies but was not sure what gravitational acceleration is. In responding to question 1 of the interview, he said:

> Hmm I think gravitational acceleration is represented by a small "g". This small "g" is difficult to calculate. So there was a guy called Isaac Newton who discovered the law of the falling bodies. He found out that if you were to take two objects and put them in a vacuum, and take others where there is air resistance, the ones that are in the vacuum will fall at the same time and arrive down simultaneously, but the other ones that are in the presence of the resistance won't fall at the same time. Maybe if it's a feather and a coin, the coin will arrive first and the feather last. Ya that's what I think about gravitational acceleration [Learner 4, Transcript L3]

He read question 2 with understanding and was able to identify the problem. He also listed all the information that was given to him as indicated below:

> I can say "g" is always $10m/s^2$ because you drop a ball from the height of 2m above, so my "g" is going to be negative 10 because you are dropping something in the top. So, my "g" is going to be negative. No it's not going to be negative. I'm sorry. It's going to be positive 10. Let me just see: I have my height which is 2m. Hmmm, how long will it take to reach the ground? Hmm I'm looking for "t" here. Hmm initial velocity is zero [Learner 4, Transcript L3].

Learner 4 did not translate the words into diagram. Pictorial representation was not evident. However, Learner 4 was able to select the correct equation for question 2 but at some point got confused and wanted to start with question 2(b). This is evident in the discussion below:

Learner 4: Initial velocity is zero because the ball starts from first, let me see which equation. I should use, yes I'm going to use this equation yes, $s = ut + gt^2$. My distance is 2m and my "g" is positive $10m/s^2$, so

$$s = ut + \frac{1}{2} gt^2$$

$$2 = 0 \times t + \frac{1}{2} \times 10 \times t^2$$

Hmmm basically there is a mistake I made.

Researcher: Why do you think you made a mistake? What is your problem now?

Learner 4: My calculation

Researcher: What is wrong about your calculations?

Learner 4: I'm trying to calculate time. Is it possible for me to start with (b) first then I can just carry on?

Ultimately, he substituted correctly and got the correct answers even though he started with question 2(b) which he worked out as follows:

$$v^2 = u^2 + 2gs$$

$$v^2 = 0 + 2 (10) 2$$

$$v = \sqrt{40}$$

$$v = 6{,}3 \text{ m/s}^1$$

Researcher: That's for B.

Learner 4: Yes, now let me do the first question, how does it reach the floor, so I have to use the first equation because I have "u" and "g"

$$v = u + gt$$

$$6{,}3 = 0 + 10 \times t$$

$$t = 0{,}63 \text{ s}$$

And finally, Learner 4 was unable to solve question 3 and was confused most of the time.

The results of this study show that all four learners began problem-solving by reading the question with understanding at some point. Although all of them read the question with understanding, their style of reading was not the same. Some of them read the question in parts and others tried to process the information when they were reading the question. As they were reading the questions they were all able to identify the problem, to note all information directly provided by the question, and then proceeded to listing all the given information. For example, one of the learners said:

> Ok here they are looking for time that took the ball to reach the ground if it is dropped from the height of two meters above the ground, right from my statement I'm having my displacement which is 2m and my gravitational acceleration which is $10m/s^2$ [Learner 1 Transcript L1].

Learner 3 said:

> The initial velocity is zero and I have the "g", which is the gravitational acceleration, and "g" is always constant $10m/s^2$ and then I'm asked to calculate time. So I must make time the subject of the formula in order to calculate it" [Learner 3, Transcript L3].

Although the learners tried to some extent, the results of this study show that they lacked proper initial analysis of a problem as described by Reif (1995). The learners were able to identify the problem and were also able to list all given information.

In the same way as novice problem solvers the four learners did not develop a plan of attack before manipulating equations (Singh, 2002). Evaluation of the solution did not take place. Evaluation of the solution involves the checking of the solution to ensure that it is properly stated, reasonable and complete. Checking of the correctness of the solution was very minimal between these learners. They wrote the answer and went straight to the next problem.

Therefore, from the study, the following are the problem-solving strategies grade 12 learners possess when solving problems in gravitational acceleration problems:

1. Identifying the problem
2. Listing of the given data
3. Selection of the equation and substitute
4. Finding the solution

These results are similar to the findings of Heller and Heller, (1995) where students in the introductory physics course began to solve the problem by searching for and manipulating equations. Heller and Heller's results show that these students rarely used their conceptual knowledge of physics to qualitatively analyze the problem situation and they rarely check if the answer is correct.

The learners in this study showed problem-solving strategies that use textbook problem-solving method. This, suggest that they are more exposed to the textbook problem-solving methods. Textbook problem-solving methods steps are (a) Identify the problem, (b) Find the known and unknown, (c) select the equation, (d) solve the equation and (e) check the answer. Textbook problem-solving method merely provides general framework for solving a problem and they provide fewer specific instruction on how to perform each step and how to make a translation from one step to the next (Huffman, 1997).

4.3 Factors that Promote or Hinder Grade 12 Learners' Problem-Solving Strategies in Gravitational Acceleration Problems

Another purpose of this study was to find the factors that hinder or promote learners' mastery of problem-solving skills in physics, that is, alternatively, what makes them not to describe the physics behind a problem and evaluate their answers. The results of this study show that learners do not have a clear understanding of the concept "gravitational acceleration".

The results from the multiple-choice questionnaire show that learners have a problem with this concept. In the multiple- choice questionnaire learners were asked to choose the correct answer from the options given and to provide the reason why they chose that option. Some of the learners chose the correct option but the reasons they stated showed no clear understanding of the concept ‘gravitational acceleration’. For example, in question 1, learners were asked the following question.

A ball is thrown upwards and then returns to the ground. What is the acceleration of the ball at the top of its path?
The options were A) It is zero. B) It is $10m^{-2}$ upward. C) It is $10m.s^{-2}$ downward. D) It changes from $10m^{-2}$ upward to $10m^{-2}$ downward.

Learners chose the correct option C but the reason provided did not show that learners understand the concept, for example some of the learners gave the following reasons.

Force of gravity is pulling the ball down
A force of $10ms^{-2}$ is always acting on a ball
Because acceleration is not increasing and the ball returns at the same time
Because (g) always pushes downwards
It’s because the force which pulls down
Because the downward force is pulling force of gravity

Learner’s responses were re-written in table form (see appendix F), options counted and converted into a percentage and the information from the table was used to draw the graphs (see Figures 4.1 to 4.5 below). (The correct options in the questionnaire are: for Question 1 is C, Question 2 is D, Question 3 is D, Question 4 is B, and Question 5 is D).

Table 4.1 shows that 46% of the learners chose the correct option for multiple-choice question 1. This could suggest that learners have clear understanding of the concept gravitational acceleration but the reasons given by the learners are incorrect (see few reasons given above)
31% of the learners chose option D for question 2, 28% chose option D for question 3, 42% chose option B for question 4 and 9% chose the correct option D for question 5.

Table 4.1: Learners' Reponse Frequencies from the Questionnaire

Question	Option A		Option B		Option C		Option D	
	No. of learners	%	No. of learners	%	No. of learners	%	No. of learners	%
1	20	37	2	4	25	46	6	11
2	10	19	22	41	5	9	17	31
3	4	7	27	50	9	17	14	28
4	7	13	23	42	10	19	12	22
5	25	46	15	27	4	7	5	9

Figure 4.1 below shows the responses of the learners who answered questionnaire. The x-axis shows the question's options and y-axis gives the percentages. Correct option is C and 46% of learners chose C.

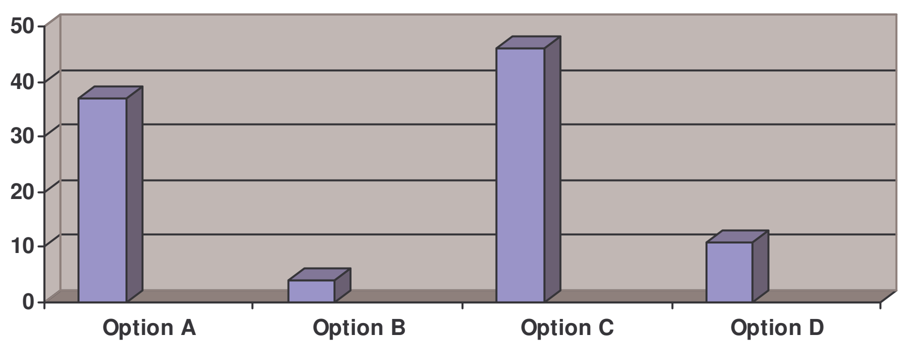

Figure 4.1: Graph of Responses to Questionnaire Question 1

The correct answer for question 2 is option D and 31% learners chose D,as shown in Fig. 4.2 below.

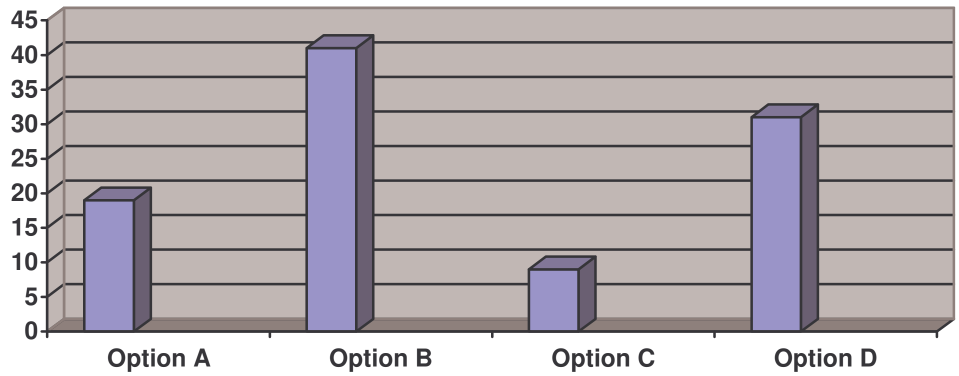

Figure 4.2: Graph of Responses to Questionnaire Question 2

The correct option for question 3 is D and only 28% learners chose option D, as shown in Fig. 4.3 below.

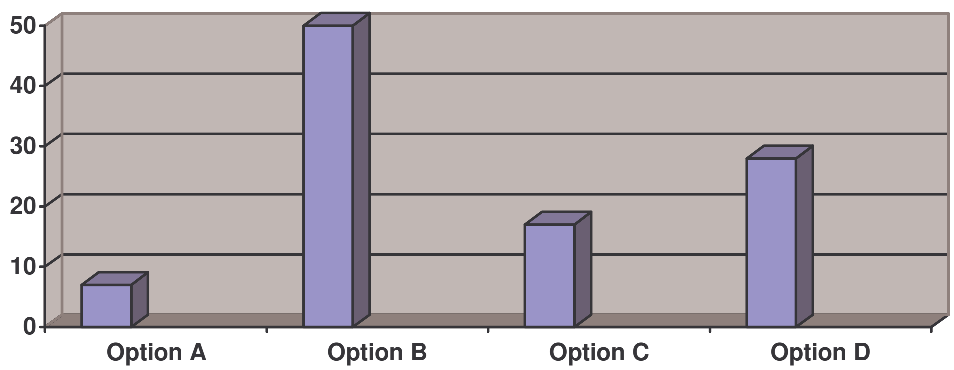

Figure 4.3: Graph of Responses to Questionnaire Question 3

The correct option for question 4 is B and 42% of learners chose option B as shown in Fig. 4.4 below.

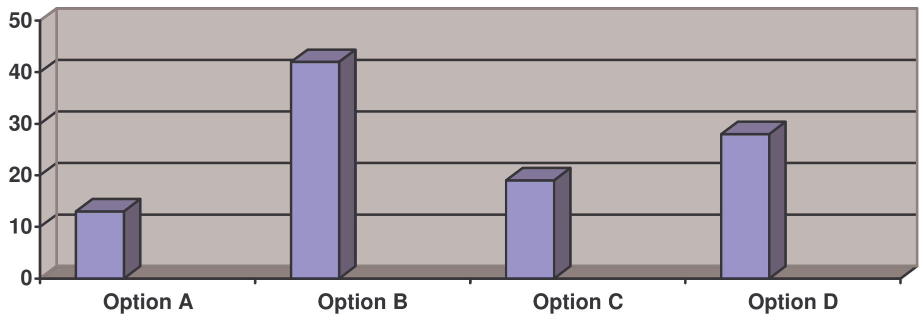

Figure 4.4: Graph of Responses to Questionnaire Question 4

The correct answer for question 5 is D and 9% of learners chose option D as shown in Fig. 4.5 below.

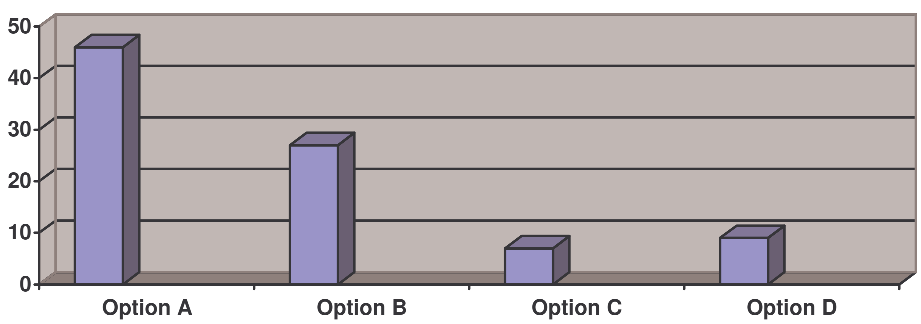

Figure 4.5: Graph of Responses to Questionnaire Question 5

The table and the graphs above indicate that learners have no clear understanding of gravitational acceleration. Not understanding the concept gravitational acceleration and the rules inter-relating them could be the reason why all learners could not successfully solve question 3(b) and 3(c). On the other hand learners were able to solve question 2(a) and 2(b) successfully although they had no clear understanding of the concept "gravitational acceleration". According to the study conducted by Nurrenbern and Pickering (1987), it is possible for learners to solve problems and get correct answers without conceptual understanding. Gabel, Sherwood and Enochs (1984) asserts that large numbers of learners depend only on algorithmic procedure and they give no evidence of reasoning out the problem. The result of this study confirms that learners relied on strictly algorithmic methods for questions 2(a) and 2(b).

Mathematical skills also played an important role in problem-solving. 75% of learners got the correct answer for questions 2(a) and 2(b) because of their ability to manipulate equations. However, 25% of the learners got wrong answer for questions 2(a) and 2(b) because of the lack of mathematical skill.

The results of this study showed that the lack of qualitative description of physics involved when solving the problem hindered these learners' problem-solving ability. Novice problem solvers lack problem-solving strategies not because of the lack of the ability to solve but because they lack prior knowledge of the specific content area (Shuell, 1990). Shuell continues to indicate that prior problem-solving experience is important in determining successful problem-solving. Learners' ability to solve question 2 suggests that they had some prior knowledge however their difficulty to solve question 3 suggest that the prior knowledge and appropriate knowledge they had was not sufficient enough for them to master problem-solving. The results of this study reveal that learners had some appropriate knowledge and prior knowledge but it was not sufficient.

To summarize my findings, the following are the factors that hinder the mastery of problem-solving:

1. Not understanding concept and principles of physics.
2. Learners' lack of mathematical skills.
3. The learners' application of algorithms in problems that are conceptual.
4. Learners' lack of sufficient appropriate knowledge for solving a problem, for example, lack of prior knowledge or content knowledge.

4.4. Strategies to Help Grade 12 Learners Acquire Problem-Solving Skills in Gravitational Acceleration

According to Anderson (1980) and Reif (1995) problem-solving in science is based on an understanding of concepts and rules interrelating them. From the results of this study learners could not solve some problems because they did not understand the concept “gravitational acceleration” and the interrelating rules. If more time could be spent on helping learners understand the concepts and their rules they will successfully solve these problems (Gabel et al., 1984).

The results of this study suggest that learners depend on algorithmic techniques more than reasoning skills. One way of helping learners overcome algorithmic techniques is for teachers to make certain that learners understand concepts qualitatively before they are presented quantitatively (Bodner, 1991). Educators need to find a way to communicate the importance of conceptual problem-solving to their learners just as they have communicated the importance of using the correct formula and obtaining correct numerical answer (Phelps, 1996). Once learners understand the concepts qualitatively teachers need to help them to become problem solvers by teaching them how to solve problems in a more organized fashion (Phelps, 1996).

4.5. Limitations

Even though to a large extent my study achieved what it intended to achieve, there were challenges. The timing of fieldwork was a major limitation. It was conducted in the afternoons. At this time, learners were tired, hungry and wanted nothing else than to go home.

4.6. Significance

Even though there were all these limitations, there are a number of significances from this study. Amongst others, the study provides teachers with a basis for structuring effective teaching strategies to help students develop problem-solving strategies. Researching problem-solving strategies using gravitational acceleration revealed learners’ difficulties in understanding the concept. Thus it will also help educators to acquire the knowledge that would guide them in better educating learners to think about problem-solving.

4.7. Recommendations for Further Research

For future research, I therefore recommend more work to be done in understanding the identified problem-solving strategies above, context that supports or hinders factors that inhibit acquisition of skills, and actual development and implementation of intervention strategies to help learners acquire those skills.

4.8. Conclusion

The results of this study confirmed the lack of problem-solving strategies amongst Grade 12 learners. The results of this study revealed that learners begin to solve the problem by plunging into the algebraic and numerical solution. They search randomly for and inappropriately use an equation they associate with the given features until they get the answer. They rarely use their conceptual knowledge of physics to qualitatively analyze the problem situation.

The results from multiple-choice questionnaire revealed that learners did not have a clear understanding of the concept ‘gravitational acceleration’. The reason could be that most high school educators do not help learners understand the concept qualitatively.

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APPENDICES

Appendix A: Questionnaire

Identifying Grade 12 Learners' Problem Solving Strategies in
Gravitational Acceleration Problems

Questionnaire

Presented to the University Committee on Human Subjects
of the University of the Witwatersrand for
Masters of Science

By
Judith Mokhele

PURPOSE

I want to know your PROBLEM-SOLVING STRATEGIES when solving problems in gravitational acceleration.

INSTRUCTIONS

This questionnaire takes only one hour to complete. It has two sections: SECTION A and SECTION B. Section A asks you about your PERSONAL BACKGROUND (demographics) and Section B asks you to solve gravitational acceleration problems.

Please complete both sections and ENSURE that you do the following:

1. Read the questions carefully
2. Answer them on your own
3. Be as honest as possible
4. Write your answers as neatly and as clearly as possible in the spaces and blocks provided
5. Make sure that you fill in the date in the space provided
6. Circle the best answer and in the provided space write a reason why you chose the answer you circled

SECTION A: DEMOGRAPHIC INFORMATION

Please tell me the following about yourself. The information you provide will be treated highly confidential and with anonymity:

1. Name (First and Surname): ____

2. Age (in years): ____

3. Sex (Male/Female): ____

4. Place of Origin (Farm/Township/Town/City/Other): ___________________

5. Family (Poor/Middle/Rich): ____

6. Grade: ____

7. Previous Grade Pass Symbol: ____

8. Subjects Passed and Symbols:

Learning Area	Level (1 or 2 or 3 or 4)
1 ____________________________________	______
2 ____________________________________	______
3. ____________________________________	______
4. ____________________________________	______
5. ____________________________________	______
6. ____________________________________	______
7. ____________________________________	______
8. ____________________________________	______

SECTION B : GRAVITATIONAL ACCELERATION PROBLEMS

All questions taken from Physical Science Tutor Study Guide

Question 1

A ball is thrown upwards and then returns to the ground. What is the acceleration of the ball at the top of its path?

A. It is zero
B. It is $10m^{-2}$ upward
C. It is $10ms^{-2}$ downward
D. It changes from $10m^{-2}$ upward to $10m^{-2}$ downward

Reason:---

Question 2

A cricket ball is thrown vertically upwards. During the time the ball is moving upwards towards its maximum height, the magnitude of its acceleration is

A. Zero
B. Decreases
C. Increases
D. Remains constant, but not zero

Reason:---

Question 3

Ball X has a mass twice as large as mass of ball Y, but they have the same size. Both balls are dropped simultaneously from the same height. Which statement is true?

A. Y reaches the ground first
B. X reaches the ground first
C. X hit the ground with the greatest speed than Y
D. X and Y will reach the ground at the same time

Reason:---

Question 4

Zuko and Paul stand on a balcony. They lean over the balcony rail and each throws a cricket ball. Zuko throws the ball vertically upwards and Paul throes the ball vertically downwards at the same speed. If air resistance is negligible, how will the speed of the two balls compare on reaching the ground?

A. Zuko's ball will have the greater speed
B. Both balls will have the same speed
C. Paul's ball will have the greater speed
D. The speeds of the two balls cannot be compared without more information.

Reason: ---

Question 5

A ball is tossed vertically upwards, reaches its topmost point and then falls back to its starting point. While the ball is in the air, which of the following is true?

A. The acceleration is always in the same direction as the velocity
B. The acceleration is always opposite to the direction of the velocity
C. The acceleration is first in the same direction as the velocity and then in the opposite direction
D. The acceleration is first in the opposite direction to the velocity and then in the same direction

Reason: --

Appendix B: Interview Guide

Identifying Grade 12 Learners' Problem Solving Skills in
Gravitational Acceleration Problems

Interview Guide

Presented to the University Committee on Human Subjects
of the University of the Witwatersrand for
Masters of Science

By
Judith Mokhele

INTRODUCTION

1. Introducing myself

I am ____ (name of the interviewer), a ________________________________ (position in the organization, e.g. researcher), in the ____ (name of the university).

2. Restating Purpose, Context, and Intended Use of the Interview

The purpose of this interview is to identify and assess your problem-solving skills in solving gravitational acceleration problems. First, it asks you to explain how you will solve the problem. Second, it asks you to solve the problem. And finally it asks you to check whether your strategy worked or not.

3. Assuring Confidentiality and Anonymity

Please note that whatever you say, or do, or show me will be treated completely confidential and in case I have to quote you verbatim, I will use pseudonyms instead of your actual name.

4. Permission to Tape

I would like to tape the conversation for accurate recollection of our discussion and to avoid writing disturbances during the conversation. You have a right to ask for the transcript to review it before any use of it in the report or to totally cancel it. Do you have a problem if we tape this conversation? [If the answer is yes, switch the tape on; if the answer is no, take notes during the conversation].

5. Any Questions

Before we start, do you have any questions, e.g. about the purpose of the interview, intended use of data collected, confidentiality, anonymity, tape recording, or any other thing you would like to ask us? [If the answer is no, ask the first question in the guide. If the answer is yes, spent some time answering the questions by providing more clarifications].

KEY QUESTIONS

Question 1

In your own words explain what you understand about the term gravitational acceleration.

For question 2 and 3, PLEASE SPEAK ALOUD:

Question 2

You drop a ball from a height of 2m above the ground

a) How long will it take to reach the ground?
b) With what velocity does the ball strike the ground

(a) Speaking aloud, *explain* how you will solve this problem?

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………….

(b) Speaking aloud, *solve this problem* by applying what you said you will do above?

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………….

(c) Speaking aloud, assess your problem solving strategy that is, did your problem solving strategy work? If it did, why? If it did not, why too?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

<u>*Question 3*</u>

A ball is projected vertically upwards from the ground with a velocity of 20 m/s

- How high will the projectile go?
- What will be the velocity of the ball after 1s?
- How long will it take the ball to return to the ground?

a) Speaking aloud, e*xplain* how you will solve this problem?

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………….

b) Speaking aloud, *solve this problem* by applying what you said you will do above

………………………………………………………………………………………..

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………………………………………………………………………………………..

c) Speaking aloud, *assess your problem solving strategy* that is, did your problem strategy work? Why?

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Appendix C: Letter to the School Principal

UNIVERSITY OF THE WITSWATERSRAND

WITS SCHOOL OF EDUCATION

Dear Madam

RE: REQUEST TO CONDUCT A MASTER'S RESEARCH STUDY IN YOUR SCHOOL

I hereby request permission to conduct my Master's research study in your school.
I am a student at the above university and the research project is part of fulfillment for the degree Masters in Science Education.

The purpose of this research is to identify Grade 12 learners' present problem-solving strategies and factors that hinder or promote these learners' mastery of problem-solving strategies in physics.

For the study I request to use two Grade 12 Physical science classes I teach.

Yours sincerely

M. J. MOKHELE

Appendix D: Consent Form

UNIVERSITY OF THE WITWATERSRAND

WITS SCHOOL OF EDUCATION

Consent Form

I, ………………………………………………………………………………………..
(Your first and last names) hereby consent to be surveyed, interviewed and observed by

………………………………………………………………………………………..
(Full names of the researcher)

For the purpose of her research study to identify Grade 12 learner's present problem-solving strategies and factors that hinder or promote these learners' mastery of problem-solving skill in physics, required in partial fulfillment of Master's degree at the University of the Witwatersrand.

Signature of the learner: ____

Date: __________________________

Signature of the Researcher: ____

Date: ______________________________

Appendix E: Responses of Learners from the Questionnaire

Name	Question 1	Question 2	Question 3	Question 4	Question 5
1. GR	A. Before return there was a state of rest	D. It's moving in the same speed	C. Because of the bigger mass. X than Y but if there was no air disturbance they will drop at the same time	B. Because there is no air disturbance	D. It moves in the same direction.
2. GN	A. Because it has return to a place where it was.	D. Because it is moving in a vertical towards its height	A. Because of the amount of the mass of Y is less than X	D. Because of the air resistance	B. Because the ball will be affected.
3. ZZ	C. Gravitational acceleration is always 10m/s^{-2} downward	B. No reason	B. Ball Y has smaller mass than X,	B. Air resistance is negligible	B. No reason
4. MN	C. Acceleration due to gravity is always 10m/s^{-2}	C. As the ball move upwards the acceleration increases	B. Ball Y has a smaller mass than X, so air resistance will disturb ball Y	B. Because the air resistance is negligible	B. No reason
5. N	A. Because it is subtracting the upward speed	C. Because of its maximum height	B. Because the ball X has more mass than ball Y	B. Same speed	A. It did not change the direction
6. T	A. A ball is thrown upwards it is + then returns to the ground it is – so it cancel each other	B. Because they are inversely proportional to each other	D. There is no air friction	A. Because when thrown upwards it will reach its topmost	A. It falls back to its starting point
7. NP	A. The ball stop at the top and then accelerate downward at 10m/s^{-2}	D. The ball is moving at the same velocity	B. Because ball X has bigger mass so it land first	A. When the ball returns it will have twice the speed than Paul's ball has	A. The more the velocity changes the acceleration also change.
8. NN	D. The speed the ball travels either down or up is always 10m/s^{-2}	B. The force of gravity will be pulling it down and it accelerates	D. Ignoring air friction the balls will reach the ground at the same time	B. The ball travel at 10m/s always	B. No reason
9.RR	C. Because gravitational acceleration is always 10m/s^{-2}	D. Because the velocity is not changing	B. Because of air friction	D. Because we do not know who throw the ball first	A. Acceleration is always in the same direction as the velocity
10. MM	C. Because it is always accelerating downwards at 10m/s^{-2}	A. There would be no change	D. Because of acceleration due to gravity	B. Because there is no applying of force of which is acting or moving so the force are balanced	B. No reason
11. Z	C. Force of gravity is pulling the ball downwards	A. No reason	D. They have the same size & dropped simultaneously	C. Because of Zuko's ball is still going to come back after it reaches the highest point	A. When acceleration increase velocity increase
12. FM	B. Acceleration does not change	D. At its maximum height velocity is decreasing till zero	B. Because X is bigger than Y in mass	D. The two balls are thrown in opposite direction	C. Because at it's maximum height v=0
13. LN	A. As it reaches the highest point its acceleration would decrease till it reaches zero	B. As the applied force decreases its acceleration decreases	D. They have the same mass	A. Because firstly it went upward as it moves downwards its speed will increase	A. As velocity changes, so does acceleration
14. TE	A. Because it is at rest	B. Because of the pulling of earth	B. Because in that case mass is directly proportional to speed	B. No reason	D. Because the ball act against gravity
15. NG	It is a force due to gravity	D. It moves at a constant speed	B. Because of the friction force acting on ball Y	B. They throw the ball with the same speed.	No reason
16. OB	A. Ep at the top is equal to Ep at bottom	D. The opposing friction will make acceleration not increase yet the ball is going to its maximum	B. Because in sky there is air causing disturbance especially to the light objects	B. Since the balls are identical and there is no air resistance	A. The rate of change in velocity is the acceleration

		point			
17. NM	C. A force of $10m/s^{-2}$ is always acting on the ball	D. Gravitational acceleration (g) upward is = (g) downwards	B. F is directly proportional to mass	B. Both have the same speed downwards	B. Acceleration due to gravity
18. SM	C. Because (g) always pushes us downwards	B. When acceleration increases the mass decreases	A. a α 1/m so acceleration is less than	D. because the distance created by Zuko's ball is not known	A. because acceleration is the rate at which velocity changes.
19. BD	C. It's because the force which the earth pulls us down with	B. it's because a a1/m the other one increase & the other decrease	C. X is heavy then Y & Y is light because of air resistance	B. because of the acceleration to gravity, they will have same speed	A. because acceleration is the rate of change in velocity
20. TC	C. Because the acceleration is not increase & the ball return & same time	B. because the magnitude of its acceleration not change the speed	D. because they have same size & same height	C. Because the air will push the ball with 10m.s	A. Because the remain at the same direction as the velocity
21. NI	C. because the downward force it a pulling force of gravitation	A. because the maximum point is where the ball become at rest and change its acceleration	B. the bigger the mass its going to research the ground first because air friction would disturb.	C. because the force of gravitation would the Paul's ball reached the ground first	B. because the speed is not the same when the ball falls down
22. ST	A. because at the top the final velocity is zero & there is no acceleration	B. because as it moves upwards the final velocity will be zero	B. because of air friction	D. because the distance created by Zuko's ball is not known	A. because acceleration is the rate at which velocity changes.
24. LA	C. because of the gravitational acceleration attraction of the earth	B. because of when it moves up and the final velocity will be zero	C, because of X ball has a bigger mass twice the Y ball.	D. because the distance that both boys throw the ball is not equal	C. because of the direction & magnitude has not change
25. VH	B. Because at the gravity of the earth which pulls it back	B. because of the air friction	B. because it has greater mass and the air friction cant affect it	D. because we are not give the speed at each ball	A. because acceleration is directly propotion to velocity
26.SN	D. since there is force gravity	A. always of the object reach at maximum height at become zero	C. ball X exerts more force then ball Y	C.. acceleration & velocity are directly proportional	B. there is no air friction
27. RT	D. gravitational acceleration is always constant no matter what happens	A. after it has reached its maximum height the acceleration change and goes in the opposite direction	D. they would have the same time because no air friction	C. Paul's ball will arrive first on the ground with greater speed because of the earths gravity pulling the ball	B. it is the change in velocity
28. MM	C. due to force of gravity	D. because they move at a constant velocity	B. ball X will reach the ground first & ball Y after	B. Because there is no air disturbance	. D. It moves in the same direction
29. KS	C. Gravitational acceleration is always $10m/s^{-2}$ downward	C. As the ball move upwards the acceleration increases	C. Because of the bigger mass. X than Y but if there was no air disturbance they will drop at the same time	B. No reason	.A.
30. SS	A. Because it has return to a place where it was.	C. Because of its maximum height	A. Because of the amount of the mass of Y is less than X	D. Because of the air resistance	B. Because the ball will be affected.
31. MV	A. Before return the was a state of rest	B. No reason	B. Ball Y has smaller mass than X,	B. Air resistance is negligible	B. No reason
32. NI	C. Acceleration due to gravity is always $10m/s^{-2}$	D. It's moving in the same speed	B. Ball Y has a smaller mass than X, so air resistance will disturb ball Y	B. Because the air resistance is negligible	B. No reason
33. CM	A. Because it is subtracting the upward speed	D. Because it is moving in a vertical towards its height	B. Because the ball X has more mass than ball Y	B. Same speed	A. It did not change the direction
34. KL	D. The speed the ball travels either down or up is always $10m/s^{-2}$	B. Because they are inversely proportional to each other	D. There is no air friction	B. The ball travel at 10m/s always	A. It falls back to its starting point
35. BH	A. The ball stop at the top and then accelerate downward at $10m/s^{-2}$	D. The ball is moving at the same velocity	B. Because ball X has bigger mass so it land first	A. When the ball returns it will have twice the speed than Paul's ball has	A. The more the velocity changes the acceleration also change.
36. ZS	A. A ball is thrown	B. The force of gravity	D. Ignoring air friction the	A. Because when thrown	B. No reason

	upwards it is + then returns to the ground it is – so it cancel each other	will be pulling it down and it accelerates	balls will reach the ground at the same time	upwards it will reach its topmost	
37. HU	C. Force of gravity is pulling the ball downwards	A. No reason	D. They have the same size & dropped simultaneously	C. Because of Zuko's ball is still going to come back after it reaches the highest point	A. When acceleration increase velocity increase
38. DF	B. Acceleration does not change	D. At its maximum height velocity is decreasing till zero	B. Because X is bigger than Y in mass	D. The two balls are thrown in opposite direction	C. Because at it's maximum height v=0
39. MJ	A. As it reaches the highest point its acceleration would decrease till it reaches zero	B. As the applied force decreases its acceleration decreases	D. They have the same mass	A. Because firstly it went upward as it moves downwards its speed will increase	A. As velocity changes, so does acceleration
40. FR	A. Because it is at rest	B. Because of the pulling of earth	B. Because in that case mass is directly proportional to speed	B. No reason	D. Because the ball act against gravity
41. VG	It is a force due to gravity	D. It moves at a constant speed	B. Because of the friction force acting on ball Y	B. They throw the ball with the same speed.	No reason
42. BB	A. Ep at the top is equal to Ep at bottom	D. The opposing friction will make acceleration not increase yet the ball is going to its maximum point	B. Because in sky there is air causing disturbance especially to the light objects	B. Since the balls are identical and there is no air resistance	A. The rate of change in velocity is the acceleration
43. GP	C. A force of $10m/s^{-2}$ is always acting on the ball	D. Gravitational acceleration (g) upward is = (g) downwards	B. F is directly proportional to mass	B. Both have the same speed downwards	B. Acceleration due to gravity
44. OX	C. Because (g) always pushes us downwards	B. When acceleration increases the mass decreases	A. a α 1/m so acceleration is less than	C. Because the air will push the ball with 10m.s	A. Because the remain at the same direction as the velocity
45. CV	C. It's because the force which the earth pulls us down with	B. it's because a a1/m the other one increase & the other decrease	C. X is heavy then Y & Y is light because of air resistance	B. because of the acceleration to gravity, they will have same speed	A. because acceleration is the rate of change in velocity
46. KN	C. Because the acceleration is not increase & the ball return & same time	B. because the magnitude of its acceleration not change the speed	D. because they have same size & same height	C. Because the air will push the ball with 10m.s	A. Because the remain at the same direction as the velocity
47. KKE	C. Because the downward force it a pulling force of gravitation	A. Because the maximum point is where the ball become at rest and change its acceleration	B. The bigger the mass its going to research the ground first because air friction would disturb.	C. Bbecause the force of gravitation would the Paul's ball reached the ground first	B. Because the speed is not the same when the ball falls down
48. ZZE	A. Because at the top the final velocity is zero & there is no acceleration	B. Because as it moves upwards the final velocity will be zero	B. Because of air friction	D. Because the distance created by Zuko's ball is not known	A Because acceleration is the rate at which velocity changes.
49. NME	C. Because of the gravitational acceleration attraction of the earth	B. Because of when it moves up and the final velocity will be zero	C, Because of X ball has a bigger mass twice the Y ball.	D. Because the distance that both boys throw the ball is not equal	C. Because of the direction & magnitude has not change
50. WWE	A Because at the gravity of the earth which pulls it back	B. Because of the air friction	B. Because it has greater mass and the air friction cant affect it	D. Because we are not give the speed at each ball	A. Because acceleration is directly propotion to velocity
51. CX	D. since there is force gravity	A. always of the object reach at maximum height at become zero	C. ball X exerts more force then ball Y	C.. acceleration & velocity are directly proportional	B. there is no air friction
52. DZ	D. gravitational acceleration is always constant no matter what happens	A. after it has reached its maximum height the acceleration change and goes in the opposite direction	D. they would have the same time because no air friction	C. Paul's ball will arrive first on the ground with greater speed because of the earths gravity pulling the ball	B. it is the change in velocity
53. MME	C. due to force of gravity	D. because they move at	B. ball X will reach the	B. No reason	A. No reason

		a constant velocity	ground first & ball Y after		
54. SSE	C. Gravitational acceleration is always $10m/s^{-2}$ downward	C. As the ball move upwards the acceleration increases	C. Because of the bigger mass. X than Y but if there was no air disturbance they will drop at the same time	B. Because there is no air disturbance	D. It moves in the same direction.

Appendix F: Interviews Responses

Learner 1: Transcript L1

Interviewer: How are you Learner 1?
Learner 1: How are you Mam?
Interviewer: The purpose of this research is to identify Grade 12 learners' present problem-solving strategies and factors that hinder or promote these learners' mastery of problem-solving strategies in physics. What I would like you to do is to go through these questions answer them and while you are answering them I want you to think aloud.
Learner 1: Ok

<u>Learner 1 starts to read question 1 aloud</u>

<u>Question 1</u>

In your own words explain what you understand about the term gravitational acceleration.

Learner 1: Firstly we know that acceleration is the rate at which velocity change, hence velocity is the rate at which displacement changes meaning, where there is acceleration obvious there is an increase in velocity then in my own words what I can say gravitational acceleration is an increase rate at which velocity changes towards or away from the earth.
Interviewer: What do you mean by towards or away from the earth?
Learner: Madam, what I mean is if I throw a ball upwards it is going to accelerate upwards and then it is going to come back accelerating downwards Gravitational acceleration depends on the direction of an object if an object is going up (g) = $-10 m/s^2$, If an object is going down gravitational acceleration is equal to $10 m/s^2$

Interviewer: Ok you can continue

Learner reading Q2 (a)

<u>Question 2</u>

You drop a ball from a height of 2m above the ground

c) How long will it take to reach the ground?
d) With what velocity does the ball strike the ground

Ok here they are looking for time that took the ball to reach the ground if it is dropped from the height of two meters above the ground; right from my statement I'm having my displacement, which is 2m and my gravitational acceleration, which is $10m/s^2$

Interviewer: What is it that you are doing now?

Learner 1: I'm collecting the data

Here they did not give us initial velocity, since they did not give us (u) and (v) that is not a problem since our initial velocity is always zero. No! let me read again, the statement says (learner reads the statement again). Yes initial velocity is zero because the ball is dropped from the certain height. So the equation that I'm going to use is S=ut + 1/2gt2

Now I'm going to substitute:

$s = ut + ½ gt^2$

$2 = 0 x t + ½ (10) t^2$

$2/5 = 5t^2/5$

t = 0.63s

The learner reads the question again to answer Q2 (b)

Now they want the velocity that they did not give to me at the beginning then I'm going back to the equation that says v = u + gt now I know that my (u) = 0, my (g) = 10m/s2 then my time is the value that I calculated above

v = u + gt

v = 0 + 10 x 0.63

v = 6.3 m/s

My (v) is going to be 6,3 m/s

Learner 1: The strategy that I used, firstly I collected the data. Secondly I selected the equation that will correspond with the data that I have. Thirdly I substituted the values and I got the value of my velocity.

Teacher: Ok

The learner now reads Q3

A ball is projected vertically upwards from the ground with a velocity of 20m/s

- How high will the projectile go?
- What will be the velocity of the ball after 1s?
- How long will it take the ball to return to the ground?

The question says how high will the projectile go, so they want the displacement. Okay having my data i.e. my initial velocity = 0 final velocity = 20m/s

I: Why is your initial velocity equal zero?

L: Nothing is said about initial velocity so it is equal to zero.

I: To you if nothing is said about initial velocity is it taken as zero?

L: That's correct, okay what else do I have here? I want distance, do I have time no, I do not have time. The equation that I'm going to use is

$v^2 = 2gs$

$20 = 2gs$

$\frac{400}{20} = \frac{2(10)s}{20}$

$s = 20m$

Question 3(b)

Learner reads question 3 (b)

$v = gt$

-10×1

$v = -10$ m/s

Question 3(c)

Learner reads the question

Okay, now this ball accelerates upwards with the velocity of 20m/s and it is coming back with the certain velocity and it took 1 sec, okay all in all it took 2 sec cause if it is 20 m/s for the ball to reach its maximum height, hence I calculated 10m/s as a velocity in each second, meaning there is 2 sec cause I'm going to take this 10m/s times 1 sec plus 10m/s equal 20m/s so I'm going to have 2sec.

I: So you are using ratio to get your answer?

L: Yes, the time is equal to 2s

I: Thank you very much learner 1.

Learner 2: Transcript L2

Interviewer: How are you learner 2?

Learner 2: I'm fine mam, how are you

Interviewer: Thank you for agreeing to take part in this research. The purpose of this research is to identify African learners' present problem-solving skills, factors that hinder or promote these learners' mastery of problem-solving skills in physics, and ways to help them understand and acquire correct problem-solving skills.

Interviewer: I want you to go through these questions and I also want you to think aloud while answering.

Question 1

In your own words explain what you understand about the term gravitational acceleration.

Learner 2: Gravitational acceleration, what I think is mmmm a force that the earth pulls us with.

Interviewer: Is force and acceleration one and the same thing?

Learner2: No, force is the pull or a push and gravitational acceleration pulls, yes I can refer it as force.

Teacher: What is acceleration? And what is weight

Learner 2: Acceleration is chance of speed and gravitational acceleration is like weight

Question 2

You drop a ball from a height of 2m above the ground

e) How long will it take to reach the ground?
f) With what velocity does the ball strike the ground

Learner reads the question

Learner: Firstly I need to check the question i.e. what do they need from me.
Secondly I will look for the equation.

The key word from the question is How long? So they need time. Now I'm going to write all what is given and then calculate.

Learner: g = 10, s = 2m, and t =? v = ? u = 0 (because the ball starts from rest)

I'm now going to substitute

a) $s = ut + ½ gt^2$

$2 = 0 \times t + ½ (10) t^2$

$2/5 = 5t^2/5$

$t = 0.63s$

Learner reads question 2(b)

Now I have time, gravitational acceleration and distance, so they are looking they are looking for velocity,

b) $v^2 = u^2 + 2gs$

$= 0 + 2 \times 10 \times 2$

$= 40$

$v = 6,3m/s$

Interviewer: Right continue, I want you to look at your C?

Learner: My problem-solving strategy, I think somewhere it does help, because when you analyze the question you need to know the question and treat it as if it is happening now to you. What did you observe? What did you see? It helps a lot to work out the question.

Interviewer: Lets go to the next question

<u>Question 3</u>

A ball is projected vertically upwards from the ground with a velocity of 20m/s

- How high will the projectile go?
- What will be the velocity of the ball after 1s?
- How long will it take the ball to return to the ground?

Learner reads question 3

Learner: Question 3- the ball is projected vertically upward from the ground with a velocity of 2m.s-1,how high will the projected ball go.

So here the problem is like a person on the ground throwing the ball vertically upward, while throwing the ball hmm. The question is I am required to find the height because the key word is how high that means they are looking for the certain distance. Okay I'm required to find S using distance.

When the ball is projected vertically upward that means my g is going to be negative.

Interviewer: Why is your g negative?

Learner 2: Because upwards means you are not on the ground, you are some sort of distance above the ground and to illustrate or show that the ball is going upwards, I have to show by using direction negative show that the ball is upward and positive when the ball is downward.

Interviewer: Why is your gravitational acceleration positive when the ball is going down?

Learner 2: Because gravitational acceleration is a force that pulls the matter down. .So when it pulls down it means that it is positive.

Interviewer: So what happens if an object goes up?

Learner 2: That means that there is opposite direction, the ball is going up and the gravitational acceleration is pulling down. When the ball is going up it is against the gravitational acceleration.

Interviewer: Ok continue.

Learner 2: Then this is my $g = -10m./s^2$and this is my initial velocity (20m/s)

Interviewer: Okay why is that your initial velocity

Learner 2: Because it is the first velocity they give to us. And my final velocity will equal to zero. I'm asked to find the distance. I have to check my equation which one will suit, so the first equation $v = u + gt$, I don't have time so time will equal to zero, so at the end everything will be zero. The S (distance) I don't have, so I think will use $v^2 = u^2 + 2gs$

Interviewer: Why?

Learner 2: The equation has S (distance), and we are looking for distance and I do have my (g) and do have my initial velocity

Learner: $v^2 = u^2 + 2gs$

$0 = (20m/s^1)^2 + 2(-10)\ s$

$0 = 400 + (-20)\ s,$

$s = 20m$

Interviewer: Right lets go on.

Learner 2: Now I have found my distance.

Interviewer: What will the velocity be after 1 second?

Learner 2: After 1 second okay, now I got my time, I'm given time which is one second I have already solved to find my distance and now they want to know my velocity after 1 second. I must check my equation, again here I am required to find velocity after one second, initial velocity equals zero

Interviewer: Why now is the initial velocity equal to zero?

Learner 2: I think because I am looking for my final velocity after given time, which means

Interviewer: Why are you changing the initial velocity to zero?

Learner 2: Because now they want to know the velocity after one second.

Interviewer: So they want you to refer, when the ball is moving in the air after one second, so now why do you say initial velocity is zero?

Learner 2: Because…. they want to know the velocity after that segment

Interviewer: So where is the ball still going?

Learner 2: Vertically upward!

Interviewer: So when is your final velocity equal to zero?

Learner 2: I think my final velocity is equal to zero because it is where the ball is falling out, it will reach a maximum point whereby it will come back to the person who is throwing the ball, that is the maximum point where my velocity is equal to zero

Interviewer: Okay when do you say your initial velocity is zero?

Learner 2: When the ball strikes the ground, coming back to the ground

Interviewer: Okay choose the equation that you are going to use

Learner 2: I think I'll use this one $s = ut + 1/2gt^2$

Interviewer: Why, what are you calculating?

Learner 2: I have my distance which is 20m and (g) which is $10m/s^2$ and initial velocity which is equal to zero

Learner: They want to know after time, so I've got to use the time they have given me. So I'll go back to the $v = u + gt$

$$= 0 + -10 \times 1$$

$$v = -10m/s^1$$

Interviewer: continue

Learner: Okay for the first seconds projected upwards and time will be equal to 1 second when it's projected upwards and also when going downwards.

Interviewer: Okay so you've got your answer for (b), lets go on or do you want to look at it again?

Learner: I will look at it again. Okay when it is projected upwards my time is equal to one second so I've got to change something, I have to go back to my statements and my equations. I have chosen my equation $v = u + gt$ I have to make u the subject of the formula $v=0$

$v = u + gt$

$0 = u + -10 \times 1$

$u = -10 m/s^1$

Interviewer: Continue

Learner: How long will it take the ball to return to the ground? Okay now they are looking for time, because now its return back to the ground, now it's projecting vertically down and (g) is going to be + $10m/s^2$ I've got my initial velocity which is 20m/s

Interviewer: Now you are using the initial velocity given to you.

Learner 2: I think the time taken to throw the ball vertically upward is also the time that the ball will take to return vertically downwards. time up = time down

Interviewer: What is your time up?

Learner 2: Time is equal to 1 sec

Interviewer: So you have solved this question?

Learner 2: $s = ut + 1/2gt^2$,$s = 20$ $t=?$ $g=10$

$$20 = 20t + 1/2(10)\ t^2$$

$$5t^2 + 20t - 20 = 0$$

$t^2 + 4t - 4 = 0$

$(t + 2)(t + 2) = 0$

Learner 2: This is not correct,

Interviewer: So don't you think you should go back to your strategy

Learner 2: I think so in the first question, analysis the question and after I read my givens and what was required and found my equation that will suit my problem then I tried to solve it and somehow it helped, then after solving the question it helped me to solve the following questions.

Interviewer: Are you satisfied by the way you solved this problem?

Learner 2: The 2nd question yes I am and my 3rd ??

Interviewer: So your strategy is not working?

Learner 2: for the first question it worked, but for 2 & 3 not sure

Interviewer: What is the problem with answering 2 & 3

Learner 2: 2 & 3 you have to be exactly sure with initial velocity and the last question finding time, I thought the time used to throw the ball is the same time the ball came down. I'm now confused.

Interviewer: THANK YOU Learner 2

Learner 3: Transcript L3

Interviewer: How are you Learner 3?

Learner 3: How are you Mam?

Interviewer: The purpose of this research is to identify African learners' present problem-solving skills, factors that hinder or promote these learners' mastery of problem-solving skills in physics, and ways to help them understand and acquire correct problem-solving skills. What I would like you to do is to go through these questions answer them and while you are answering them I want you to think aloud.

<u>Question 1</u>

In your own words explain what you understand about the term gravitational acceleration.

Learner 3: Hm I think gravitational acceleration is a speed that the earth pulls us with.

<u>Question 2</u>

You drop a ball from a height of 2m above the ground

a) How long will it take to reach the ground?
b) With what velocity does the ball strike the ground

Learner 3: At first you must find an equation in order to solve the problem and you must make a statement and find out what you are given and not given. Then you write a data and equation.

Learner 3: You drop a ball from height of 2m above the ground, (a) how long will it take to reach the ground. so we are going to take down the data that we are given. From the statement we are given the height, which is the distance and then we must find an appropriate equation to solve these statements and the equation that we are going to use is $S = ut + 1/2gt^2$. The initial velocity is zero and I have the (g), which is the gravitational acceleration, and (g) is always constant $10m/s^2$ and then I'm asked to calculate time. So I must make time the subject of the formula in order to calculate it.

Teacher: Why the initial velocity is equal to zero?

Learner 3: Because of the acceleration due to gravity when you throw something upwards your initial velocity is always equal to zero and your final velocity is always equal to zero due to force of gravity.

Interviewer: Okay

Learner 3: Okay now I have made (t) the subject of the formula and now I'm substituting the values in my equation.

$s = ut + 1/2gt^2$

$t = \frac{u + 1/2g}{2}$

$t = \frac{0 + ½(10)}{2}$

t = 2,5 s

Learner 3: With what velocity does the ball strike the ground? I must first find the equation. In order to solve the problem, the equation I'm going to use.

v = u + gt.

v = 0 + 10 x 2,5

$v = 25m/s^1$

Okay, what I did first was to write the table of data and then after I chose the appropriate equation and I substituted the values and (g) =10 (s) is 2 then when I calculated the values I found that t is equal to 2,5 seconds. To find the velocity I used the equation that says V=u +gt then I substituted the values u=0 and $g=10m/s^2$ I used the time which I solved from the first question which is 2,5 second and than I multiply $10m/s^2$ with 2,5 seconds.

Interviewer: So you are saying that the strategies that you used helped you to get the correct answer?

Learner 3: Yes they did help especially writing down the data.

Interviewer: Thank you yah continue.

Learner reads question 3

Question 3

A ball is projected vertically upwards from the ground with a velocity of 20m/s

- How high will the projectile go?
- What will be the velocity of the ball after 1s?
- How long will it take the ball to return to the ground?

Learner 3: Okay I'm going to find an equation, which is going to help me solve this problem. Let me use the equation which say $s = 1/2gt^2$ no, this is not going to work. Okay now I have found the appropriate equation in order to solve this problem. I'm going to use $V^2 = u^2 + 2gs$, we know that our (g) is always =10 and, V=0 and u=0 because we are looking for (s). Okay sorry I've made a mistake the statement says the ball is projected vertical upwards from the ground of the ground of the velocity of $20m/s^2$ so our initial velocity is $20m/s^1$ and then let's write data 1st in order for us not to forget than our initial velocity is = 20 final V= 0 .we have g=10 we have S we must find distance ……………

$v^2 = u^2 + 2gs$

$s = \frac{v^2 - u^2}{2g}$

$s = \frac{0 - (20)^2}{2(10)}$

s = 20m

Now I'm going to the next question. The question goes like this what will be the velocity of the ball after one second, okay now I'm going to calculate the velocity. First I'm going to find the equation so the equation is

$v = gt$

$v = 10 \times 1$

$v = 10m/s^{1}$

Learner 3: I'm going to the next question now, which is, how long will it take the ball to return to the ground? Need to calculate the time; I'm going to use another equation in order to find a time taken for the ball to reach the ground again.

Okay fine now I'm still looking for an appropriate equation in order to find the time that is taken. The equation that I'm going to use is:

$v = u + gt.$

$$t = \frac{u + g}{v}$$

$$t = \frac{0 + 10}{10}$$

$t = 1s$

Okay our time is 1 second.

Interviewer: Are you happy with the answers that you got?

Learner 3: Yes I'm happy my strategy worked.

Interviewer: Thank you very much Learner

Learner 4: Transcript L4

Interviewer: How are you Learner 4?

Learner 4: How are you Madam?

Interviewer: Thank you for agreeing to take part in this research. The purpose of this research is to identify African learners' present problem-solving skills, factors that hinder or promote these learners' mastery of problem-solving skills in physics, and ways to help them understand and acquire correct problem-solving skills.

Interviewer: I want you to go through these questions and I also want you to think aloud while answering.

<u>Question 1</u>

In your own words explain what you understand about the term gravitational acceleration.

Learner 4: Hmm I think gravitational acceleration it is represented by a small g, this small g is difficult to calculate. So there was a guy called Isaac Newton who discovered the law of the falling bodies, and he found out that if you were to take to objects and put them in a vacuum or the others where there is air resistance, the ones that are in the vacuum they will fall at the same time and arrive down simultaneously, but the other ones that are in the presence of the resistance they wont fall at the same time. Maybe if it's a feather and a coin, the coin will arrive first and the feather last. Ya that's what I think about gravitational acceleration.

<u>Question 2</u>

You drop a ball from a height of 2m above the ground

g) How long will it take to reach the ground?

h) With what velocity does the ball strike the ground

Learner reads the question

The second question says you drop a ball from the height of 2 m above how many does it take to reach the ground, so this one we can say. Do we need to do some calculations?

Interviewer: Yes you need to do some calculation, and then you can tell me in fact how…you are going to solve this problem.

Learner 4: Okay to solve this problem the first thing I have to do is to write down the data, five data's and I must find three unknown because if I can find two unknown it is impossible that you can do the equation, so to me I can say g is always $10m/s^2$ because you drop a ball from the height of 2m above, so my g is going to be negative 10 because you are dropping something in the top so my g is going to be negative. No it's not going to be negative I'm sorry Its going to be positive 10 let me just see, I have my height which is 2m Hmmm how long will it take to reach the ground Hmm I'm looking for (t) Here Hmm initial velocity zero, so I must use this equation let me see which equation I must use.

Interviewer: Why do you say initial velocity is zero?

Learner 4: Because the ball it started from first, let me see which equation I should use, yes I'm going to use this equation yes,

$S=ut + gt^2$ my distance is 2m my g is positive $10m/s^2$,

$$s = ut + ½ gt^2$$

$$2 = 0xt + ½ x10 x t^2$$

Hmmm basically there is a mistake I made

Interviewer: Why do you think you made a mistake? What is your problem now?

Learner 4: My calculation

Interviewer: What are you calculating?

Learner 4: I'm trying to calculate (time). Is it possible for me to start with (b) first then I can just carry on?

Interviewer: If it is fine with you.

Learner 4: $v^2 = u^2 + 2gs$

$$v^2 = 0 + ½ (10) t$$

$v = \sqrt{40}$

$v = 6{,}3\ m/s^1$

Interviewer: That's for B

Learner 4: Yes, now let me do the first question, how does it reach the floor, so I have to use the first equation because I have u and g

$v = u + gt$

$6{,}3 = 0 + 10 \times t$

$t = 0{,}63\ s$

Oh man I am not satisfied by these answers.

Interviewer: Why are you not satisfied

V: I don't think I've used the equation properly & the data. Okay I drop the ball from 2 meters above the ground, so 2meters is the distance I need to have g which is 10 and the initial velocity which is zero so what we basically do from here is T the first one, how long will it take for it to reach the ground, they are looking for (t) so the equation we have utilized is equal to u +gt, I started using the second question and I did get my answer which I think is right but the first one I don't think it's right.

Interviewer: You don't think it's right, okay the strategies you used to solve, what is it that you did first that helped you solve the problem.

Learner 4: I first read the statement then I collected the data and then I chose what I thought was the correct equation which is. I'm not pretty sure about it but my instincts tell Ha Ha it's the truth but I've tried.

Interviewer: Okay so I want you to go on to the next question

Learner reads question 3

<u>Question 3</u>

A ball is projected vertically upwards from the ground with a velocity of 20m/s

- How high will the projectile go?

- What will be the velocity of the ball after 1s?
- How long will it take the ball to return to the ground?

Learner 4: The ball is projected vertically upwards, yes I think this I can do it let me just check it out.
Interviewer: Okay now tell me the strategy first.
Learner: Okay the ball is projected vertically upwards and as it has been projected it will come back so my acceleration for calculations sake I'm going to write negative $10m/s^2$ because the ball is projected upwards

Interviewer: Why negative 10
Learner 4: Because for calculations sake if you can just drop the ball vertically upwards it will go with decreasing velocity until it reaches the top and then it will come back again with acceleration so I think negative 10 is for calculations sake
Interviewer: Okay continue
Learner 4: How long will the projectile go, I have my velocity the ball is projected vertically with the velocity of $20m/s^1$, I think $20m/s^1$ is my initial velocity because is where the ball starts and my (g) = $- 10\ m/s^2$. How will the projectile go? Here I'm looking for…

Interviewer: It's how high
Learner 4: Okay how high so I'm looking for S and so the velocity is going to be zero
Interviewer: Why?
V: Because I have my initial velocity, it's what I think I'm not sure

Interviewer: So you are saying once you have the initial velocity automatically the final velocity is going to be zero?
Learner 4: Yes if I'm not given
Interviewer: Okay you can continue
Learner 4: SO I am going to use this equation $v^2=u^2 + 2gs$.

$v^2 = u^2 + 2gs$

$0 = 20^2 + 2(-10)\ s$

$s = 20m$

Learner 4: My answer is 20 meters for the first question and the second question says what will be the velocity of the ball after 1s? I'm going to use this equation:

$v = u + gt$

$v = 20 + 10 \times 1$

$v = 30m/s^1$

Learner 4: How long will it take for the ball to return to the ground? Here I'm looking for (s).

The equation that I'm going to use is

$v^2 = u^2 + 2gs$

$30^2 = 0^2 + 2 \times 10\ s$

$s = 45m$

Interviewer: Are you happy with your answers? Did the strategy you employed help you?

Learner 4: Somewhere it helped me but I'm happy with my question 2. I'll try it at home.

Interviewer: Thank you Learner 4.

Appendix G: Answers to the questionnaire

Question 1

In your own words explain what you understand about the term gravitational acceleration.

The acceleration that is produced by the gravitational force is called acceleration due to gravity or gravitational acceleration. It is denoted by small letter g. The experimental value of g is approximately 9,8m.s-2. The direction of g is always downwards.

Question 2

You drop a ball from a height of 2m above the ground

i) How long will it take to reach the ground?

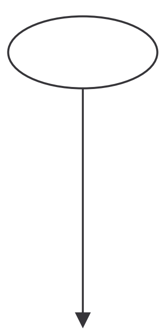
j) With what velocity does the ball strike the ground

Step 1 Identify the problem

a) Question: How long will it take to reach the ground?

We need time

b) Question: What is the final velocity?



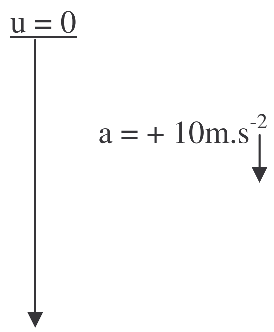
The ball is dropped

Step 2 Describe the physics

Velocity: Since the ball is dropped it starts from rest. Its initial velocity is zero.

Acceleration: Since acceleration due to gravity and is always directed downwards we will take it to be positive $10 m.s^{-2}$

Displacement: Since displacement is below the point of release we will take it as positive 2m.



u	s	a	t	v
0	+ 2m	$+10 m.s^{-2}$	?	?

Step 3 <u>Plan the solution</u>

a) The equation to use is: $s = ut + \frac{1}{2} gt^2$

b) The equation to use is: $v = u + gt$

Step 4 <u>Execute the plan</u>

a) $s = ut + \frac{1}{2} gt^2$

$2 = 0 \times t + \frac{1}{2}(10)\, t^2$

$2/5 = 5t^2/5$

$t = 0.63s$

b) $v = u + gt$

$v = 0 + 10 \times 0.63$

$v = 6.3$ m/s downwards

Step 5 <u>Evaluate the solution</u>

The time that the ball took to reach the ground is 0,63s

The velocity is going to be 6,3 m/s downward.

Question 3

A ball is projected vertically upwards from the ground with a velocity of 20m/s

a) How high will the projectile go?

b) What will be the velocity of the ball after 1s?

c) How long will it take the ball to return to the ground?

Step 1 Identify the problem

a) Question is: what is the maximum height the ball is going to reach?

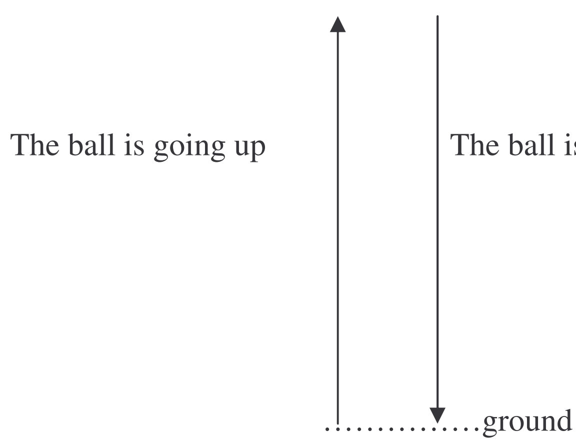
Distance is needed here (s)

b) Question is: What is the final velocity?

(v) is needed here

c) Question is: What time is needed for the ball to reach the ground

time is needed here (t)

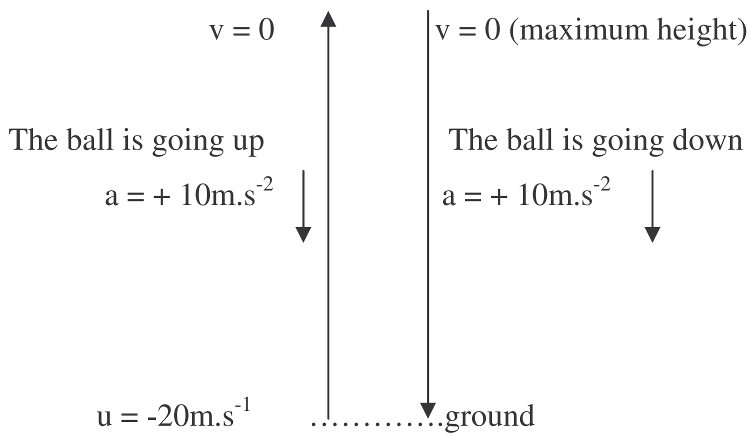


Step 2 Describe the physics

Velocity: All upwards velocity will be taken as negative

Acceleration: It is free fall motion where a body is projected upwards or downwards at a certain initial velocity, or from rest. The body therefore experiences a downward gravitational acceleration of $10m.s^{-2}$ through out the motion.

Displacement: All displacements above the point of release of free falling bodies will be taken as negative



When the ball return to the ground, its displacement is zero

U	s	A	t	v
$-20m.s^{-1}$	?	$+10m.s^{-2}$	1s	?

Step 3 <u>Plan the solution</u>

a) The equation to use is: $v^2 = u^2 + 2as$

Find (s)

b) The equation to use is: $v = u + at$

Find (v)

c) The equation to use is: $s = ut + ½gt^2$

Find (t)

Step 4 <u>Execute the plan</u>

a) How high will the projectile go?

$v^2 = u^2 + 2gs$

$0 = (-20m/s^1)^2 + 2(+10) s$

$0 = 400 + (20) s,$

$s = -20m$

Displacement is above the point of release, so it is negative,

b) What will be the velocity of the ball after 1s?

$v = u + gt$

$= -20 + 10 \times 1$

$v = -10 m/s^1$

The velocity is negative, the ball is moving upwards.

c) How long will it take the ball to return to the ground?

$s = ut + ½gt^2$

$0 = -20t + ½(10) t^2$

$0 = -20t + 5t^2$

$0 = 5t^2 – 20t$

$t = 4s$ or $t = 0$

The ball takes 4s to return to the ground.

Step 5 Evaluate the solution

- All the answers are in correct units
- The direction of all vectors is mentioned and is according to choice of direction given above.

Substitution is correct and the changing of the subject of the formula is correct