YOU MAY NOT BE AS SMART AS YOU THINK: AN ALTERNATIVE ACCOUNT OF THE DUNNING-KRUGER EFFECT

by

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ABSTRACT

Perception of abilities plays an important role in informing one's decisions at times and often in forming one's self perception. The Dunning-Kruger effect is a fascinating and empirically observable bias in which top performers tend to make more accurate estimations of their ability than bottom performers. The current theory states that the effect is caused by top performers possessing greater metacognitive ability than bottom performers. There have been many alternative theories and explanations proposed to explain the observed Dunning-Kruger effect. The current study is the first to test whether top and bottom performers base their predictions on inflated preconceived notions of ability, rather than their metacognitive ability. This theory proposes that if top and bottom performers both based their predictions of performance on their preconceived notions of ability it would create a Dunning-Kruger effect. This presupposes that that both top and bottom performers make above average estimates of performance as they hold preconceived notions of above average ability. Thus, top performers' predictions of performance would be most accurate as their performance would be above average, whereas bottom performers would most overestimate their performance as their performance would be below average. The intention of this study was, thus, to assess whether either top or bottom performers based their predictions of performance on preconceived notions of ability or using metacognitive ability. A total of 97 university students were divided into two groups and given an identical test, one group containing 49 participants were told the test measured Logical Thinking and the remaining 48 participants were told the test measured Computational Mathematics. After completing the test, which was a 23 item preparatory test for the LSAT, participants were asked to estimate their ability in the domain being assessed, their performance relative to their peers and their score out of 23. A t-test was used to compare the two groups and it was found that the Logical Thinking and Computational Mathematical group made significantly different predictions of ability and therefore held significantly different preconceived notions of ability. Further t-tests were used to compare the estimates of ability and predictions of performance of the two groups of top and bottom performers. A significant difference was found between the two groups of top performers' prediction of ability. However, there was no significant difference between any of the other scores of the two groups of top and bottom performers. Therefore, the alternative theory that top and bottom performers base their predictions of performance on preconceived notions of ability was found to be invalid. Therefore, the current theory which states that top performers' superior metacognitive ability allow them to make more accurate estimates of performance than bottom performers is still the best account for the Dunning-Kruger effect.

KEY WORDS: above average effect, bottom performers, bottom quartile, cognitive bias, Dunning-Kruger effect, estimate performance, metacognition, metacognitive ability, preconceived notions, top performers, top quartile.

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CHAPTER 1:
INTRODUCTION TO THE STUDY

1.1. Introduction

This study aims to advance the current understanding of the Dunning-Kruger effect through proposing and testing an alternative theory, which accounts for the results of previous studies of the Dunning-Kruger effect. This first chapter presents some background to the topic as well as a problem statement, research questions, the hypothesis of the study, importance of the study and an overview of the methodology. The final section of this chapter will contain an overview of each of the remaining chapters of this dissertation.

1.2. Background

Early studies on the accuracy of people's self-evaluations found that people tend to hold inherently biased view of their abilities. Alicke (1985) showed that college students tended to be more likely to claim to possess traits which they viewed as desirable and more likely to deny traits they viewed as undesirable. The majority of studies have shown the process of self-evaluation to be more biased towards positive or self-serving evaluations. The reason for this self promoting bias is to maintain a positive self concept (Alicke, 1985; Brown, 1992). Some viewed these positive illusions as adaptive for mental health (Taylor & Brown, 1988). In particular, unrealistically positive self-evaluations, exaggerated perceptions of control or mastery and unrealistic optimism may serve many cognitive, affective and social functions (Taylor & Brown, 1988). Kruger, (1999) however, demonstrated ways that self-evaluations are not always positively skewed but may have negative effects. He concluded that "people base their assessments of how they compare with their peers on their own level of ability and insufficiently take into account the skills of the comparison group" (Kruger, 1999, p. 222). These studies demonstrate a bias in the ability to accurately self-evaluate stemming from the fact that many people base their judgements on faulty perceptions they hold of themselves.

Justin Kruger and David Dunning (1999) expanded the field of self-evaluation by demonstrating a difference in accuracy of self-evaluations in high and low performing groups. They found that poor performers were more likely to overestimate their performance in an assessment than top performers. The experimenters attributed this tendency to; poor performers possessing poorer metacognitive abilities than top performers. However, “none of this [previous] research has examined whether metacognitive deficiencies translate into inflated self-assessments or whether the relatively incompetent are systematically more miscalibrated about their ability than are the competent” (Kruger & Dunning, 1999, p. 1122).

This study is therefore geared towards finding whether top and bottom performers are equally able to make accurate self evaluations.

1.3. Problem statement

The Dunning-Kruger effect is the observable phenomenon wherein top quartile performers tend to underestimate their performance and bottom quartile performers tend to overestimate their performance (Dunning, 2011). Thus far, all research in the field of the Dunning-Kruger effect has been based on the premise that the differences in predictions of performance are due to a difference between top and bottom performers’ metacognitive ability (Kruger & Dunning, 1999; Dunning, Johnson, Ehrlinger & Kruger, 2003; Dunning, 2011). There has, however, been research which shows that people tend to base their predictions of performance on preconceived notions of ability (Dunning, 2011; Dunning, Meyerowitz & Holzberg, 1989; Heine & Lehman, 1997; Kruger, 1999; Weinstein, 1980). Furthermore, several studies have shown people possess a tendency to estimate themselves as above average in comparison to their peers (Ehrlinger et al., 2009; Haun et al., 2000; Hoges, Regehr & Martin, 2001). If participants of Dunning-Kruger studies were to base their predictions of performance on above average perceptions of ability it would account for creation for the Dunning-Kruger effect. This study therefore sets out to test whether both top and bottom performer’s estimations of performance are based in preconceived notions of ability or metacognitive ability.

1.4. Purpose, aims and objectives

The aim of this research was to examine whether preconceived notions of ability or metacognitive ability are utilised in predictions of performance. The purpose was to advance an understanding of performance estimates and test an alternative account of the Dunning-Kruger effect. In order to test the alternative account of the Dunning-

Kruger effect it was necessary to find whether predictions of performance were based on preconceived notions of abilities or through the use of metacognitive ability.

1.5. Hypotheses

This study hypothesises an alternative explanation for the Dunning-Kruger effect. In opposition to the current theory of the Dunning-Kruger effect, this study proposes that people base their predictions of performance on preconceived notions of ability rather than through the use of metacognitive ability. In order to assess whether the difference in predictions of performance is due to metacognitive ability or preconceived notions of ability the following hypotheses were tested:

Hypothesis 1: The predictions of ability made by a group told they are taking a logical thinking test will be significantly greater than the predictions of ability made by a group told they are taking a computational mathematical test.

Hypothesis 2: Top quartile performers' predictions of ability, relative performance and raw score will be significantly higher when preconceived notion of ability is high than when preconceived notion of ability is low.

Hypothesis 3: Bottom quartile performers' predictions of ability, relative performance and raw score will be significantly higher when preconceived notion of ability is high than when preconceived notion of ability is low.

1.6. Importance of research

Each person's life is, to some degree, guided by their personal beliefs regarding their abilities. It is therefore important to understand the metacognitive process of estimating one's performance as the task of self-evaluation is often employed in aiding decisions for important life circumstances. One clear example of one's life being guided by their self-evaluations is in deciding one's potential in a given career. When deciding between two potential career paths a person will partially base their decision on which of their available avenues they would be more able to succeed in. An instance where people's insight may be impaired and could lead to negative consequences is in complex fields of learning such as Science or Engineering. Learning in such complex domains, or making diagnoses in medicine, requires that learners hold substantial amounts of prior knowledge in order to understand and acquire new knowledge to solve problems. In such fields learners should be able to accurately distinguish between what they know and do not know, as it would allow them to review and try relearning imperfectly mastered materials for particular tasks (Everson & Tobias, 1998). Without the capacity to accurately discern what one knows and what one does not, one is much more likely to make mistakes or possess gaps in knowledge. It is therefore necessary to find some measure of metacognitive ability.

The reliance on preconceived notions of skill may prevent people from realizing which competencies they actually possess (Dunning, 2011). Women, for example, tend to disproportionately leave scientific and mathematical careers along every step of the educational and professional ladder (Ceci, Williams, & Barnett, 2009). This could be due to women's tendency to rate themselves as less scientifically and mathematically talented than males (Dunning et al., 2003). Ehrlinger and Dunning (2003) tested this hypothesis by administering male and female college students with a test of scientific reasoning. Prior to the test students were asked to rate their own scientific skills, which resulted in women rating themselves lower than men. When participants were asked to rate their performance on the test, the same pattern occurred with women's estimations of relative performance and number of question answered correctly being much lower than men's. Despite the differing perceptions between men and women, there was no difference in the actual performance between the two groups. After the test, each participant was offered a chance to take part in a "science competition" for fun and prizes, to which female participants were more likely to decline. This stereotype bias leads women to avoid careers in science and engineering, more than any actual lack in competence (Eccles, 1994). This study illustrates the way in which preconceived notions of ability influence decisions about one's life, which may be misinformed.

Since metacognition plays such a critical role in successful learning, it is important tstudy metacognitive activity and development to determine how students can be taught to better apply their cognitive resources through metacognitive control (Livingston, 1997).

The objective of this study is to find the ways in which people's insight into their abilities may be flawed or impaired. Research into the cause of the Dunning-Kruger effect has shown that people use their preconceived notions of skill to judge their performance (Ehrlinger & Dunning, 2003). These preconceived notions of skill only weakly to moderately correlate with objective performance (Dunning, 2005). People's inability to realise their ignorance could lead them to make many mistakes. In matters of health literacy, for example, The Institute of Medicine reports that an estimated 30% of the population of the United States has substantial difficulty understanding and following health information. This results in them taking drugs erratically or in ways that undercut their effectiveness (Nielsen-Bohlman, Panzer, & Kindig, 2004).

Studies such as this show the errors in thinking which are present in all of us. In uncovering more information regarding our own faulty insight we can hope to remove the barriers to self improvement which may rest on the answers to these questions.

1.7. Methodology

This study involved 97 University students from the University of Pretoria being split into two groups. The two groups were given a 23 item test and 35 minutes to complete the test. One group consisting of 49 participants was told the test measured logical thinking ability whereas the remaining 48 were told the test measured Computational Mathematics. After 35 minutes participants were asked to estimate their ability in the domain being assessed, their performance relative to their peers and the number of questions they answered correctly. The two groups were then compared with one another using a t-test to find whether there was a significant difference between the ratings of ability between the Logical Thinking group and the Computational Mathematical group. Further t-tests were used to compare the two groups of top quartile participants and the two groups of bottom quartile participants to find whether preconceived notion of ability affected predictions of performance.

1.8. Chapter overview

This research study is presented in five chapters. Chapter 2 presents a review of the literature, including definition and discussion of the primary constructs of this study and the way they relate to one another. Chapter 3 discusses the theoretical framework underpinning and informing the study and delineates the research methodology used including the research and sampling designs, design limitations, procedure, measurement instruments and statistical analyses used. A discussion of mediation is also provided in this chapter. Chapter 4 presents the findings of the study and includes a sample profile as well as descriptive and inferential statistics. Chapter 5 then provides a discussion of the main findings, limitations of the study, recommendations and conclusion.

CHAPTER 2:
LITERATURE REVIEW

2.1. Introduction

The aim of this chapter is to provide a theoretical explanation and review of the literature concerning the Dunning-Kruger effect. The first sections of the chapter define and clarify the research constructs used in the study, namely; the Dunning-Kruger effect, the double curse of bottom quartile performers, metacognition, alternate accounts of the Dunning-Kruger effect, preconceived notions of ability and the above average effect. Subsequent sections of the chapter then discuss previous literature and findings regarding the Dunning-Kruger effect as well as some previously proposed alternative explanations for the Dunning-Kruger effect. The studies which form the basis of the alternative explanation are also discussed thereafter.

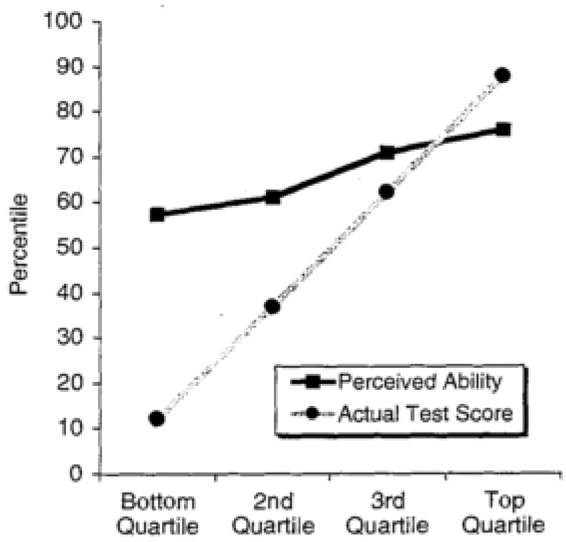
2.2. The Dunning-Kruger effect

Justin Kruger and David Dunning (1999) were the first to find that poor performers lack the necessary insight to realise they are performing poorly and therefore overestimate their performance. This tendency of poor performers to be unaware of their actual performance has come to be known as the Dunning-Kruger effect (Dunning, 2011). The way in which the Dunning-Kruger effect was first found was through the following 4 studies:

2.2.1. Study 1

The first study by Kruger & Dunning (1999) involved 65 Cornell University students from a variety of courses being asked to rate 30 jokes on a scale ranging from 1 (not at all funny) to 11 (very funny). After completing the questionnaire participants were asked to rate their "ability to recognise what's funny" with that of the average Cornell student. Participants were assigned a percentile rank based on the extent to which his or her joke rating correlated with the ratings provided by the panel of professional comedians. There was no significant difference between genders in the results of this study, nor in any of the following three studies. The results of this first study are reported in Figure 2.1.

FIGURE 2.1 Perceived Ability to Recognise Humour as a Function of Actual Test Performance (Kruger & Dunning, 1999).



On average participants rated their ability to recognise what is funny within the 66th percentile. These self-ratings of ability were significantly correlated with the measure of actual ability.

Of all the participants, 16 scored within the lowest quartile range. As displayed in Figure 2.1, these bottom quartile performers, on average, predicted their ability to recognise what is funny compared with the average student to fall within the 58th percentile. This was a great overestimation on their part as their actual relative performance placed them within the 12th percentile.

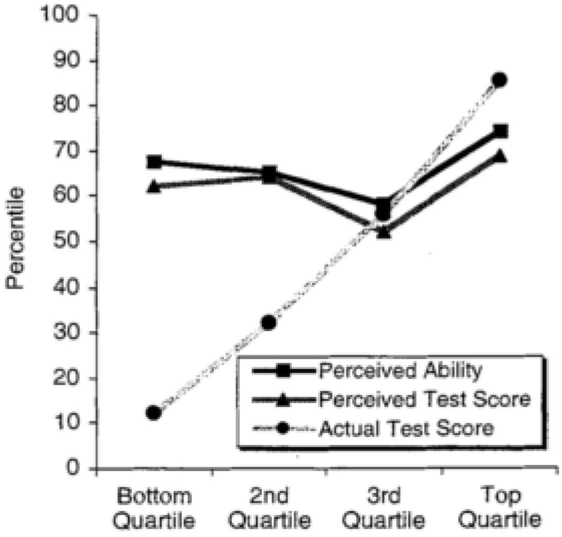
There were also 16 participants whose performance placed them in the top quartile. As displayed in Figure 2.1, the top quartile performers actually underestimated their ability relative to their peers, though their estimations were far more accurate than those of performers in the bottom quartile.

This study thus found that perceptions of relative ability are only modestly correlated with actual ability. Furthermore most participants tended to overestimate their ability relative to their peers with those in the bottom quartile making the greatest overestimations. The level of overestimation decreases with each step up the quartile ladder. Top quartile participants were the only ones to underestimate their performance relative to their peers. This pattern of bottom quartile participants greatly overestimating their performance is known as the Dunning-Kruger effect (Dunning, 2011). It is necessary to investigate the reason for this discrepancy between actual and perceived relative performance but first one must ascertain that this pattern occurs in other domains of ability and in other forms of self-estimation.

2.2.2. Study 2

Following this first study, Kruger and Dunning (1999), examined a different intellectual domain. Since humour is very subjective, it was necessary to examine a domain which is less ambiguous and where there is a definitive correct answer. Logical thinking was chosen since it is a skill central to the academic careers of participants and one which is called upon quite frequently. Participants were 45 Cornell University undergraduates from a single introductory psychology course. Participants were asked to complete a 20 item logical reasoning test with items taken from a Law School Admissions Test preparation guide. Afterward, participants made three estimates about their ability and test performance. First they compared their “general logical reasoning ability” with that of other students in the form of a percentile rank. Second, they estimated how their score would compare to their classmates in percentile form. Finally they were asked to provide the number of questions they answered correctly. In this study, participants were also asked to estimate the number of questions they had answered correctly in order to examine whether low performers are, indeed, miscalibrated with respect to their own ability or the ability of their peers. The order in which these questions were asked was counterbalanced and did not affect the results in this study. Once again, there was no significant difference between genders in the results of this study. The results of this study are reported in Figure 2.2.

FIGURE 2.2. Perceived Logical Reasoning Ability and Test Performance as a Function of Actual Test Performance (Kruger & Dunning, 1999).



Participant's on average rated their ability relative to their peers to fall within the 66th percentile and their performance relative to their peers to fall with the 61st percentile. Both these predictions were significantly higher than the actual mean of 50% showing that participants tended to overestimate their ability and performance relative to their peers. However, participants made an accurate prediction of the number of questions they answered correctly. On average participants rated the number of questions answered correctly as 14.3 while they actually attained an average of 12.9.

As reported in Figure 2.2, the 11 participants in the bottom quartile most overestimated their logical reasoning ability and test performance with their actual relative performance placing them in the 12th percentile. Their predictions of general ability fell within the 68th percentile and their predictions of performance relative to their peers fell within the 62nd. Thus, participants in the bottom quartile not only overestimated their ability but believed that they were above average. Similarly they thought they had answered 14.2 problems correctly compared with their actual mean score of 9.6.

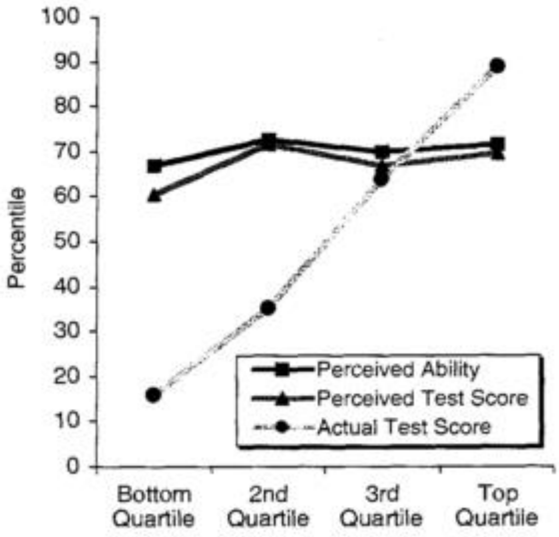
Also reported in Figure 2.2, the 13 top quartile performers once again underestimated their relative ability and performance. They estimated their relative logical reasoning ability to fall at the 74th percentile and their relative test performance to fall within the 68th percentile, their actual performance placed them within the 86th percentile. Top quartile performers also underestimated the number of questions answered correctly as their mean perceived test score was 14 and their actual mean test score was 16.9.

The Dunning-Kruger effect was evident as bottom quartile performers overestimated the number of test items they got correct as well as their relative ability and test performance. This suggests that poor performers tend to overestimate their relative performance and ability as well as the number of correct answers in several domains of ability. It is therefore necessary to find the cause of this discrepancy between perceived performance and actual performance.

2.2.3. Study 3

Kruger and Dunning's (1999) third study was conducted in two phases. In the first phase, 84 Cornell University undergraduates were asked to complete a 20 item test of grammar, with each item contained a sentence with a specific portion underlined. Participants were to judge whether the underlined portion was grammatically correct or should be changed to one of four different rewordings displayed. After completing the test, participants were asked to rate their overall ability to recognise correct grammar, how their test performance compared with that of their peers and finally how many items they had answered correctly. Again the order in which these questions were asked was counterbalanced and did not affect the results in this study and here was no significant difference between genders in the results of this study. The results of this study are reported in Figure 2.3.

FIGURE 2.3. Perceived Grammar Ability and Test Performance as a Function of Actual Test Performance (Kruger & Dunning, 1999).



Overall, participants, again, overestimated their grammar ability but this time accurately predicted their performance relative to peers as well as the number of items they scored correctly. On average participants estimated their ability as falling within the 71st percentile, overestimating their relative ability. Their predictions of relative performance fell within the 68th percentile, which was correlated with their actual score. The average of participants' predictions of number of questions answered correctly was 15.2 which correlated with their actual average performance of 13.3.

As reported in Figure 2.3, of the 17 participants in the bottom quartile most overestimated their ability and performance compared to their peers. They rated their grammar ability to be within the 67th percentile and their performance relative to their peers to be in the 61st percentile, whereas their actual performance placed them in the 10th percentile. Bottom quartile performers also, on average, overestimated the number of correct answers to be 12.9 whereas they actually attained an average of 9.2.

Also reported in Figure 2.3, the 19 participants in the top quartile once again underestimated themselves. Whereas their relative test performance placed them in the 89th percentile they rated their ability to be in the 72nd percentile and their test performance in the 70th percentile. Top quartile participants accurately predicted the number of correct answers on the test with a mean prediction of 16.9 and an actual mean of 16.4.

The second phase of Study 3 by Kruger and Dunning (1999) was intended to investigate the reason for the disparity between predictions of performance by participants in top and bottom quartiles. The overestimations of bottom performers and the underestimations of top performers when judging their relative ability and performance as well as number of questions answered correctly were believed to stem from different sources. Kruger and Dunning (1999) believed that while bottom performers overestimated their relative performance due to a deficit in metacognitive skill, top performers underestimated their relative performance due to the false-consensus effect. This hypothesis was tested four to six weeks after phase 1 of Study 3 was completed. 17 bottom performers and 19 top performers received a packet of five tests that had been completed by other students. The five tests reflected the range of performances that their peers had achieved in the study and all participants were informed of this fact. Participants were then asked to grade each test by indicating the number of questions they thought each of the five test-takers had answered correctly. After this, participants were shown their own test again and were asked to re-rate their ability and performance on the test relative to their peers in percentile scales as before. They also re-estimated the number of test questions they had answered correctly. Top and bottom performers' ability to assess competence in others were compared by correlating the grade each participant gave each test with the actual score of the test. The mean estimations of; performance, ability and number of correct answers made by both groups during the first and second phase were then compared to test whether the second phase changed the predictions of top and/or bottom performers.

TABLE 2.1 Self-Ratings (percentile scales) of Ability and Performance on Test Before and After Grading Task for Bottom- and Top-Quartile Participants (Kruger & Dunning, 1999).

Participant Quartile	**Bottom**			**Top**		
Rating	**Percentile Ability**	**Percentile test score**	**Raw test score**	**Percentile ability**	**Percentile test score**	**Raw test score**
Before	66.8	60.5	10.9	71.6	69.5	16.9
After	63.2	65.4	13.7	77.2	79.7	16.6
Difference	-3.5	4.9	0.8	5.6*	10.2**	-0.3
Actual	10.1	10.1	9.2	88.7	88.7	16.4

* $p \leq 0.05$. ** $p < 0.01$

Correlating the grade top and bottom performers gave to each test with the actual score of the test found that bottom performers' were less able to gauge the competence of others than were top performers. Bottom quartile performers' grades achieved a mean correlation score of .37 whereas top performers' grades received a mean correlation score of .66.

As Table 2.1 illustrates, of the self assessments of bottom and top quartile performers only top quartile performers' estimations of percentile ability and percentile test score changed to a significant degree. Top quartile performers raised their estimates of their own general grammar ability by 6.6 and their estimates of percentile ranking on the test by 10.2 after marking the tests of their peers. Kruger and Dunning (1999, p. 1127) theorise that because top performers have the "ability to assess competence and incompetence in others, participants in the top quartile realised the performances of the five individuals they evaluated were inferior to their own". Thus, top performers became more calibrated with respect to their actual percentile ranking and therefore overcame the false-consensus effect. Note the false-consensus interpretation does not predict any revision for estimates of one's raw score, as learning of the poor performance of one's peers conveys no information about how well one has performed in absolute terms. This is further supported by the results of the study as top performers did not adjust their predictions of performance.

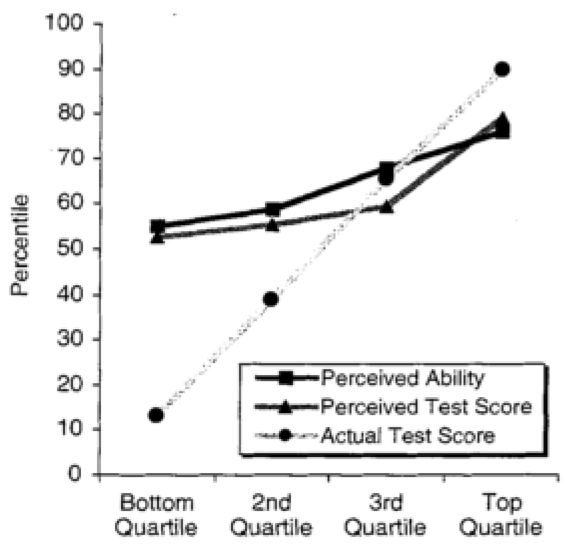
As reported in Table 2.1 bottom performers also raised their estimates of percentile ranking on the test, however not to a significant degree. Bottom performers therefore failed to gain insight into the level of their performance, as they lacked the ability of top performers to assess others' competence.

Thus, Kruger and Dunning (1999) concluded that bottom performers overestimate their relative performance because they lack the metacognitive skill to realise their incompetence. Adding onto this, top performers' superior metacognitive skill allows them to make more accurate estimations of the number of correct scores and to gain insight into their relative performance and ability.

2.2.4. Study 4

Kruger and Dunning (1999) designed a fourth study to test the assertion that poor performers' lack of metacognitive ability prevents' them from gaining insight into their own incompetence. This study aimed at improving the competence of poor performers in order to test whether this improved their metacognitive skills. This study was also carried out in two phases, the first of which involved giving 140 participants a Wason selection task and asking them to assess themselves in a manner similar to previous studies.

FIGURE 2.4 Perceived Logical Reasoning Ability and Test Performance as a Function of Actual Test Performances (Dunning, 2003).



The estimations of relative ability and relative performance are displayed in Figure 2.4. Participants overall tended to overestimated their relative logical reasoning ability to fall within the 64th percentile and their relative test performance to be within the 61st percentile. Overall participants also overestimated their raw score on the test as 6.6 whereas it was actually 4.9.

Bottom performers overestimated their performance on the test to be in the 53rd percentile and their logical reasoning ability to be within the 55th percentile, whereas their actual performance placed them within the 13th percentile. Bottom performers also, on average, overestimated their raw scores on the test, estimating on average to have answered 5.5 problems correctly when in fact they had, on average, answered 0.3 answers correctly.

Top performers underestimated their relative performance by judging it to be in the 79th percentile and their ratings of their general logical reasoning ability in the 76th percentile whereas their actual relative performance placed them in the 90th percentile. They also underestimated their raw score on the test although it was only by 1 point.

The second phase of the study occurred after participants took the test, when half of the participants were given a short training session designed to improve their logical reasoning skills. Participants' metacognitive skills were assessed by asking them to indicate which terms they had answered correctly and which incorrectly and to re-rate their relative ability and relative test performance.

It was found that those participants who received training packets graded their own tests more accurately than those who did not, with an average of 9.3. Those who did not receive the training packets on average did not differentiate between correct and incorrect responses as accurately with an average of 6.3.

Looking exclusively at bottom performers' ability to grade their own tests, they received an average score of 9.3. Top performers' ability to grade their own tests, attained an average score of 9.9. This means that those who originally scored in the bottom quartile, after receiving the training packet, were just as accurate in monitoring their test performance as were those who initially scored in the top quartile. Thus, increasing the metacognitive ability of bottom quartile performers allows those participants in the bottom quartile to accurately monitor which test problems they had answered correctly and which they answered incorrectly.

The impact of training on participants' self impressions were examined through a series of 2 (training: yes or no) X 2 (pre- vs post manipulation) X 4 (quartile: 1 though

4) mixed model analysis of variances. The results of this ANOVA are reported in Table 2.2.

TABLE 2.2 Self-Ratings in Percentile Terms of Ability and Performance for Trained and Untrained Participants.

	Untrained				Trained			
Quartile	**Bottom (n = 18)**	**Second (n = 15)**	**Third (n = 22)**	**Top (n = 15)**	**Bottom (n = 19)**	**Second (n = 20)**	**Third (n=18)**	**Top (n = 13)**
	Self-ratings of percentile ability							
Before	55	58.5	67.2	78.3	54.7	59.3	68.6	73.4
After	55.8	56.3	68.1	81.9	44.3	52.3	68.6	81.4
Difference	0.8	-2.1	0.9	3.6	-10.4*	-7*	0.1	8
Actual	11.9	32.2	62.9	90	41	41	69.1	90
	Self-ratings of percentile performance							
Before	55.2	57.9	57.5	83.1	50.5	53.4	61.9	74.8
After	54.3	58.8	59.8	84.3	31.9	46.8	69.7	86.8
Difference	-0.8	0.9	2.3	1.3	-18.6***	-6.6*	7.8	12.1*
Actual	11.9	32.2	62.9	90	14.5	41	69.1	90
	Self=ratings of raw test performance							
Before	5.8	5.4	6.9	9.3	5.3	5.4	7	8.5
After	6.3	6.1	7.5	9.6	1	4.1	8.2	9.9
Difference	0.6*	0.7	0.6*	0.3	-4.1***	-1.4*	1.2*	1.5*
Actual	0.2	2.7	6.7	10	0.4	3.3	7.9	10

Note. “Bottom” “Second” “Third” and “Top” refer to quartiles on the grading task

* $p < 0.05$. ** $p < 0.01$. *** $p < 0.0001$.

The results depicted in Table 2.2 clearly show that the degree of the impact training has on the accuracy of self-assessment is largely dependent upon each participant’s initial test performance.

Bottom quartile participants who received training became more calibrated in every way. After training, bottom quartile performers adjusted their; ratings of relative ability from 55th percentile to the 44th percentile, which was significantly closer to their actual performance which placed them within the 15th percentile. After training, bottom quartile performers also adjusted their ratings of relative performance from the 51st percentile to the 32nd percentile, which is another significantly more accurate prediction of actual performance which fell within the 15th percentile. The average ratings of the number of correct answers was also adjusted from 5.3 to 1 after training, which is also a significantly more accurate prediction of the actual average number of correct answers which was 0.4. Bottom quartile participants who received training still overestimated their logical reasoning ability and performance on test relative to their peers but their predictions had become significantly more calibrated overall.

No such increase in calibration was found for bottom quartile performers in the untrained group. Their estimates of their raw test score did change significantly however it was in a less accurate direction. In their initial ratings, they estimated that they had on average solved 5.8 problems correctly and on their second ratings, they raised their average estimate to 6.3 whereas their actual average number of correct answers was 0.2.

As reported in Table 2.2, top quartile participants' estimates of test performance and number of correct answers changed significantly as a result of training but their estimates of general ability did not change to a significant degree. Top quartile performers' initial ratings of relative performance changed from the 78th percentile to the 87th percentile after receiving training, whereas their actual performance placed them in the 90th percentile. This means their prediction became significantly more accurate after training. Top quartile participants also raised their average estimate of correct answers from 8.5 to 9.9 after training, whereas their actual average number of correct answers was 10, which means they made more accurate predictions after training.

Individuals in the top quartile who did not receive training did not change their self ratings of percentile ability, test performance or raw score to a significant degree. Thus without receiving training top quartile participants could not gain further insight into their performance.

The results of this study support the prediction that less competent individuals overestimate their abilities due to a lack in the metacognitive skill to recognise the inaccuracy of their predictions. This is demonstrated by the fact that participants in the bottom quartile grossly overestimated their test performance but became significantly more calibrated after their logical reasoning skills were improved. In contrast those who did not receive training did not change their predictions and therefore remained unaware of the inaccuracy of their predictions. The results also show that even top quartile performers' predictions of relative performance and number of correct answers became significantly more accurate after they received training. Thus by improving the metacognitive skills of participants through training participants in both the top and bottom quartiles participants were able to form more accurate predictions of performance and ability. Those participants who did not receive training maintained their level of metacognitive ability and thus maintained their prior predictions of performance and ability. Therefore the difference in accuracy of predictions of ability and performance between participants in different quartiles is due to a difference in the level of metacognitive ability.

2.2.5. The double curse of bottom quartile performers:

In a follow up study by Dunning, Johnson, Erlinger and Kruger (2003) 141 college students, who had just completed an exam, were asked to estimate, in a percentile value, their "mastery of course material" and performance on their test. Participants were also asked to estimate their raw score on the exam. Participants were then ranked in accordance with their actual performance on the test and placed into one of four groups depending on whether their raw score landed in the first, second, third or fourth quartile. This resulted in the pattern shown in Figure 2.5 and Figure 2.6.

FIGURE 2.5 Perceived Versus Actual Test Score as a Function of Actual Test Performance (Dunning, et al., 2003).

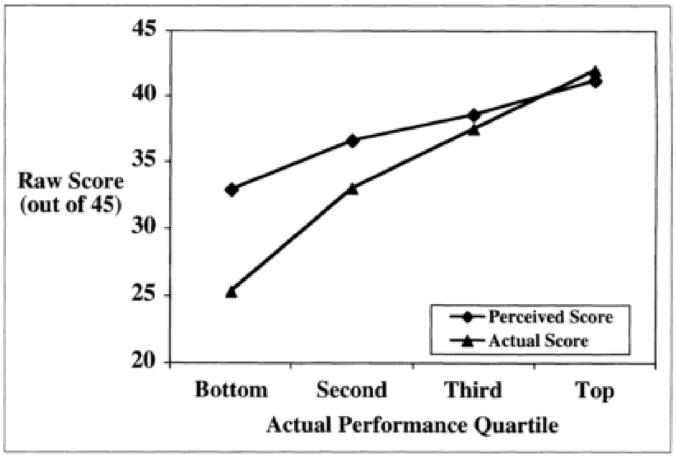
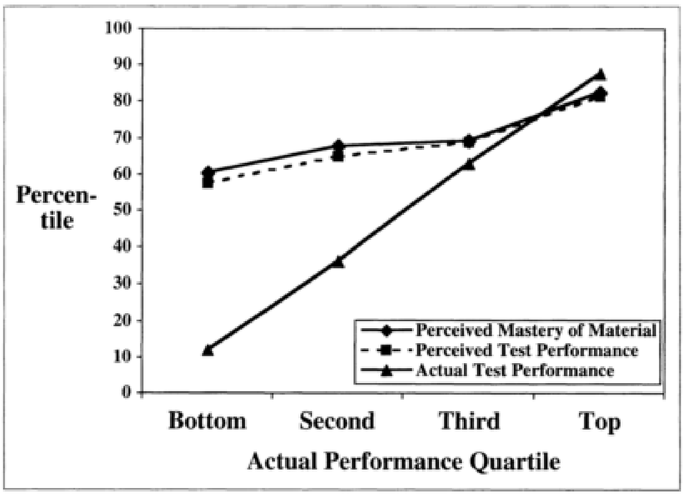


FIGURE 2.6 Perceived Percentile Rankings for Mastery of Course Material and Test Performance as a Function of Actual Performance (Dunning, et al., 2003).



The results of this study revealed that all students estimated their performance to be above the 50th percentile, with their estimations averaging 68% (Dunning, 2011). When asked to estimate their raw score they overestimated on average by 3 points perceiving an average score of 37 whereas the actual average score was 34 (Dunning, 2011).

As reported by Figure 2.5, students in the bottom quartile tended to have the largest disparity between estimated raw score and actual raw score, overestimating their performance by 30% on average (Dunning, et al., 2003). The disparity between estimations of performance and actual performance grows narrower the better participants perform. As reported in Figure 2.6 these participants estimated their mastery of course material to fall in the 60th percentile and their relative performance to fall in the 57th percentile, whereas their actual performance placed them within the 12th percentile. The level of overestimation decreased with each step up the quartile ladder with estimations of participants in the top quartile being most accurate.

As in previous studies of the Dunning-Kruger effect, the difference in accuracy between the estimations of top and bottom quartile performers is purported to be caused by a difference in metacognitive ability between these two groups. That is to say bottom quartile performers fail to realise their poor performance as their poor performance carries with it a double curse. This is because the skills necessary in producing correct responses are also necessary in evaluating the accuracy of responses. Therefore poor performers who lack the skills to produce correct answers are also cursed with the inability to recognise whether their answers or anyone else's are correct.

There was however a statistically observable relationship between perceived and actual performance. This is to say that people who scored within the bottom quartile estimated themselves to be performing worse than participants who achieved in the top quartile did. This means there is a significant, albeit weak, correlation between what people believe about their skill and their actual abilities. This is consistent with previous research on self-assessment, which found that people's impressions of their intellectual and social skills often correlate only modestly and sometimes not at all, with measures of actual performance (Falchikov & Boud, 1989).

2.3. Metacognition

The current theory of The Dunning-Kruger effect considers the difference in accuracy of top and bottom performer's predictions of performance to be caused by the difference in metacognitive ability between the two groups. Therefore, the term metacognition should be more clearly defined in order to achieve a greater understanding of why top and bottom performer's predictions differ in terms of accuracy.

2.3.1. Definition

Metacognition refers to higher order thinking which involves active control over the cognitive processes (Livingston, 1997). Metacognition is involved in; planning how to approach a given learning task, monitoring comprehension and evaluating progress toward the completion of a task (Livingston, 1997). There are several terms currently used to describe the same basic phenomenon as metacognition, such as self-regulation and executive control, which are often used interchangeably in the literature (Livingston, 1997). Metacognition is therefore often simply defined as "thinking about thinking" (Livingston, 1997). John Flavell (1979) theorised that metacognition consists of both metacognitive knowledge and metacognitive regulation. Metacognitive knowledge refers to acquired knowledge about cognitive processes such as; how human beings learn and process information and the nature of the task and the processes it demands (Livingston, 1997). Metacognitive regulation refers to the strategies one uses to control cognitive activities and to ensure that a cognitive goal has been met such as; ensuring a goal has been reached (Livingston, 1997).

2.3.2. The role of metacognition in the Dunning-Kruger effect

According to the current theory of the Dunning-Kruger effect, top quartile performers are said to possess greater metacognitive ability than bottom quartile performers (Dunning, 2011). Therefore, top performers' metacognitive abilities allow them to perform well and to make accurate estimations of performance whereas bottom performers' lack of metacognitive ability leads them to perform poorly and make weak estimates of performance. The reason for this is top performers' superior metacognitive knowledge allows them to adequately prepare for the assessment and their metacognitive regulation allows them to ensure they perform well and judge their performance accurately. Bottom performers' poor metacognitive knowledge prevents them from adequately preparing for the assessment and their poor metacognitive regulation inhibits their performance and prevents them from judging their performance accurately. Thus, since bottom performers lacked the knowledge necessary to answer most questions correctly, they made use of the completion principle when answering the questions. The use of the completion principle and the tendency to be confident in one's responses leads bottom performers to make poor estimations of their performance.

2.4. Alternative accounts of the Dunning-Kruger effect

Many psychologists have proposed possible alternative theories to account for the pattern that is now known as the Dunning-Kruger effect (Burson, Larrick & Klayman, 2006; Herbert, Hardin & Hardis, 2002; Krueger & Mueller, 2002). The majority of these alternative accounts consider possible statistical or methodological considerations which may also explain the Dunning-Kruger effect (Ehrlinger et al., 2009).

2.4.1. Regression to the mean

Certain alternative accounts of the Dunning-Kruger effect state that top and bottom quartile performers possess equal metacognitive ability to evaluate the quality of their own performances (Ehrlinger et al., 2009). Krueger and Mueller (2002) have argued that the observed pattern is produced by regression to the mean, coupled with the tendency of participants to rate themselves as above average rather than any difference in metacognitive ability. Because perceptions of ability are imperfectly correlated with actual ability, the regression effect virtually guarantees this result, and because of incompetence participants scored close to the bottom of the distribution, it was nearly impossible for them to underestimate their performance (Kruger & Dunning, 1999). Despite the inevitability of the regression effect, if regression alone was to blame for the results then the magnitude of the miscalibration among the bottom quartile would be comparable with that of the top quartile (Kruger & Dunning, 1999).

According to this theory the observed pattern of the Dunning-Kruger effect thus arises, in part, because the measures used to assess the skill level of participants are statistically unreliable. They carried out 2 studies which demonstrated that a good deal of overestimation among bottom performers and underestimation among top performers disappeared after regression towards the mean was accounted for.

Erlinger and colleagues (2009) challenged the hypothesis of Krueger and Mueller by performing their own study of top and bottom performers' self ratings in real world tasks, correcting for any unreliability by using students' performances on a second course exam. After completing an exam, participants completed a questionnaire and gave the researchers permission to obtain their scores. Five weeks later, the same procedure was repeated for a second time in order to obtain a measure of reliability of student's predictions.

Participants, as a whole, overestimated their performance and their ability level. On average, participants estimated their; mastery of course material to be in the 71st percentile when their performance actually placed them in the 49th percentile and also predicted their raw score to be 32 whereas their actual score was 28.5. Participants in the bottom quartile overestimated their performance, predicting their mastery of course material to lay in the 63rd percentile and their relative test performance at the 61st whereas their actual test performance fell in the 15th percentile. Additionally, participants in the bottom quartile estimated, on average, their raw score to be 32.9, whereas they actually had score 34.8. Participants who achieved in the top quartile predicted their mastery of course material to fall within the 74th percentile and their test performance to fall within the 73rd percentile when in actuality their scores placed them within the 87th percentile. Top quartile participants also slightly underestimated their raw score, predicting it to be 32.9, on average, whereas they actually scored 34.8.

To determine how much of this over- and underestimation was due to lack of reliability, participants' scores on the second preliminary examination were used to provide an estimate of test-retest reliability. After correcting for unreliability, the relationship between perceived and actual performance was stronger but only minimally so. Participants in the bottom quartile reduced their predictions of performance by only 5 points. In terms of raw score, bottom performers still overestimated their raw score to be 7.2. Therefore overestimations were still found in bottom performers' predictions of raw score and relative performance, even when reliability was corrected for.

2.4.2. Task difficulty

Burson, Larrick and Klayman (2006) supported the claim of Krueger and Mueller that top and bottom quartile performers do not differ in their ability to evaluate their performance. Their theory states that the pattern of the Dunning-Kruger effect is observed only in tasks that participants observe to be easy but tasks which are difficult may produce a below average effect. In difficult tasks, individuals believing themselves to be performing poorly would fail to account for the degree to which others also experience this difficulty and thus assess their relative performance as worse than average. This assertion was supported by studies conducted in which participants estimated their performance on tasks which were specifically designed to seem difficult. They found that estimates of performance did not correlate well with actual performance but correlated highly with the difficulty condition. In the case of difficult tasks, low performers tend to make more accurate assessments of their relative ability than top performers who tend to greatly underestimate their relative performance.

Ehrlinger and colleagues (2009) challenged the findings of Burson and colleagues by stating that since only tasks which were perceived as difficult or easy were used, the study is only valid for those circumstances and not for assessments in real life. It is for that reason that Ehrlinger and colleagues (2009) designed the following study as well as the previous study to assess self assessment in real world situations. The second study of Ehrlinger and colleagues (2009) involved 104 people who were competing in a debate tournament. Each participant was asked to rate whether they had won, their rank and the score the judge had given them.

The results of this study reveal that, on average, participants overestimated the number of matches won as 75% of their matches whereas they actually only won 46% of them. Participants also overestimated that they ranked 2.8 when their actual rank was 2.4. Finally participants overestimated that judges would score them as 25.6 when judges gave only a 25.0. Participants in the bottom quartile mostly overestimated their performance, predicting that they had won nearly 59% of their matches when they only won 22% of them. Participants in the bottom quartile also estimated themselves as ranking 2.4 when they actually ranked 1.9, they also estimated that they received a score of 24.9 from judges when in actuality they received 23.8. Top quartile performers overestimated the percentages of matches they had won, estimating to have won 95% when they only won 77%. They did, however, accurately estimate their rank to be 3.3 as they actually attained a score of 3.2. Similarly, they accurately estimated the score the judges gave them, estimating it to be 26.5 and actually receiving 26.4.

2.4.3. Incentives for accuracy

One could argue that the participants in the Dunning-Kruger studies lack the adequate motivation to make accurate estimations of performance (Ehrlinger et al., 2009). There are certain social incentives which could lead participants to make inaccurate self-assessments and thus invalidate the observed patterns of over- and underestimation. One such incentive is the tendency to maintain a positive self-concept and with that comes the tendency to assume one's own ability is greater than the average person (Kruger, 1999). To ensure that participants' estimations are representative of their most honest assessments of performance, incentives should be offered to participants to enhance their motivation to make their most accurate estimates. Hogarth (1999) found that, through analysing 74 studies, monetary incentives are an effective means of reducing self-presentational concerns. Ehrlinger and colleagues (2009) performed three studies to investigate the impact of incentives towards accuracy of self assessment.

46 participants were chosen from a Trap and Skeet competition with an average number of 34.5 years experience with firearms (Ehrlinger et al., 2009). Participants completed a 10 item multiple choice test of gun safety. After providing an answer for each question participants indicated the extent to which they were confident in their response by circling a number on a scale ranging from 25% to 100%. Participants were divided into two groups, one where the incentive of an additional $5 was offered if predictions of performance were within 5% of their actual score and one where no incentive was mentioned. Upon completing the test, all participants were asked to estimate how many of the 10 questions they answered correctly and to estimate their percentile rank.

Overall participants dramatically overestimated the quality of their performance on the test of gun safety knowledge, estimating they had answered 2.06 more questions than they actually did. They also showed themselves to be overconfident in the correctness of their responses to a degree of 28% on average. Participants also overestimated their relative performance to be 6.8% higher than it actually was, this was not however a significant difference. When participants were divided into quartiles based on their performance, participants in the bottom quartile's predictions were shown to be dramatically overconfident. Top performers provided self-assessments which lay nearer to their objective performance, although they tended to underestimate their performance.

To determine the influence of incentives on accuracy of self-assessments multiple regressions were used to compare the difference in the accuracy of predictions of performance between the two conditions. The results of this analysis revealed that the presence of an incentive had no effect on the accuracy of confidence ratings. Furthermore, bottom quartile participants in the incentive group made significantly greater overestimations of performance than those who were not offered any incentive. This study shows that overestimations of bottom performers are not caused by any lack of motivation to be accurate and therefore appear to be truly representative of participants' self-assessments. An additional study was performed by Ehrlinger and colleagues (2009) in which participants were offered $100 as opposed to $5, to assess whether the size of the incentive had any effect on the accuracy of predictions. This study showed that even offering a strong incentive for accuracy did not lead to more accurate estimates of the number of questions answered correctly.

Ehrlinger and colleagues (2009) carried out a study in which the incentive was a social one rather than a monetary one. This study was based on the research of Sedikides, Herbert, Hardin and Hardis (2002) which shows making individuals accountable for performance evaluations leads to less self-enhancing and more accurate estimates of performance. This study was aimed at making participants accountable for their predictions of performance to find whether it influences the accuracy of predictions. Participants were told they would be asked to complete a test of logical reasoning ability and evaluate the quality of their performance. Participants were placed into one of two conditions, an “accountable” group were told a supervising professor would interview each participant for 5-10 minutes regarding the rationale for their answers. Participants not in the “accountable” condition were not told about the interview. Participants completed a test of 10 multiple choice items taken from a law school aptitude test and asked to indicate their level of confidence in that response by circling a number on a scale ranging from 20% to 100%. Participants then estimated the number of questions they answered correctly and made a percentile estimate of their performance relative to other participants.

The results of this study showed that overall participants overestimated their percentile score by 20% on average. Overall, participants accurately estimated the number of questions they answered correctly. Participants who scored within the bottom 25% did significantly overestimate both, the number of questions they answered correctly and their percentile score. Participants who scored within the top 25% underestimated the number of answers they got correct and their percentile ranking. There was, however, a marginally significant difference between the participants in the two conditions. Participants in the “accountable” condition were marginally more confident in their estimations of the number of questions they answered correctly as well as their percentile rank than participants in the non accountable condition were. The accuracy of performance estimates were not affected by the presence or absence or of accountability. These results are identical to those obtained previously which show the presence of an incentive does not lead to more accurate predictions of performance. The presence of a monetary or social incentive for accuracy, in fact, leads to more confident judgements but these judgments remain largely inaccurate.

2.5. The current alternative account of the Dunning-Kruger effect

The current study aims to propose a new, alternative account of the Dunning-Kruger effect. This alternative theory is based on the research which shows that people tend to base predictions of performance on their preconceived notions of ability and the research on the above-average effect. Through using previous research into predictions of performance an alternative explanation for the pattern seen in Dunning-Kruger experiments is possible. In order to understand the alternative account, the theoretical basis for this research must first be discussed.

2.5.1. The role of preconceived notions of ability in performance estimates

In an earlier study by Ehrlinger and Dunning (2003) female participants rated themselves as less scientifically minded than male participants and subsequently made lower estimations of performance compared to the male participants. This study indicates the role that participants' preconceived notions of ability play in estimating performance.

2.5.1.1. Study 1

To find whether participants' predictions of performance were related to preconceived notions of ability Ehrlinger and Dunning (2003) asked 59 university students to first rate the extent to which they possessed 14 abilities. One item asked them to rate the degree to which they possessed the "ability to reason abstractly" on a scale of 1 (not at all) to 9 (to an extreme degree). Participants were then asked to complete a 10 item multiple-choice test which was labelled as measuring logical reasoning ability. Upon completion of this test participants were asked to estimate the number of items they answered correctly as well as a percentile estimate of their performance relative to other participants.

Participants tended to overestimate their relative performance but accurately estimated the number of items they answered correctly. Participants' predictions of relative performance were more closely related to their preconceived notions of ability than their actual relative performance. Participants predictions of the number of questions answered correctly were as related to their preconceived notions of ability as to the actual number of questions answered correctly.

This study shows that participants' preconceived notions of ability significantly influenced their performance estimates. This suggests that self-views are partially responsible for the mistakes people make when they evaluate how well they have performed on a task. When people hold high preconceived notions of ability in a specific domain, they are likely to make higher estimations of performance than when they hold low preconceived notions of ability.

2.5.1.2. Study 2

In a further study by Ehrlinger and Dunning (2003), 91 university students rated their ability to program a computer and their ability to think about abstract concepts and rated the desirability of these traits. Participants were then administered a short test of analytical items and either told that the test measured "abstract reasoning abilities" or "computer programming abilities". Both groups were asked to estimate their percentile achievement, the number of questions answered correctly and the average number of questions the other students had answered correctly.

Overall, participants rated their abstract reasoning ability to be greater than their computer programming ability. Participants who believed they were taking the "abstract reasoning test" rated their percentile estimates of performance much higher than did the participants who believed they were taking the "computer programming test". The abstract reasoning group estimated their percentile performance as being 70.8% on average, whereas the computer programming group rated their percentile performance as being 58.4% on average. The participants in the abstract reasoning group also estimated that they had answered more questions correctly, 7.7, than those in the computer programming group who estimated they had answered 6.7 correctly. There was however no significant difference in the actual performance between the two groups.

This study further provided more conclusive evidence that people rely on their preconceived notions of ability when estimating performance. In this study, it was manipulated whether a high or low preconceived notion of ability was relevant and this was shown to have a significant impact on their predictions of performance.

2.5.1.3. Study 3

Another study was designed by Ehrlinger & Dunning (2003) to further demonstrate that people rely on preconceived notions of ability when estimating their performance. The aim of this study was to manipulate the preconceived notions of ability of each group so that one held a favourable preconceived notion of ability and the other held an unfavourable preconceived notion of ability.

A total of 55 university students were asked a series of questions purportedly designed to see how much they had travelled and to test their knowledge of geography. The questions were either designed to lead participants to favourable or unfavourable responses regarding their knowledge of geography. Participants were then assigned a blank map and a list of 15 cities and asked to indicate where each city was located on the map. Finally, participants were asked to rate their relative performance and the number of questions answered correctly.

Those participants assigned to the unfavourable response category rated both their relative performance and the number of questions answered correctly less favourably than those assigned to the favourable response category. It was also found that the group that was manipulated to have more positive preconceived notions of performance answered a greater number of questions correctly than the group who was manipulated to have negative preconceived notions.

This study illustrates that altering the preconceived notions of an individual has a measurable impact on his or her performance estimates. Once again participants with a positive preconceived notion of ability estimated that they had performed better than participants with a negative preconceived notion of ability.

2.5.2. The above average effect

Studies have shown that when judging one’s own ability in comparison to the abilities of one’s peers, most people tend to estimate their abilities as above average (Dunning, 2011; Dunning, Meyerowitz & Holzberg, 1989; Heine & Lehman, 1997; Kruger, 1999; Weinstein, 1980). This phenomenon has been termed the “above average effect” and is evident in the previously discussed studies of Kruger and Dunning (1999) when participants were asked to estimate their logical thinking, grammar ability and sense of humour. This pattern is also evident in real world settings such as hunters estimating knowledge of firearms, among medical residents estimating patient interviewing skills and among lab technicians estimating knowledge of medical terminology (Ehrlinger et al,. 2009; Haun et al., 2000; Hoges, Regehr & Martin, 2001).

Further research into the above average effect has shown it to be a product of the fact that "people base their assessment of how they compare with their peers on their own level of ability and insufficiently take into account the skills of the comparison group" (Kruger, 1999, p. 222). Further research has shown that there are variables which influence the above average effect and in some cases lead to a below average effect.

2.5.2.1. The role of task difficulty

Kruger (1999) administered 37 university students a questionnaire in which eight domains of ability were described and asked them to rate their own ability in each domain relative to their peers. Participants were then asked to estimate their absolute level of ability and the level of ability of their classmates. The 8 domains were determined by a separate group of pretest participants who selected four traits in which they rated their skill level to be high skill and four traits which they rated their skill level to be low.

On average, participants rated themselves as above average in all four of the easy ability domains and rated themselves as below average for all but one of the difficult ability domains.

Therefore, the perceived difficulty of the domain of ability determines whether participants rate their relative ability as above or below that of their peers. The more difficult a particular domain appears the more likely They will estimate their ability as below average in that domain and the easier a particular domain appears the more likely one will estimate their ability as above average in that domain.

2.5.2.2. The role of ambiguity and desirability

Dunning, Meyerowitz and Holzberg (1989) carried out a study on 27 university students which required them to rate their abilities relative to their peers characteristics. A total of 20 separate university students provided ratings for 28 traits along the dimensions of ambiguity and social desirability in order to divide all traits into four categories; ambiguous positive, ambiguous negative, unambiguous positive and unambiguous negative. In this collection of traits, ambiguity was not confounded with social desirability, which is to say that ambiguous positive traits were just as socially acceptable as unambiguous characteristics and vice versa.

Participants of this study rated themselves more highly on ambiguous positive characteristics than on unambiguous positive ones. Similarly participants rated themselves lower on ambiguous negative traits than on unambiguous negative ones. Participants of this study tended to rate themselves higher on positive traits than on negative traits. Further analysis revealed that participants rated themselves as above average on ambiguous positive traits and rated themselves as below average for ambiguous negative traits.

This study illustrates that ambiguity of traits as well as desirability of traits plays a part in whether participants will estimate themselves as above or below average. The more ambiguous and desirable a particular domain appears the more likely one will estimate their ability as above average in that domain. In the same way, the less desirable and more ambiguous a domain appears the more likely one will estimate their ability as below average.

2.6. Conclusion

In summary, The Dunning-Kruger effect refers to bottom quartile performers overestimating their ability, relative performance and raw score in an assessment and top quartile performers making more accurate predictions of performance. The current theory attributes this difference in accuracy of prediction to be due to a difference in metacognitive ability between the two groups. There have been several alternative theories to the Dunning-Kruger effect but the theory of differing metacognitive ability remains the most popular and most widely known. Further studies by Ehrlinger and Dunning (2003) have also highlighted the influence of preconceived notions of ability on predictions of performance. The above average effect has been shown to play a major part in people's ratings of ability. Certain variables also determine whether an above average or below average effect occurs, such as perceived difficulty of domain as well as ambiguity and desirability of trait. It is the purpose of this study to find whether the predictions of performance are based on metacognitive ability or on preconceived notions of ability.

CHAPTER 3:
RESEARCH METHODOLOGY

3.1. Introduction

This chapter discusses the theoretical basis of the research by first describing the current theory of the Dunning-Kruger effect and then explaining the alternative theory and providing further elaboration of the variables. Also discussed in this chapter are the research questions and an overview of the methodology. The research methodology is discussed in line with the design, sampling procedure, participant recruitment method, data collection method and measurement instruments and procedure used. The ethics and limitations of the methodology utilised are also considered in this section.

3.2. Theoretical framework

3.2.1. The alternative theory of the Dunning-Kruger effect

The alternate theory of the Dunning-Kruger effect postulates that the Dunning-Kruger effect is the product of participants basing their estimations of performance on their preconceived notions of ability. This is to say that both top and bottom performers are equally skilled at judging their relative performance as both groups base their judgements on their inherently biased preconceived notions of ability. Since several previous studies have shown a poor relationship between people's perception of ability and their actual ability, basing judgements of performance on preconceived notions of ability would most likely lead to inaccurate predictions. Due to the tendency to hold above average preconceived notions of one's own abilities, estimations of performance will tend towards the above average range, as reported in the Dunning-Kruger effect (Dunning, 2011; Dunning, Meyerowitz & Holzberg, 1989; Heine & Lehman, 1997; Kruger, 1999; Weinstein, 1980). The difference between top and bottom performers' accuracy when predicting performance would therefore not be caused by a difference in metacognitive ability but in a difference in actual ability. That is to say that all participants estimate their ability and relative performance to lie in the above average range, this is evident in previously discussed studies of the Dunning-Kruger effect (Kruger & Dunning, 1999; Dunning et al., 2003). Because top performers ability places them above the above average range and poor performers lack of ability places them far below the above average range the Dunning-Kruger pattern is created.

3.2.1.1. Application of the alternative theory of the Dunning-Kruger effect

In Study 3 of Kruger and Dunning (1999) participants were administered with a test of grammar ability and asked to estimate their ability, relative performance and raw score. As predicted, participants, overall, estimated their grammar ability to be within the 71st percentile, their performance on the test to be within the 68th percentile and their raw score to be 15 out of 20.

Participants in the bottom quartile estimated their ability to be within the 67th percentile, their relative performance to fall within the 61st percentile and their raw score to be 12 out of 20.

Participants in the top quartile estimated their ability to be within the 72nd percentile, their relative performance to fall within the 70th percentile and their raw score to be 16 out of 20.

The alternative theory of the Dunning-Kruger states that all participants above average predictions of performance would be due to participants holding an above average preconceived notion of ability. This is because the domain of grammar ability is perceived as easy, ambiguous and desirable. This study is, thus far, comparable to all other Dunning-Kruger effect studies. However, in the next phase of this study was aimed to prove the current theory of the Dunning, Kruger effect. In phase 2 of the study, top and bottom participants were given 5 tests which represented the spectrum of student performances and asked to grade the tests. Participants were then handed their own tests back and asked to re-evaluate their ability, relative performance and raw score.

Top performers were significantly better at grading the tests of other participants than bottom performers, which one could safely assume, since top performers possess superior grammar ability. Top performers were the only participants to significantly change their predictions of performance. Top performers raised their estimates of ability and relative performance, to more accurate estimations.

The current theory of the Dunning-Kruger effect states that top performers possess greater metacognitive ability, which allowed them to gain insight into their relative performance when exposed to their peers' tests. Similarly, the current theory of the Dunning-Kruger effect states that bottom performers did not improve the accuracy of their predictions of performance as their lack of metacognitive skills prevented them from gaining insight into their relative performance. Whereas the alternative theory of the Dunning-Kruger effect would state that the estimates of performance were based on preconceived notions of ability, rather than through the use of metacognitive ability. Thus, top performers most likely have many of their answers affirmed by marking tests from across the spectrum of performance. They would thus feel more confident in their performance and adjust their predictions of ability and relative performance. Bottom quartile performers would, most likely, see fewer of their answers affirmed through marking tests from across the spectrum of performance. They would, thus, feel less confident and not raise their predictions of performance to a significant degree.

In Study 4 of Kruger & Dunning (1999) top and bottom performers were given training to improve their metacognitive skills, which thus, improved their predictions of performance. However, this training was done after participants had completed a test of logical reasoning and, though training, received feedback about their performance which would lead to more accurate predictions of performance.

3.2.1.2. Metacognition vs. preconceived notions of ability

To elaborate on the alternative theory of the Dunning-Kruger effect, this alternative explanation does disagree with the assertion of the original theory which states that top performers have superior metacognitive ability. The alternative theory merely posits that regardless of metacognitive ability, the predictions of ability and relative performance would most likely be based on preconceived notions of ability. The reason one's predictions of performance would be based on preconceived notions of ability rather than metacognitive ability is because, people rarely hold accurate perceptions of their own and much less other people's knowledge and abilities. That is to say that judgement of one's own knowledge and abilities is inherently biased towards a self serving view (Alicke, 1985; Brown, 1992). Therefore to make a judgement of relative performance, which requires one to compare their knowledge and ability against that of their peers, would suffer the same bias. Regardless of how much metacognitive ability one possesses, the estimation of one's performance in comparison to one's peers is not a task in which metacognition can lead to success. This is because metacognitive knowledge does not include knowledge about one's peers and their ability. This leaves bottom performers and top performers on the same footing when making judgements of one's own ability and relative performance.

The final prediction of top and bottom performers is that of raw score. This prediction is a task more suited to the domain of metacognitive ability as this task only requires knowledge of one's own knowledge. This is most likely why top performers generally make more accurate predictions of raw score than bottom performers. However, results of studies done on predictions of performance and preconceived notions of ability have shown that participants given the same test but told they were being assessed on different abilities made different estimations of raw scores. Thus, this study will seek to assess whether top and bottom performers differ in their assessments of raw score when they hold differing preconceived notions of ability.

3.2.2. The predictions in the alternative theory of the Dunning-Kruger effect

There are several predictions made by participants in studies of the Dunning-Kruger effect. Participants are asked to estimate their ability in the domain being assessed, their performance relative to their peers as well as their raw score. It is necessary to explore each prediction in detail in order to better account for the source of each prediction according to the alternative account of the Dunning-Kruger effect.

3.2.2.1 Ratings of ability

Participants in studies of the Dunning-Kruger effect are asked to estimate their ability in the field they are being assessed, generally in the form of a percentile ranking (Dunning et al., 2003; Kruger & Dunning, 1999). This score is thus a representation of participants' perceived ability in the domain being assessed in the form of a percentile ranking. As reported in previous studies, people tend to make above average predictions of ability, particularly when the field of ability is perceived to be easy, ambiguous and desirable.

3.2.2.2. Ratings of relative performance

The ratings of relative performance in studies of the Dunning-Kruger effect are also generally asked in the form of a percentile ranking (Dunning et al., 2003; Kruger & Dunning, 1999). This score is thus a representation of how well participants' performance compare to their peers in the form of a percentile ranking. This would require participants to first estimate their performance on this assessment and then to estimate how the average participant would perform and then to apply a percentile value to their position relative to the average participant. As previously discussed is Ehrlinger and Dunning's (2003) first study; participants' predictions of relative performance were more closely related to their preconceived notions of ability than their actual relative performance. Once again studies show that when participants rely on their preconceived notions of ability it leads to estimations of above average performance (Kruger & Dunning, 1999; Dunning, 2011; Dunning et al., 2003,; Dunning, Meyerowitz & Holzberg, 1989; Heine & Lehman, 1997; Kruger, 1999; Weinstein, 1980). The above average effect is more pronounced in cases where the assessment was considered easy and the field of assessment is perceived as ambiguous and desirable.

3.2.2.3. Ratings of raw score

Participants in Dunning-Kruger effect studies are generally asked to estimate their raw score, as a measure of their performance. This score is thus a representation of the participants' estimation of the number of questions they answered correctly. As reported in Kruger & Dunning's (1999) studies, which were discussed earlier, top performers tend to make more accurate estimations of their raw scores than low performers. This seems to be an indication of metacognitive ability as top performers are able to apply their knowledge of what they know and what they don't whereas bottom performers lack this metacognitive ability. However, in Study 2 of Ehrlinger and Dunning (2003), participants given the same test but told that it measured computer programming ability rated their raw score as lower than did participants who were told that it measured abstract reasoning ability. This shows that the preconceived notions of ability interfered with participants' ability to estimate the number of questions they answered correctly. Further research is necessary to ascertain whether top performers are as susceptible to basing judgements of performance on preconceived notions of ability as bottom performers. This in essence is what this research aims to do.

3.3. **Research questions**

In order to ascertain the source of predictions or performance this study will manipulate the preconceived notion of ability which participants may use to base their predictions of performance on. One group will be manipulated to hold low preconceived notions of ability and the other will be manipulated to hold high preconceived notions of ability. The way in which preconceived notions of ability will be manipulated is through convincing participants they are being assessed in two separate fields of ability, whilst actually taking the same test. The two domains of ability will consist of one that is perceived as easy, ambiguous and desirable and another which will be perceived as difficult, unambiguous and undesirable. After completing the assessment participants are asked to estimate; their percentile score of ability in the domain being assessed, a percentile score of their relative performance in comparison to peers and an estimation of their raw score. The predictions made by both groups will be compared to find whether there was a significant difference between the two conditions.

Sub question 1: Is there a significant difference between two group's predictions of ability, relative performance and number of questions answered correctly for identical tests but when they are told they are being assessed in either a difficult or easy ability domain?

In order to answer the subsequent research question, there would have to be a significant difference between each group's predictions of ability. If there is not a significant difference between predictions of ability made between the two groups then the manipulation of the dependent variable will have been unsuccessful. Therefore the following questions will only be considered if each group hold significantly different preconceived notions of ability. If the two groups do have significantly different ratings of ability, further comparisons will be made between the actual performance and the accuracy of predictions of top and bottom performers in each condition.

Sub question 2: In each of the two conditions how did top and bottom performers' predictions relate to their actual performance?

The final stage of analysis will entail comparing the predictions made by both groups of top performers and bottom performers to find whether the predictions of performance were based on preconceived notions of ability or actual performance.

Research Question 1: Is there a significant difference between the predictions of ability, relative performance and number of questions answered correctly between the two groups of top performers?

Research Question 2: Is there a significant difference between the predictions of ability, relative performance and number of questions answered correctly between the two groups of bottom performers?

3.4. Overview of methodology

3.4.1. Research design

A quasi-experimental design was used in which both between subjects and within subjects comparisons were made (Graveter & Forzano, 2007). All participants were divided into two groups, who received the same test, but with the independent variable of either being told they were being assessed in Logical Thinking or Computational Mathematics. The dependent variables which both groups had to provide were estimates of ability, relative performance and actual score. The Logical Thinking and Computational Mathematical groups were each split into groups of top quartile performers and bottom quartile performers. A 2x2 between subjects and 2x2 within subjects design were both used to compare the dependent variables of the two sets of groups. The dependent variables of the two top performers groups and two bottom performing groups were also compared in an independent samples t-test.

3.4.2. Sampling

The sample consisted of a group of 97 university students currently enrolled at the University of Pretoria. Participants were primarily from the Humanities faculty and included students from 1st years up until 4th year. Participants were asked to provide some biographical details such as; age, it was thus expected that characteristics such as gender, age, field of study, race and language would represent the characteristics of the population of students attending the University of Pretoria.

3.4.3. Participant recruitment

Non-probability convenience sampling was used to recruit students. Students were approached during a lecture and asked to participate in the study on a voluntary basis. There was no incentive offered for participation. Participants were also asked to sign a consent form agreeing to take part in the study and allow the use of their data.

3.4.4. Data collection

Participants provided their age, race and gender upon the test they personally wrote as well as predictions of ability, relative performance and raw score. The tests were marked after they were handed back to the examiner and the actual raw scores were used as a measure of actual performance.

3.4.4.1. Measurement instruments

Participants were administered a preparatory test from the LSAT aptitude test of 23 items from the Law School Administration Council (2007, July). The estimations of ability of each group measure their preconceived notions of ability. The estimations of relative performance serve as a measure of the participants' perceived relative performance in the field in which they believe they are being assessed. If there is a significant difference in the estimations of relative performance between the two groups it suggests that predictions are based on preconceived notions of ability. If there is no significant difference in estimations of relative performance between the two groups it suggests that predictions of performance were based on metacognitive ability. Predictions of raw score serves as a measure of participants' perceived number of questions answered correctly. This will serve as a further measure for whether participants estimate their predictions of number of question answered correctly on preconceived notions of ability or using metacognitive ability. The actual raw scores of participants will be used to compare the number of correct answers to participants' predictions of performance. Raw scores will also be used to group participants into top and bottom performers. Those who attain scores in the highest quarter percentile are classed top performers and those in the lowest quarter percentile are classed as bottom performers.

3.4.5. Procedure

Participants were offered a chance to participate in this study and informed that they may withdraw at any time. Participants were then divided into two groups and administered a preparatory version of the LSAT. One group was informed that their test measured Logical Thinking ability and the other group were informed that their test measures Computational Mathematical ability. Upon completing the test, participants were asked to estimate their overall ability in that field, relative performance as a percentile value and raw score they attained.

3.4.6. Statistical procedures

SPSS will be used for all statistical procedures. A 2x2 factorial ANOVA was done to determine main effects of Logical Thinking and Computational Mathematical groups and top and bottom quartile performers and interaction between these for the three dependent variables. Post hoc comparisons were done when main effects were present (thus the omnibus F-test was significant) by means of independent sample t-tests with a Bonferroni adjustment for the number of comparisons made. When comparing dependant variable's within groups, a number of related-sample t-tests were done again with a Bonferroni adjustment for the number of comparisons made.

3.4.6.1 Descriptive statistics

Sample means, standard deviations, measures of central tendency and measures of dispersion were calculated for each of the variables. The relationships between variables were examined using Pearson’s bivariate correlations. The results of these analyses are reported in the following chapter.

3.5. Ethics

Anonymity will be ensured for all participants of this study as in place of using names we will code them according to their student number. Permission to use participants test results will be ascertained and participants will be given the option of whether they would like to participate in this study or not. Deception will be used as part of this study as participants will be told the test measures abilities which it does not measure and so participants will be debriefed after the study and informed as to the reason for the use of the dishonesty.

The term “bottom performer” is used throughout this paper, however it is not intended to carry any negative label or cause any offence. “Bottom performer” is used to describe the group of performers who achieved the lowest scores in a given assessment; it does not imply they are in any way inept or that their abilities are poor. This term is not meant to be used pejoratively as the purpose of this study is to find whether all people suffer the same impairments regardless of the amount of actual knowledge.

3.6. Chapter summary

This chapter provided an overview of the theoretical framework underpinning the study and the research design utilised. The alternative theory of the Dunning-Kruger effect is explained and the variables are elaborated upon. The methodology and statistical analysis are also discussed here. The following chapter presents and discusses the results of the statistical analysis regarding the sample as well as relationships between variables and whether significant differences exist between the scores of different groups.

CHAPTER 4:
RESULTS

4.1. Introduction

This chapter presents the results of the study. Descriptive and inferential statistics were utilised to analyse the collected data through the use of SPSS 22.0 (Gravetter & Wallnau, 2007). The research questions and sub questions as well as all hypotheses were tested through the use of several t-tests. Furthermore three factorial ANOVAs were used to find the accuracy of predictions of performance. At first a description of the sample and descriptive statistics, correlation analysis, followed by the results of the ANOVAs, are provided, followed by the t-tests and the chapter is concluded.

4.2. Sample profile

The sample, as mentioned in the previous chapter, was obtained using non-probability convenience sampling. The overall sample, consisting of both treatment groups, consisted of 97 university students, 78.4% female and 21.6% male. The mean age of the overall sample was 19.9 years with participants ranging from 17 to 28 years of age. Of the 97 participants, 59.8% were White, 30.9% were Black, 5.2% were Indian and 4.1% were Coloured. Table 4.1 contains a breakdown of the sample according to the demographic variables measured and illustrate the characteristics of each group.

TABLE 4.1 Demographic Information of Sample as well as Logical Thinking and Computational Mathematical Group.

	Number of Participants	Average Age	Gender		Race			
			Male	Female	White	Black	Indian	Coloured
Overall	97	19.9	21.6%	78.4%	59.8%	30.9%	5.2%	4.1%
Logical Thinking Group	49	20.2	18.4%	81.6%	61.2%	30.6%	6.1%	2%
Computational Mathematical Group	48	19.6	25%	75%	58.3%	31.3%	4.2%	6.3%

As reported in Table 4.1 above, the number of participants in the Logical Thinking group was 49 and in the Computational Mathematical group was 48. The mean age in each groups was; 20.2 in the Logical Thinking group and 19.6 in the

Computational Mathematical Group, respectively. The Logical Thinking group was made up of 18.4% males and 81.6% females, whereas the Computational Mathematical group was 25% males and 75% females. The Logical Thinking group comprised of; 61.2% White participants, 30.6% Black participants, 6.1% Indian participants and 2% Coloured participants. Similarly the Computational Mathematical group comprised of; 58.3% White participants, 31.3% Black participants, 4.2% Indian participants and 6.3% Coloured participants.

4.3. Descriptive statistics

The overall sample (*N* = 97) achieved an average score of 7.3 (*SD* = 3.22) with scores ranging from 1 to 18 out of a possible 23. Overall participants rated their ability to be 57.9% (*SD* = 17.79), note that this includes participants who were asked to rate their logical thinking ability as well as participants who were asked to rate their computational mathematical ability. On average participants rated their relative performance to be 46.3% (*SD* = 17.36). Participants also predicted their overall score to be 9.8 (*SD* = 4.39). The actual scores as well as predictions made by the overall group as well as individual groups are reported in Table 4.2 below.

TABLE 4.2 Scores and Predictions of Ability, Relative Performance and Score of Sample, Logical Thinking Group and Computational Mathematical Group.

	Mean Actual Score (SD)	Mean Ability Rating (SD)	Mean Relative Performance Rating (SD)	Mean Predicted Score (SD)
Overall	7.3 (3.22)	57.9% (17.79)	46.3% (17.36)	9.8 (4.39)
Logical Thinking Group	7.3 (3.23)	67.1% (14.3)	47.8% (17.61)	9.9 (4.61)
Computational Mathematical Group	7.2 (3.24)	48.5% (16.05)	44.7% (17.14)	9.7 (4.2)

As reported above, in Table 4.2, the Logical Thinking group (*n* = 49) achieved a mean score of 7.3 (*SD* = 3.23), while the Computational Mathematical group (*n* = 48) achieved a mean score of 7.2 (*SD* = 3.24). The Logical Thinking group, on average, rated their ability to be 67.1% (*SD* = 14.3) whereas the Computational Mathematical group rated their ability to be 48.5% (*SD* = 16.05). The Logical Thinking group rated their relative performance to be 47.8% (*SD* = 14.61) and the Computational Mathematical group rated their relative performance to be 44.7% (*SD* = 17.14). On average the Logical Thinking group predicted their score to be 9.9 (*SD* = 4.61) and the Computational Mathematical group predicted their score to be 9.7 (*SD* = 4.2).

4.3.2. Descriptive statistics according to race

The overall sample (*N* = 97) was made up of 58 White participants, 30 Black participants, 5 Indian participants and 4 Coloured participants. White participants achieved an average score of 8 (*SD* = 3.2), Indian participants also achieved mean score of 8 (*SD* = 4.9) whereas Black participants achieved a mean score of 5.8 (*SD* = 2.52) and Coloured participants attained a mean score of 6.8 (*SD* = 3.21). The average ability rating of White participants was 60.2% (*SD* = 17.6) whereas Black participants predicted their ability to be 56.3% (*SD* = 18.22), Indian participants predicted their ability to be 50.6% (*SD* = 20.23) and Coloured students rated their ability to be 46.3% (*SD* = 17.79). These scores include participants in both Logical Thinking and Computational Mathematical groups. In terms of average ratings of relative performance; White participants rated their performance to be 48.8% (*SD* = 16.3) Black participants rated their performance to be 43.4% (*SD* = 18.12), Indian participants rated their performance to be 40.2% (*SD* = 25.5) and Coloured participants rated their performance to be 38.8 (*SD* = 17.36). Finally, on average, White participants predicted their score to be 10 (*SD* = 4.03), Black participants predicted their score to be 9.7 (*SD* = 5.25), Indian participants predicted their score to be 7.8 (*SD* = 4.32) and Coloured participants predicted their score to be 9.5 (*SD* = 4.39). The number of participants of each race as well as the mean scores and estimations of each racial group are reported below in Table 4.3.

TABLE 4.3 Numbers, Mean Scores and Predictions of Ability, Relative Performance and Score of Each Racial Group.

	Number of Participants	Mean Actual Score (SD)	Mean Ability Rating (SD)	Mean Relative Performance Rating (SD)	Mean Predicted Score (SD)
White	58	8 (3.2)	60.2% (17.6)	48.8% (16.3)	10 (4.03)
Black	30	5.8 (2.52)	56.3% (18.22)	43.4% (18.12)	9.7 (5.25)
Indian	5	8 (4.9)	50.6% (20.23)	40.2% (25.5)	7.8 (4.32)
Coloured	4	6.8 (3.21)	46.3% (17.79)	38.8% (17.36)	9.5 (4.39)

4.3.2. Descriptive statistics according to gender

The overall sample (*N* = 97) consisted of 21 male participants and 76 female participants. Male participants on average achieved a score of 7.9 (*SD* = 3.37) whereas female participants on average achieved a score of 7.1 (*SD* = 3.18). Male participants, on average, rated their ability to be 65.6% (*SD* = 18.13) while female participants rated their ability to be 55.8% (*SD* = 17.21) on average, this, however, comprises of participants from both Logical Thinking and Computational Mathematical groups. Males rated their relative performance to be 55% (*SD* = 14.92) and females rated their relative performance to be 43.8% (*SD* = 17.29). Finally, males predicted their score to be 10.9 (*SD* = 3.7) and females predicted their score to be 9.5 (*SD* = 4.55). The number of males and females, as well as the mean scores and estimations of each gender are reported below in Table 4.4.

TABLE 4.4 Numbers, Mean Scores and Predictions of Ability, Relative Performance and Score of Each Gender.

	Number of Participants	Mean Actual Score (SD)	Mean Ability Rating (SD)	Mean Relative Performance Rating (SD)	Mean Predicted Score (SD)
Male	21	7.9 (3.37)	65.6% (18.13)	55% (14.92)	10.8 (3.7)
Female	76	7.1 (3.18)	55.8% (17.21)	43.8% (17.29)	9.5 (4.55)

4.4. Correlation analysis

In the overall sample (*N* = 97), the actual score correlated significantly with the rating of relative performance to the mean rating of relative performance (r = 0.49, $p \leq$ 0.01) as well as with the mean score predicted (r = 0.43, $p \leq$ 0.01) but not with their rating of ability (r = 0.19, $p \geq$ 0.01). Similarly, participants' estimated ability correlated significantly with their ratings of relative performance (r = 0.57, $p \leq$ 0.01) and also with participants predicted score (r = 0.33, $p \leq$ 0.01). Participants' rating of relative performance was also significantly correlated to predictions of score (r = 0.65, $p \leq$ 0.01).

4.5. Main effects and Interactions between top and bottom quartile performers

A 2 x 2 mixed factorial ANOVA was used to analyse the following data. Top and bottom performers from Logical Thinking and Computational Mathematical groups were compared to find whether there were any main effects for the two factors or interaction between the factors between these 4 groups with regards to their scores and predictions. Note that the actual score as well as predicted score have been converted to percentages for easier comparison to ability rating and relative performance rating which are also percentages.

4.5.1. Comparisons between top and bottom quartile of logical thinking group

The Logical Thinking group had 14 participants in the bottom quartile and 14 in the top quartile. Table 4.5 below shows the mean scores and predictions of the top and bottom quartile of the Logical Thinking group.

TABLE 4.5 Mean Actual Score, Ability Rating, Relative Performance Rating and Predicted Score for Top and Bottom Quartile of Logical Thinking Group.

	Top Quartile Performers (SD)	Bottom Quartile Performers (SD)	t-value	p
Mean Actual Score	49.69% (8.81)	16.46% (5.17)	12.17	*0.00
Mean Ability Rating	70.29% (13.98)	62.71% (17.52)	1.26	0.22
Mean Relative Performance Rating	57.14% (11.22)	36% (*SD* = 22.32)	3.17	*0.005
Mean Predicted Score	56.21% (13.8)	31.68% (18.48)	3.98	*0.001

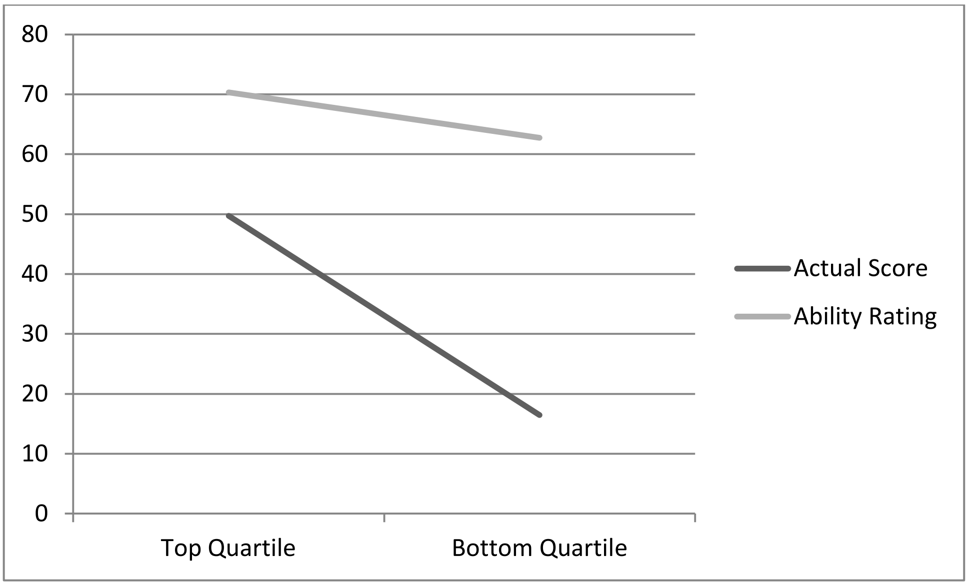
*$p \leq 0.012$

As displayed in Table 4.5 above, in the Logical Thinking group, the actual score of top quartile participants, 49.69% (*SD* = 8.81), was significantly higher than the actual score of bottom quartile participants, 16,46% (*SD* = 5.17), (t = 12.17, *df* = 26, $p \leq$ 0.012). The ability rating of top quartile participants, 70.29% (*SD* = 13.98), was not significantly higher than the ability rating of bottom quartile participants, 62.71% (*SD* = 17.52), (t = 1.26, *df* = 26, p = 0.22). The relative performance rating for top quartile participants, 57.14% (11.22), was significantly higher than the relative performance rating for bottom quartile participants, 36% (*SD* = 22.32), (t = 3.17, *df* = 19.17, $p \leq$ 0.012). The predicted score for top quartile participants was significantly higher, 56.21% (*SD* = 13.8), than the predicted score for bottom quartile participants, 31.68% (*SD* = 18.48), (t = 3.98, *df* = 26, $p \leq$ 0.012).

4.5.1.1. Score and ability rating

In terms of the Logical Thinking group (n = 49) there was a significant main effect for top and bottom quartile groups, ($F_{(1,26)}$ = 34.63, $p \leq 0.001$, $\eta 2$ = 0.57), and also a significant main effect for score and ability rating, ($F_{(1,26)}$ = 115.86, $p \leq 0.001$, $\eta 2$ = 0.82). There was also a significant top and bottom quartile x score and ability rating interaction, ($F_{(1,26)}$ = 17.07, $p \leq 0.001$, $\eta 2 = 0.40$). The actual score and ability rating for top and bottom participants in the Logical thinking group are reported in Figure 4.1

FIGURE 4.1 Graph showing Mean Actual Score and Mean Ability Rating for Top and Bottom Quartile Performers in Logical Thinking Group

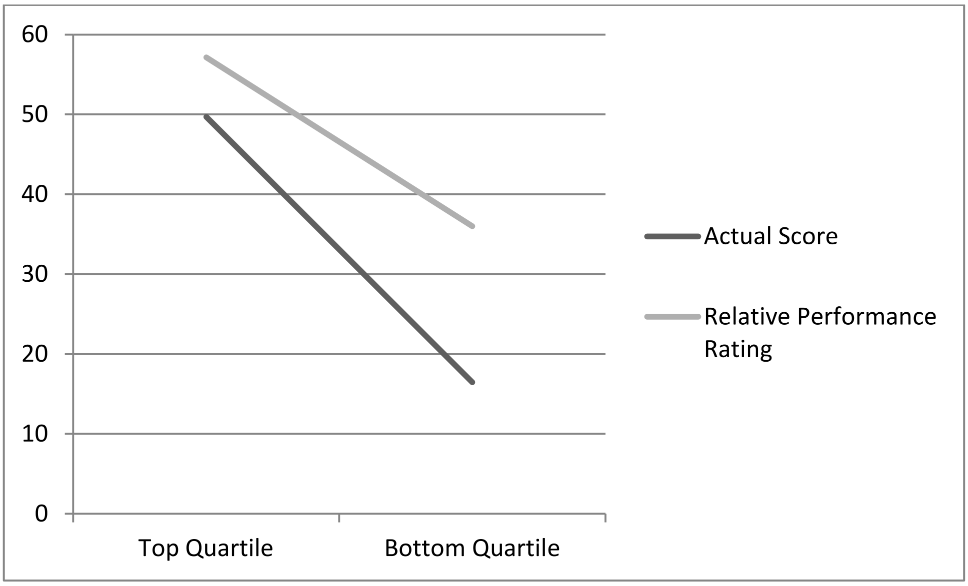


As displayed in Figure 4.1 above the top quartile for the Logical Thinking group rated their logical thinking ability as 70.29% (*SD* = 13.98), which was significantly higher than their actual score of 49.69% (*SD* = 8.81), ($t = 4.80$, $df = 13$, $p \leq 0.01$). The bottom quartile of this group rated their logical thinking ability to be 62.71% (*SD* = 17.52), which was significantly higher than their actual score of 16.46% (*SD* = 5.17), ($t = 10.30$, $df = 13$, $p \leq 0.01$).

4.5.1.2. Score and mean relative performance rating

In terms of the Logical Thinking group ($n = 49$) there was a significant main effect for top and bottom quartile groups, ($F_{(1,26)}$ = 48.15, $p \leq 0.001$, $\eta 2 = 0.65$), and also a significant main effect for score and relative performance rating, ($F_{(1,26)}$ = 17.08, $p \leq 0.001$, $\eta 2 = 0.40$). There was however, no significant top and bottom quartile x score and relative performance rating interaction, ($F_{(1,26)}$ = 3.43, $p = 0.8$, $\eta 2 = 0.12$). The mean actual score and mean relative performance rating for top and bottom participants in the Logical thinking group are reported in Figure 4.2.

FIGURE 4.2 Graph showing Mean Actual Score and Mean Relative Performance Rating for Top and Bottom Quartile Performers in Logical Thinking Group.

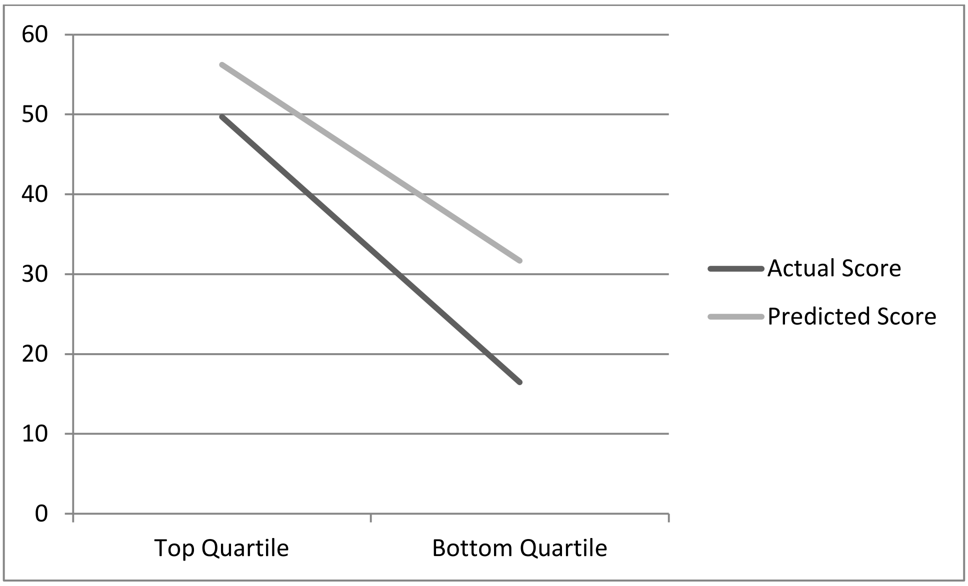


As displayed in Figure 4.2 above the top quartile for the Logical Thinking group rated their relative performance as 57.14% (*SD* = 11.22), which was not significantly higher than their actual score of 49.69% (*SD* = 8.81), (*t* = 2.31, *df* = 13, *p* = 0.038). The bottom quartile of this group rated their relative performance to be 36% (*SD* = *SD* = 22.32), which was significantly higher than their actual score of 16.46% (*SD* = 5.17), (*t* = 3.44, *df* = 13, *p* ≤ 0.01).

4.5.1.3. Score and mean predicted score

In terms of the Logical Thinking group (*n* = 49) there was a significant main effect for top and bottom quartile groups, ($F_{(1,26)}$ = 58.18, *p* ≤ 0.001, *η2* = 0.69), and also a significant main effect for score and predicted score, ($F_{(1,26)}$ = 14.09, *p* ≤ 0.01, *η2* = 0.35). There was however, no significant top & bottom quartile x score and predicted score, ($F_{(1,26)}$ = 2.25, *p* = 0.145, *η2* = 0.08.) The mean actual score and mean predicted score for top and bottom participants in the Logical thinking group are reported in Figure 4.3

FIGURE 4.3 Graph showing Mean Actual Score and Mean Predicted Score for Top and Bottom Quartile Performers in Logical Thinking Group.



As displayed in Figure 4.3 above the top quartile for the Logical Thinking group predicted their score to be 56.21% (*SD* = 13.8), which was not significantly higher than their actual score of 49.69% (*SD* = 8.81), (t = 2.03, *df* = 13, p = 0.063). The bottom quartile of this group predicted their score to be 31.68% (*SD* = 18.48), which was significantly higher than their actual score of 16.46% (*SD* = 5.17), (t = 3.16, *df* = 13, $p \leq 0.01$).

4.5.2. Comparisons between top and bottom quartile of computational mathematical group

The Computational Mathematical group had 14 in the bottom quartile and 17 in the top quartile. Table 4.6 below shows the mean scores and predictions of the top and bottom quartile of the Logical Thinking group.

TABLE 4.6 Mean Actual Score, Ability Rating, Relative Performance Rating and Predicted Score for Top and Bottom Quartile of Computational Mathematical Group.

	Top Quartile Performers (SD)	Bottom Quartile Performers (SD)	t-value	p
Mean Actual Score	46.29% (10.86)	16.46% (4.24)	10.4	*0.00
Mean Ability Rating	51.29% (15.9)	47.79% (14.76)	0.63	0.53
Mean Relative Performance Rating	53.24% (17.85)	40% (*SD* = 11.77)	2.38	0.24
Mean Predicted Score	48.08% (17.01)	44.1% (21.63)	0.57	0.57

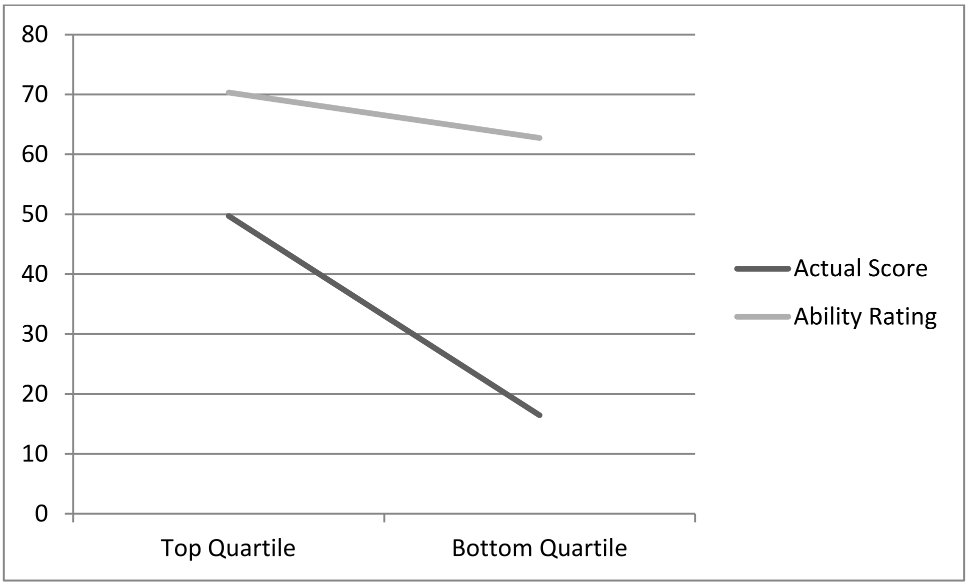
*$p \leq 0.012$

As displayed in Table 4.6 above, in the Computational Mathematical group, the actual score of top quartile participants, 46.23% (*SD* = 10.86), was significantly higher than the actual score of bottom quartile participants, 16,46%, (*t* = 10.40, *df* = 21.56, *p* ≤ 0.012). The ability rating of top quartile participants, 51.29% (*SD* = 15.9), was not significantly higher than the ability rating of bottom quartile participants, 47.79% (*SD* = 14.76), (*t* = 0.63, *df* = 29, *p* = 0.53). The relative performance rating for top quartile performers, 53.24% (*SD* = 17.85), was also not significantly higher than the relative performance rating for bottom quartile participants, 40% (*SD* = 11.77), (*t* = 2.38. *df* = 29, *p* = 0.24). The predicted score for top quartile participants was also not significantly higher, 48.08% (*SD* = 17.01), than the predicted score for bottom quartile participants, 44.1% (*SD* = 21.63), (*t* = 0.57, *df* = 29, *p* = 0.57).

4.5.2.1. Score and ability rating

In terms of the Computational Mathematical group (*n* = 48) there was a significant main effect for top and bottom quartile groups, ($F_{(1,29)} = 20.62$, $p \leq 0.001$, $\eta 2 = 0.42$), and also a significant main effect for score and ability rating, ($F_{(1,29)} = 48.99$, $p \leq 0.001$, $\eta 2 = 0.63$). There was also a significant top & bottom quartile x score and ability rating interaction, ($F_{(1,29)} = 25.72$, $p \leq 0.001$, $\eta 2 = 0.47$). The mean actual score and mean ability rating for top and bottom participants in the Computational Mathematical group are reported in Figure 4.4

FIGURE 4.4 Graph showing Mean Actual Score and Mean Ability Rating for Top and Bottom Quartile Performers in Computational Mathematical.

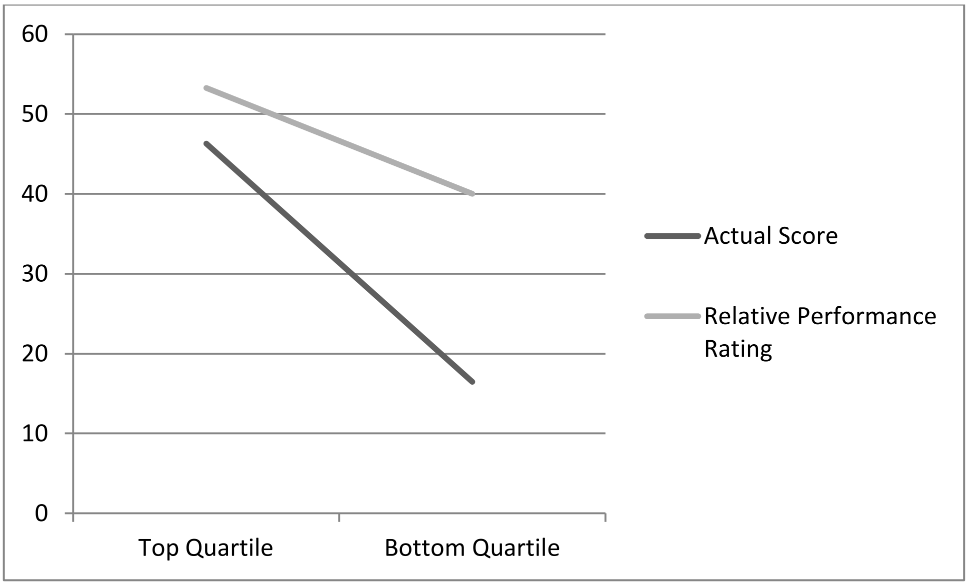


As displayed in Figure 4.4 above the top quartile for the Computational Mathematical group predicted their mathematical computational ability to be 51.29% (*SD* = 15.9), which was not significantly higher than their actual score of 46.23% (*SD* = 10.86), ($t = 1.37$, $df = 16$, $p = 0.188$). The bottom quartile of this group predicted their computational mathematical ability to be, 47.79% (*SD* = 14.76), which was significantly higher than their actual score of 16.46% (*SD* = 4.42), ($t = 8.64$, $df = 13$, $p \leq 0.01$).

4.5.2.2. Score and mean relative performance rating

In terms of the Computational Mathematical group ($n = 48$) there was a significant main effect for top and bottom quartile groups, ($F_{(1,29)} = 31.84$, $p \leq 0.001$, $\eta 2 = 0.52$), and also a significant main effect for score and relative performance rating, ($F_{(1,29)} = 40.83$, $p \leq 0.001$, $\eta 2 = 0.59$). There was a significant top & bottom quartile x score and relative performance rating interaction, ($F_{(1,29)} = 12.1$, $p \leq 0.01$, $\eta 2 = 0.29$). The mean actual score and mean ability rating for top and bottom participants in the Computational Mathematical group are reported in Figure 4.5

FIGURE 4.5 Graph showing Mean Actual Score and Mean Relative Performance Rating for Top and Bottom Quartile Performers in Computational Mathematical Group.

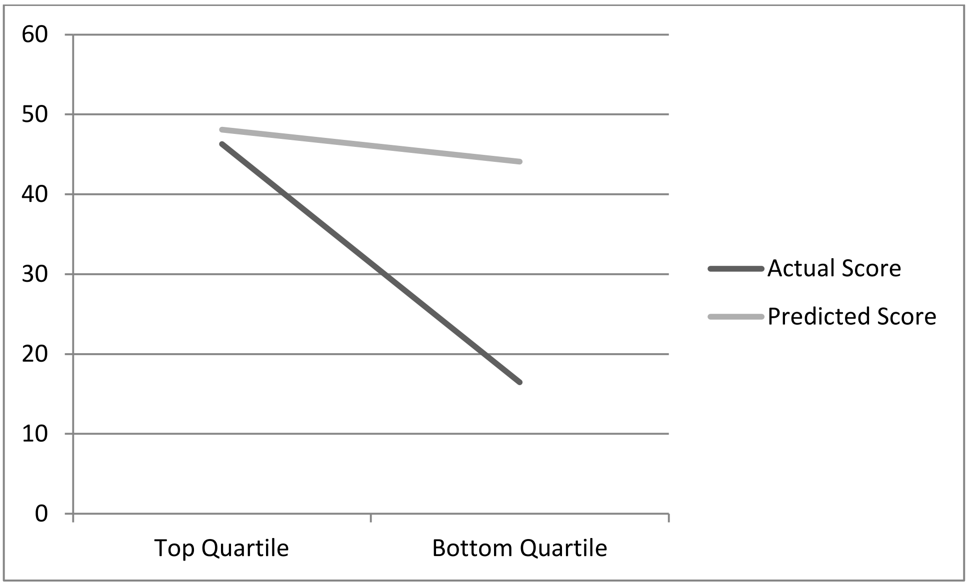


As displayed in Figure 4.4 above the top quartile for the Computational Mathematical group predicted their relative performance to be 53.24% (*SD* = 17.85), which was not significantly higher than their actual score of 46.23% (*SD* = 10.86), (t = 1.98, df = 16, p = 0.065). The bottom quartile of this group predicted their relative performance to be, 40% (*SD* = 11.77), which was significantly higher than their actual score of 16.46% (*SD* = 4.42), (t = 7.64, df = 13, $p \leq 0.01$).

4.5.2.3. Score and mean predicted score

In terms of the Computational Mathematical group (n = 48) there was a significant main effect for top and bottom quartile groups, ($F_{(1,29)}$ = 14.99, $p \leq 0.01$, $\eta 2$ = 0.34), and also a significant main effect for score and ability rating, ($F_{(1,29)}$ = 22.21, $p \leq$ 0.001, $\eta 2$ = 0.43). There was also a significant top & bottom quartile x score and ability rating interaction, ($F_{(1,26)}$ = 17.13, $p \leq 0.001$, $\eta 2$ = 0.37). The mean actual score and mean ability rating for top and bottom participants in the Logical thinking group are reported in Figure 4.6

FIGURE 4.6 Graph showing Mean Actual Score and Mean Predicted Score for Top and Bottom Quartile Performers in Computational Mathematical Group.



As displayed in Figure 4.4 above the top quartile for the Computational Mathematical group predicted their score to be 48.08% (*SD* = 17.01), which was not significantly higher than their actual score of 46.23% (*SD* = 10.86), (t = 0.50, *df* = 16, p = 0.624). The bottom quartile of this group predicted their score to be, 44.1% (*SD* = 21.63), which was significantly higher than their actual score of 16.46% (*SD* = 4.42), (t = 5.17, *df* = 13, $p \leq 0.01$).

4.6. Comparisons between logical thinking and computational mathematical groups

Multiple t-tests were performed to compare the Logical Thinking group (n = 49) and Computational Mathematical groups' (n = 48) scores and predictions. Table 4.7, below, illustrates the mean scores and predictions of the Logical Thinking group and Computational Mathematical group.

TABLE 4.7 Scores and Predictions of Logical Thinking and Computational Mathematical Groups.

	Logical Thinking Group (SD)	Computational Mathematical Group (SD)	t-value	p
Mean Actual Score	7.29 (3.23)	7.23 (3.24)	0.09	0.93
Mean Ability Rating	67.12% (14.3)	48.46% (16.05)	6.05	*0.000
Mean Relative Performance Rating	47.76% (17.61)	44.71% (17.14)	0.86	0.39
Mean Predicted Score	9.94 (4.61)	9.67 (4.2)	0.30	0.76

*$p \leq 0.012$

The mean actual score of the Logical Thinking group was 7.29 (*SD* = 3.23), which was not significantly different from the mean actual score of the Computational Mathematical group which was 7.23 (*SD* = 3.24), (*t* = 0.09, *df* = 95, *p* = 0.93). There was a significant difference between the mean ability rating of the Logical Thinking group, 67.12% (*SD* = 14.3), and the Computational Mathematical group, 48.46% (*SD* = 16.05), (*t* = 6.05, *df* = 95, $p \leq 0.012$). There was not a significant difference between the mean relative performance rating of the Logical Thinking group, 47.76% (*SD* = 17.61), and the Computational Mathematical group, 44.71% (*SD* = 17.14), (*t* = 0.86, *df* = 95, *p* = 0.39). There was no significant difference between the mean predicted score of the Logical Thinking group, 9.94 (*SD* = 4.61), and the Computational Mathematical group, 9.67 (*SD* = 4.2), (*t* = 0.30, *df* = 95, *p* = 0.76).

4.6.1. Comparison between top quartile performers in logical thinking and computational mathematical groups

In accordance with the hypothesis, further t-test were performed to compare the scores and predictions of top quartile performers in Logical Thinking (*n* = 14) and Computational Mathematical (*n* = 17) groups.

TABLE 4.8 Scores and Predictions of Top Quartile Performers in Logical Thinking and Computational Mathematical Groups.

	Logical Thinking Group (SD)	Computational Mathematical Group (SD)	t-value	p
Mean Actual Score	11.43 (2.03)	10.65 (2.5)	0.94	0.35
Mean Ability Rating %	70.28% (13.98)	51.29% (15.9)	3.49	*0.002
Mean Relative Performance Rating %	57.14% (11.22)	53.24% (17.85)	0.71	0.48
Mean Predicted Score	12.93 (3.17)	11.06 (3.91)	1.44	0.16

*$p \leq 0.012$

As reported in Table 4.8 above, top performers in Logical Thinking group achieved a mean actual score of 11.43 (*SD* = 2.03), whereas top performers in Computational Mathematical group achieved mean actual scores of 10.65 (*SD* = 2.5). There was no significant difference between the mean actual score of top performers in each of the groups, (t = 0.94, df = 29, p = 0.35). There was however a significant difference between the mean ability rating of top quartile performers in the Logical Thinking group, 70.28% (*SD* = 13.98), and Computational Mathematical group, 51.29% (*SD* = 15.9), (t = 3.49, df = 29, $p \leq 0.012$). There was however no significant difference between the mean relative performance rating of top quartile performers in the Logical Thinking group, 57.14% (*SD* = 11.22), and the Computational Mathematical group, 53.24% (*SD* = 17.85), (t = 0.71, df = 29, p = 0.48). There was also no significant difference between the score rating of the top quartile performers in the Logical Thinking group, 12.93 (*SD* = 3.17), and the Computational Mathematical group, 11.06 (*SD* = 3.91), (t = 1.44, df = 29, p = 0.16).

4.6.2. Comparison between bottom quartile performers in logical thinking and computational mathematical groups

In accordance with the hypothesis, further t-tests were performed to compare the scores and predictions of bottom quartile performers in Logical Thinking (n = 14) and Computational Mathematical (n = 14) groups.

TABLE 4.9 Scores and Predictions of Bottom Quartile Performers in Logical Thinking and Computational Mathematical Groups.

	Logical Thinking Group (SD)	Computational Mathematical Group (SD)	t-value	p
Mean Actual Score	3.79 (1.19)	3.79 (0.98)	0.00	1.00
Mean Ability Rating %	62.71% (17.52)	47.79% (*SD* = 14.76)	2.44	0.02
Mean Relative Performance Rating %	36% (*SD* = 22.32)	40% (*SD* = 11.77)	0.59	0.56
Mean Predicted Score	7.29 (*SD* = 4.25)	10.14 (*SD* = 4.98)	1.63	0.11

*$p \leq 0.012$

As reported in Table 4.9 above, bottom quartile performers in Logical Thinking group achieved a mean actual score of 3.79 (*SD* = 1.19) and those in the Computational Mathematical group also achieved mean actual scores of 3.79 (*SD* = 0.98). There was therefore no significant difference between the mean actual score of bottom performers in each of the groups, (*t* = 0.00, *df* = 26, *p* = 1.00). There was also no significant difference between the mean ability rating of bottom quartile performers in the Logical Thinking group, 62.71% (*SD* = 17.53), and Computational Mathematical group, 47.79% (*SD* = 14.76), (*t* = 2.44, *df* = 26, *p* = 0.022). There was no significant difference between the mean relative performance rating of bottom quartile performers in the Logical Thinking group, 36% (*SD* = 22.32), and the Computational Mathematical group, 40% (*SD* = 11.77), (*t* = 0.59, *df* = 26, *p* = 0.56). There was also no significant difference between the score rating of the bottom quartile performers in the Logical Thinking group, 7.29 (*SD* = 4.25), and the Computational Mathematical group, 10.14 (*SD* = 4.98), (*t* = 1.63, *df* = 26, *p* = 0.11).

4.7. Chapter summary

The results of the statistical analyses conducted were reported in this chapter. The chapter was opened with a description of the sample followed by the descriptive statistics of the study including race and gender statistics. This was followed by a correlation analysis of the overall sample. Main effects and interaction between top and bottom quartile performers were then discussed in terms of how the actual score related to predictions of performance. The scores and predictions of the Logical Thinking and Computational Mathematical groups were compared, which found a significant difference between the ratings of ability of these two groups. Finally, the two groups of top quartile performers were compared, as were the two groups of bottom quartile performers, in terms of their scores and predictions of performance to find whether there was a significant difference between the two. The only significant difference found through these analyses was that between top performers in the Logical Thinking and Computational Mathematical groups, their ratings of ability were significantly different. A discussion of these results in line with the literature presented in chapter 2, as well as the implications and recommendations thereof, are presented in the following chapter (chapter 5).

CHAPTER 5:
DISCUSSION

5.1. Introduction

The aim of this study was to advance the current understanding of the Dunning-Kruger effect through testing an alternative account of the theory. In this chapter, the results provided in the previous chapter are discussed and interpreted in line with relevant literature.

5.2. Summary of study

The current theory of the Dunning-Kruger effect states that top performers possess greater metacognitive ability and thus make more accurate predictions of performance than bottom performers (Kruger & Dunning, 1999; Dunning, Johnson, Ehrlinger & Kruger, 2003; Dunning, 2011). There has, however, been research which shows that people tend to base their predictions of performance on preconceived notions of ability (Dunning, 2011; Dunning, Meyerowitz & Holzberg, 1989; Heine & Lehman, 1997; Kruger, 1999; Weinstein, 1980). Due to the tendency of people to hold above average preconceived notions of abilities, it would then be possible that top performers and bottom performers base their judgements on the same inflated preconceived notion of ability (Ehrlinger et al., 2009; Haun et al., 2000; Hoges, Regehr & Martin, 2001). Thus, in the case that all participants made judgements on above average preconceived notions of ability, top performers would seem to make accurate predictions as their actual performance would classify them as above average. Therefore, it was necessary to assess whether the difference in predictions of performance is due to metacognitive ability or preconceived notions of ability. This dissertation sought to discover the effect of preconceived notions of ability upon predictions of performance between top and bottom performers.

A study was designed in which two groups of participants were all administered a preparatory version of the LSAT test. One group was told the test measured Logical Thinking ability and the other group was told the test measured Computational Mathematical ability. The Logical Thinking group was expected to hold high preconceived notions of ability as people generally estimate their logical thinking ability as above average (Kruger & Dunning, 1999). The Computational

Mathematical group was expected to hold low preconceived notions of ability. All participants were asked to estimate their ability in the field of assessment, their relative performance and their actual attained score.
The following hypotheses were tested to find the effect of preconceived notions of ability on predictions of performance.

Hypothesis 1: The predictions of ability made by a group told they are taking a logical thinking test will be significantly higher than the predictions of ability made by a group told they are taking a computational mathematical test.

Hypothesis 2: Top quartile performers' predictions of ability, relative performance and raw score will be significantly higher when preconceived notion of ability is high than when preconceived notion of ability is low.

Hypothesis 3: Bottom quartile performers' predictions of ability, relative performance and raw score will be significantly higher when preconceived notion of ability is high than when preconceived notion of ability is low.

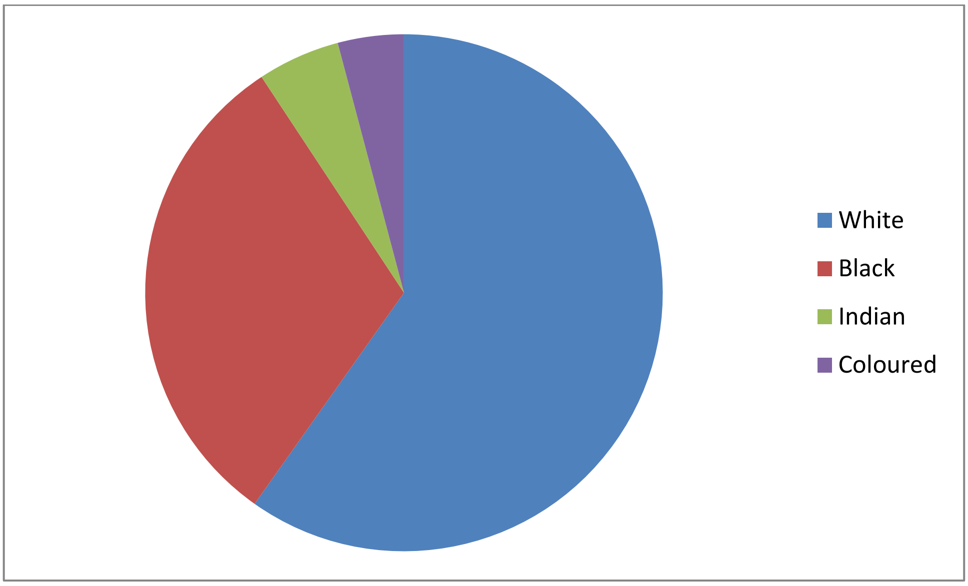
If these three hypotheses are correct, the theory that people place their predictions of relative performance and actual score on their preconceived notions of ability, which is their prediction of ability, will be shown to be true. Thus, the theory that top performers' metacognitive ability allows them to make more accurate predictions than bottom performers will be shown to be false. Alternatively, if neither of the second or third hypotheses is found to be correct, then the hypothesis that people base their predictions on preconceived notions of ability will be shown to be false. Thus, the theory that top performers' metacognitive ability allows them to make more accurate predictions than bottom performers will be shown to be correct.

5.3. Descriptive statistics in sample according to race and gender

5.3.1. Descriptive statistics according to race

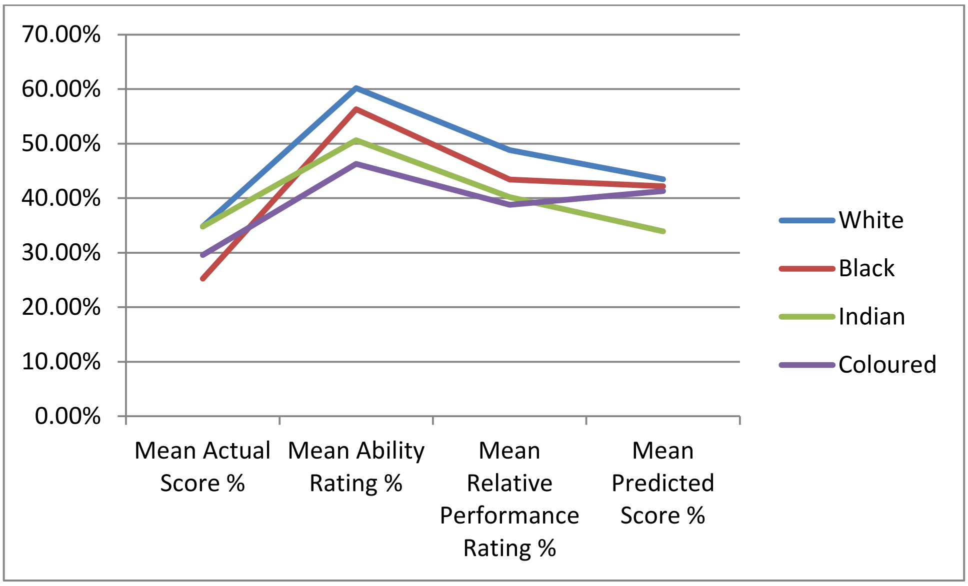
The overall sample was made up of 58 White participants, 30 Black participants, 5 Indian participants and 4 Coloured participants. The ratio of race groups is reported in Figure 5.3 below.

FIGURE 5.1 Ratio of Race of Participants in Overall Sample.



White and Indian participants achieved the highest average score of 8 whereas Black participants achieved the lowest mean score 5.8. This could mean that the test holds some cultural bias. White participants made the highest rating of overall ability with a mean ability rating of 60.2%. Coloured students made the lowest rating of ability of 46.3%. These scores include participants in both Logical Thinking and Computational Mathematical groups. Seeing as there were only 4 Coloured participants it is not possible to draw any inferences from this information. White participants however were the most confident in their overall ability. In terms of average ratings of relative performance White participants, once again made the highest predictions of performance to be 48.8%. Coloured participants, once again, made the lowest rating of their relative performance, estimating it to be 38.8. Once again White participants were the most confident in their relative performance. White participants, on average, predicted their score to be 10, once again having the highest estimates of performance. This time, Indian participants predicted their score to be 7.8, which was the lowest score rating on average. The mean scores and estimations of each racial group are reported below in Figure 5.4.

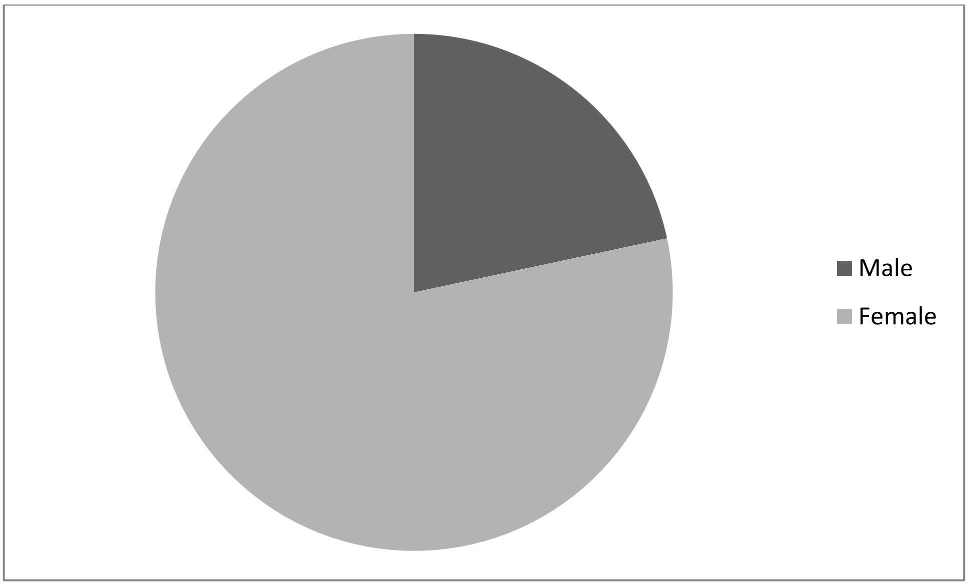
FIGURE 5.2 Mean Scores, Predictions of Ability, Relative Performance and Score of Each Racial Group.



5.3.2. Descriptive statistics according to gender

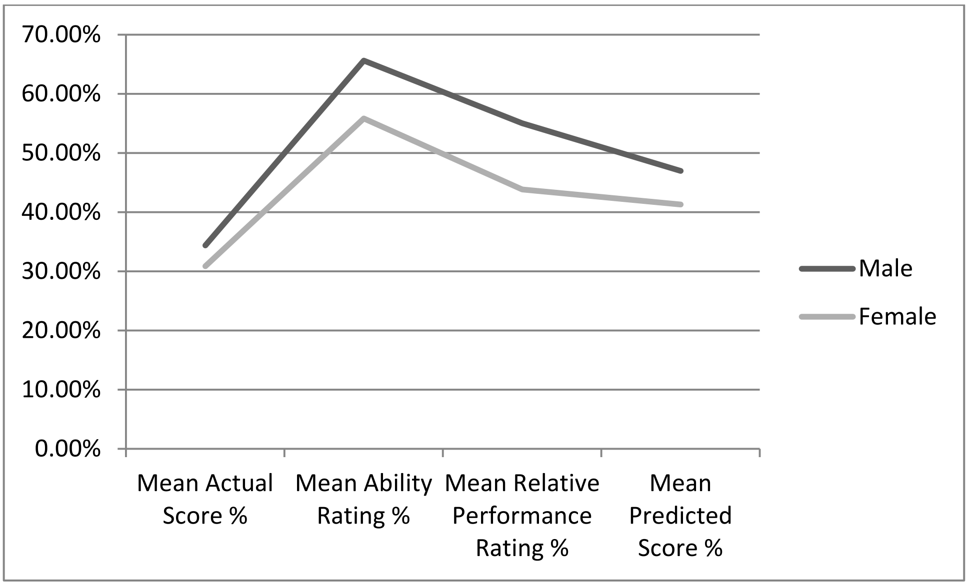
The overall sample consisted of 21 male participants and 76 female participants. The ratio of males to females is reported below in Figure 5.5.

FIGURE 5.3 Ratio of Male and Female Participants in Overall Sample.



Male participants on average achieved a score of 7.9 whereas female participants on average achieved a score of 7.1, thus males performed higher than females by only about 0.8 points. Male participants, on average, rated their ability to be 65.6% while female participants rated their ability to be 55.8% on average, this, however, comprises of participants from both Logical Thinking and Computational Mathematical groups. None the less, males rated their abilities almost 10% higher than females rated their abilities. Males also rated their relative performance to be 55% and females rated their relative performance to be 43.8%. Once again males made higher estimations of performance than females, with males making estimations of relative performance over 10% higher than females. Finally, males predicted their score to be 10.9 and females predicted their score to be 9.5. Males once again made higher predictions of performance than females, this time only by 1.4. The mean scores and estimations of each gender are reported below in Table 5.6.

FIGURE 5.4 Mean Scores, Predictions of Ability, Relative Performance and Score of Male and Female Participants.



5.4. Discussion of results

The results of the t-test were performed to compare the scores and predictions of Logical Thinking and Computational Mathematical groups will be discussed here as they are most relevant to our hypotheses. These results can be found in Section 4.6, above.

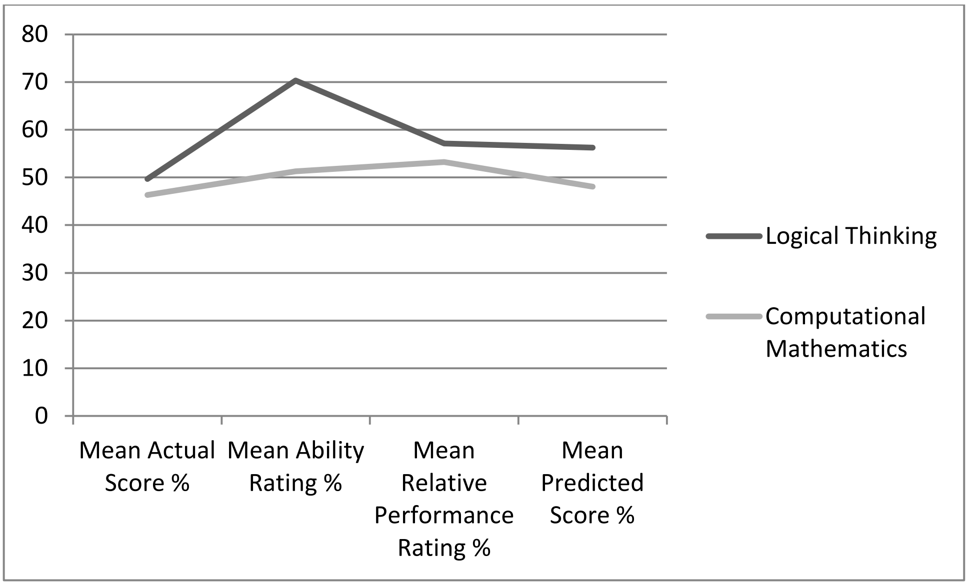
5.4.1. Ability rating of logical thinking group and computational mathematical group

The Logical Thinking group, on average, rated their ability to be 67.1% whereas the Computational Mathematical group rated their ability to be 48.5%. A t-test revealed a significant difference between the estimations of the two groups. The Logical Thinking group estimated their ability to be above average, whereas the Computational Mathematical group rated their ability to below average. This confirms our first hypothesis in that the preconceived notions of ability were different for each group. It is therefore assumed that the two groups held significantly different preconceived notions of ability. Therefore, if the two groups of top performers have significantly different estimations of; ability, relative performance and actual score, from one another then it will be concluded that top performers base their estimations of performance on preconceived notions of ability. Similarly, if the two groups of bottom quartile performers have significantly different estimations of; ability, relative performance and actual score, from one another then it will be concluded that bottom performers base their estimations of performance on preconceived notions of ability.

5.4.2. Top performers in logical thinking group and computational mathematical group compared

Scores and predictions of top quartile participants can be seen in Figure 5.1 below. The t-tests used to compare the scores and predictions of the two groups of top quartile performers found no significant difference between the mean actual score of top performers in each of the groups. This means that despite the two groups being told they were being tested on different domains of ability, there was no significant change in their score. There was however a significant difference between the mean ability rating of top quartile performers in the Logical Thinking and the Computational Mathematical group. Top performers in the Logical Thinking group estimated their logical thinking ability significantly higher than top quartile performers in the Computational Mathematical group rated their computational mathematical ability. The two groups therefore held significantly different preconceived notions of ability. However, there was no significant difference between the mean relative performance rating of top quartile performers in the Logical Thinking group and Computational Mathematical group. Nor was there a significant difference between the score rating of the top quartile performers in the Logical Thinking group and the Computational Mathematical group. This means that top quartile performers' estimations of performance were not affected by their preconceived notions of ability. These results show that top quartile performers do not base their predictions of performance on preconceived notions of ability.

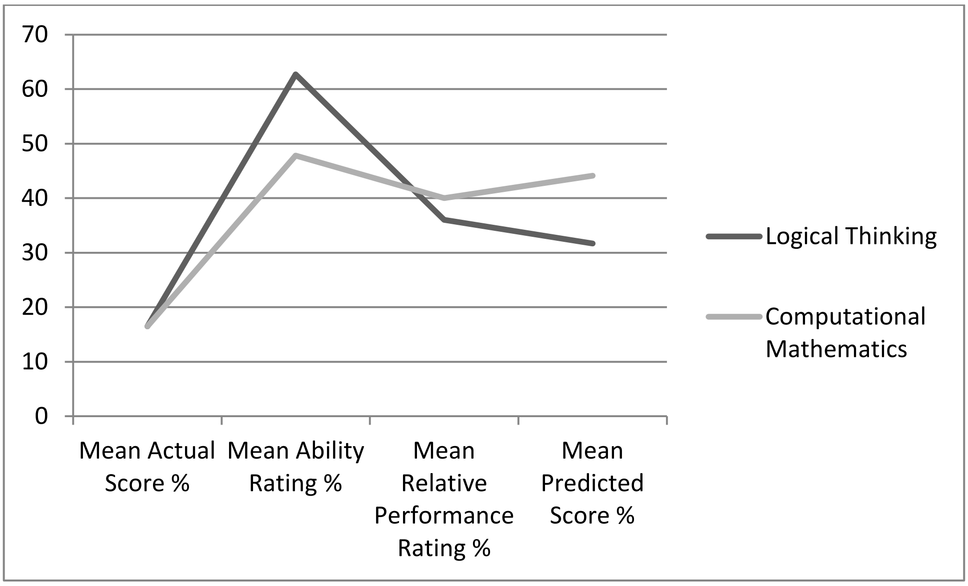
FIGURE 5.5 Scores and Predictions of Top Performers from Logical Thinking and Computational Mathematical Group.



5.4.3. Bottom performers in logical thinking group and computational mathematical group compared

Scores and predictions of bottom quartile participants can be seen in Figure 5.2 below. The t-tests used to compare the scores and predictions of the two groups of bottom quartile performers found no significant difference between the mean actual score of bottom performers in each of the groups. This means that despite the two groups being told they were being tested on different domains of ability, there was no significant change in their score. There was, in this case, not a significant difference between the mean ability rating of bottom quartile performers in the Logical Thinking and the Computational Mathematical group. Therefore, bottom quartile performers in the Logical Thinking group's rating of logical thinking ability was not significantly different from bottom quartile performers in the Computational Mathematical groups' rating of computational mathematical ability. This means that there was not a significant difference between the preconceived notions of ability held by the two groups of bottom quartile performers. Similarly, there was no significant difference between the mean relative performance rating of bottom quartile performers in the Logical Thinking group and Computational Mathematical group. Nor was there a significant difference between the score rating of the bottom quartile performers in the Logical Thinking group and the Computational Mathematical group. Since there was not a significant difference between the preconceived notions of performance, it is not known whether bottom performers based their predictions of performance on preconceived notions of ability. As it could not be shown that bottom quartile performers base their predictions of performance on preconceived notions of ability, the null hypothesis should be accepted and thus, bottom quartile performers do not base predictions of performance on preconceived notions of ability.

FIGURE 5.6 Mean Scores, Predictions of Ability, Relative Performance and Score of Logical Thinking and Computational Mathematical Groups.



5.5. Actual performance compared to predictions of performance for logical thinking group and computational mathematical group.

After testing all hypotheses further statistical analysis was done to find whether any other significant results could be found. Top and bottom quartile performers were compared with one another in each of the groups to find whether there was a significant difference between the accuracy of their predictions.

5.5.1. Logical thinking group

The top quartile for the Logical Thinking group rated their logical thinking ability as 70.29%, which was significantly higher than their actual score of 49.69%. The bottom quartile of this group rated their logical thinking ability to be 62.71%, which also was significantly higher than their actual score of 16.46%. Thus, both top and bottom quartiles rated their ability as being higher than their actual performance. This does not necessarily reflect inaccurate prediction as the actual score is not an accurate reflection of logical thinking ability.

The top quartile rated their relative performance as 57.14%, which was not significantly different from their actual relative performance of 49.69%. The bottom quartile, however, significantly overestimated their relative performance to be 36%, while their actual relative performance was 16.46%. The top performers thus made a more accurate prediction of their relative performance than did bottom quartile performers with bottom performers overestimating their relative performance. This pattern is typical of Dunning-Kruger effect.

The top quartile participants predicted their score to be 56.21%, which was not significantly different from their actual score of 49.69%. The bottom quartile participants significantly overestimated their score to be 31.68%, whereas their actual score was 16.46%. Once again the top quartile performers made more accurate predictions of their performance while bottom quartile performers overestimated their actual score. This, too, is typical of Dunning-Kruger studies.

5.5.2. Computational mathematical group

For the Computational Mathematical group, top quartile performers estimated their mathematical computational ability to be 51.29%, which was not significantly different from their actual score of 46.29%. The bottom quartile of this group predicted their computational mathematical ability to be, 47.79%, which was significantly higher than their actual score of 16.46%. This does not indicate accuracy of prediction as this test did not measure computational mathematical ability.

The top quartile predicted their relative performance to be 53.24%, which was not significantly higher than their actual score of 46.29%. The bottom quartile overrated their relative performance to be, 40%, whereas it was actually 16.46%. The top performers thus made a more accurate prediction of their relative performance than did bottom quartile performers with bottom performers overestimating their relative performance. This, as in the Logical Thinking group, is typical of Dunning-Kruger experiments.

Top quartile performers predicted their score to be 48.08% which was quite accurate compared to their actual score of 46.29%. The bottom quartile of this overestimated their actual score as, 44.10%, while it was actually 16.46%. Once again the top quartile performers made more accurate predictions of their performance while bottom quartile performers overestimated their actual score. This pattern is also typical of the Dunning-Kruger effect.

5.6. Correlation analysis of overall sample.

In the overall sample, the mean actual score was significantly correlated to the mean rating of relative performance as well as with the mean score predicted but not with their rating of ability. This means that the higher one scored the higher one's predictions of relative performance and score were. Similarly the lower one scored, the lower their predictions of relative performance and score were. This was not the case with predictions of ability, possibly because of the overall group includes both participants asked to estimate their logical thinking ability as well as participants asked to estimate their computational mathematical ability. Interestingly, estimated ability correlated significantly with ratings of relative performance and also with predicted score. This means that the higher one predicts their ability the higher they will predict their relative performance and score and the same is true for the opposite. Participants' rating of relative performance was also significantly correlated to predictions of score. Meaning that the higher one's rating of relative performance, the higher their estimated score and the lower one's rating of relative performance, the lower their estimated score.

5.7. Answers to research question and hypotheses

The purpose of this study was to find whether predictions of performance were based on preconceived notions of ability or on metacognitive ability. To test this, two groups were told they were being assessed in different domains of ability, but given the same test. One group was told their logical thinking ability was being assessed whereas the other was told their computational mathematical ability was being assessed. Participants in both groups were asked to estimate their ability in the domain being assessed, their performance relative to the other participants and their score. Through manipulating the preconceived notions of ability of the two groups it was possible to see whether the two groups made significantly different predictions of performance. This would be particularly relevant in the case of top and bottom performers as previous studies have shown that top performers make more accurate predictions of performance than bottom performers because of their higher metacognitive ability. However, if top performers' predictions were shown to be based on preconceived notions of ability then the theory that top performers judged their predictions of performance by their metacognitive ability would be shown to be incorrect. Similarly if bottom performers' predictions of performance were shown to depend on their preconceived notions of ability, then the theory of them judging their predictions of performance on preconceived notions of ability would be shown to be incorrect. The following hypotheses were tested to find whether predictions of performance of top and bottom performers were based on preconceived notions of ability of metacognitive ability.

5.7.1. Hypothesis 1

It was hypothesised that the predictions of ability made by a group told they are taking a logical thinking test will be significantly greater than the predictions of ability made by a group told they are taking a computational mathematical test. This hypothesis was shown to be correct as participants in the logical thinking group rated their ability to be significantly higher than participants in the computational mathematical group rated their ability.

5.7.2. Hypothesis 2

It was further hypothesised that top quartile performers' predictions of ability, relative performance and raw score would be significantly higher when preconceived notion of ability is high than when preconceived notion of ability is low. The prediction of ability was found to be significantly higher in top quartile performers in the Logical Thinking group compared to the top quartile performers in the Computational Mathematical group. However, there was no significant difference between the predictions of relative performance and score between top quartile performers in the

Logical Thinking group and the Computational Mathematical group. This means that this hypothesis was found to be incorrect. Top quartile performers' predictions of performance were, thus, found to not be based on preconceived notions of ability.

5.7.3. Hypothesis 3

Finally, it was hypothesised that bottom quartile performers' predictions of ability, relative performance and raw score would be significantly higher when preconceived notion of ability is high than when preconceived notion of ability is low. Neither the predictions of ability, relative performance or score were found to be significantly different between the group of bottom quartile performers in the Logical Thinking group and the Computational Mathematical group. Thus, the bottom quartile groups were not shown to hold significantly different estimations of ability. This is possibly a sign of them basing their preconceived notion of ability on their experience of the test. Since, the two groups of bottom performers did not hold significantly different preconceived notions of ability, this study cannot conclude whether bottom performers based their predictions of performance on preconceived notions of ability. This hypothesis was not proven correct and is therefore assumed incorrect until proven otherwise.

5.8. Limitations

The most apparent limitation of this study is the fact that bottom quartile performers' estimations of ability in the Logical Thinking group were not significantly different from the estimation of ability in the Computational Mathematical group. This means that the 3rd hypothesis could not be accurately assessed to find whether bottom quartile performers base predictions of performance on preconceived notions of ability.

Furthermore, the difficulty of the test used in this study may have influenced the predictions of ability and performance. Of the 23 questions, the average score was 7.3, indicating a very challenging test. Furthermore the mean relative performance of the overall group was 46.3 and the mean predicted score was 9.8. A study by Kruger (1999), showed that of a group of 37 university students, tended to rate themselves as above average in ability domains perceived to be easy and rated themselves as below average in ability domains perceived to be difficult. However, top quartile performers still made more accurate predictions of performance than bottom quartile performers. Therefore the difficulty of the chosen test did not disrupt the presence of the Dunning-Kruger effect.

The sampling method used in this study is one of the further potential limitations. Since convenience sampling is a non-probability sampling technique, there was an inherent bias that the sample was not representative of the general population. This is likely as the sample was comprised of university students. This is typical of the majority of studies on the Dunning-Kruger effect.

5.9. Recommendations for future research

Future studies in the field of the Dunning-Kruger effect could attempt to broaden the diversity of the sample to not only university students. A more conclusive sample could be gathered through including a wider age group and a bigger representation of from other racial groups.

Furthermore, there appears to have been some difference in the performance and estimations of ability and performance between males and females, as well as between the different racial groups. A further study may focus on the effect of gender and race on predictions of performance. It may be found that certain biases exist in the predictions of ability and performance of certain races or genders depending on the domain of ability being assessed. An example of such a study would be the previously discussed in Dunning et al (2003), where women were shown to rate themselves as less scientifically and mathematically talented than males.

5.10. Conclusion

The results of the present study have shown that manipulations of preconceived notions of ability do not affect predictions of performance in top or bottom performers. Furthermore, the presence of the typical Dunning-Kruger effect was shown to be present in both the groups, regardless of the domain of ability they believed the test to be measuring. This leads to the conclusion that the current theory of the Dunning-Kruger effect in which; top performers base their predictions of performance on their superior metacognitive ability which allows them to make more accurate predictions than bottom performers, who possess inferior metacognitive ability, is true.

REFERENCES

Alicke, M. D. (1985). Global self-evaluation as determined by the desirability and controllability of trait adjectives. *Journal of Personality and Social Psychology*, *49(6)*, 1621–1630.

Brown, J. D. (1992). Coming to terms with failure: Private self-enhancement and public self-effacement. *Journal of Experimental Social Psychology, 28,* 3-22.

Burson, K. A., Larrick, R. P., & Klayman, J. Skilled or unskilled, but still unaware of it: How perceptions of difficulty drive miscalibration in relative comparisons. *Journal of Personality and Social Psychology, 90, 60-77.*

Ceci, S. J., Williams, W. M., & Barnett, S. M. (2009). Women's underrepresentation in science: Sociocultural and biological considerations. *Psychological Bulletin*, *135(2)*, 218-261.

Dunning, D. (2005). *Self-insight: Roadblocks and detours on the path to knowing thyself*. New York: Psychology Press.

Dunning, D. (2011). The Dunning-Kruger effect: On being ignorant of one's own ignorance. In J. Olson & M. P. Zanna (Eds.), Advances in experimental social psychology (vol. 44, pp. 247-296). New York: Elsevier.

Dunning, D., Johnson, K., Ehrlinger, J. & Kruger, J. (2003). Why people fail to recognize their own incompetence. *Current Directions in Psychological Science*, *12(3)*, 83-87.

Dunning, D., Meyerowitz, J. A., & Holzberg, A. D. (1989). Ambiguity and self-evaluation: The role of idiosyncratic trait definitions in self-serving assessments of ability. *Journal of Personality and Social Psychology*, *57(6)*, 1082–1090.

Eccles, J. S. (1994). Understanding women's educational and occupational choices: Applying the Eccles et al., model of achievement-related choices. *Psychology of Women Quarterly*, *18(4)*, 585–609.

Ehrlinger, J., & Dunning, D. (2003). How chronic self-views influence (and potentially mislead) assessments of performance. *Journal of Personality and Social Psychology*, *84(1)*, 5–17.

Everson, H. T., & Tobias, S. (1998). The ability to estimate knowledge and performance in college: A metacognitive analysis. *Instructional Science*, *26(1-2)*, 65–79.

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. *American Psychologist*, *34(10)*, 906-911.

Gravetter, F. J. & Wallnau, L. B., (2007). *Statistics For The Behavioral Sciences*. 7th ed. Belmont, CA: Thompson publishing.

Haun, D.E, Zeringue, A., Leach, A., & Foley, A. (2000). Assessing the competence of specimen processing personnel. *Labaratory Medicine*, 31, 633-637.

Heine, S. J., & Lehman, D. R. (1997). The cultural construction of self enhancement: An examination of group-serving biases. *Journal of Personality and Social Psychology*, *72(6)*, 1268-1283.

Heine, S. J., Lehman, D. R. Markus, H. R., & Kitayama, S. (1999). Is there a universal need for positive self regard? *Psychological Review, 106(4)*, 766-794.

Hogarth, R. (1999) The effects of financial incentives in experiments: A review and capital-labor production framework. *Journal of Risk and Uncertainty,* 19, 7-42.

Krueger, J., & Mueller R. A. (2002). Unskilled, unaware, or both? The contribution of social-perceptual skills and statistical regression to self-enhancement biases. *Journal of Personality and Social Psychology*, 82, 180-188.

Kruger, J. (1999). Lake Wobegone be gone! The “below-average effect” and the egocentric nature of comparative ability judgements. *Journal of Personality and Social Psychology*, *77(2)*, 221-232.

Kruger, J., & Dunning, D. (1999). Unskilled and unaware of it: How difficulties in recognizing one’s own competence lead to inflated self-assessments. *Journal of Personality and Social Psychology*, *77(6)*, 1121-1134.

Law School Administration Council. (2007, July). The official LSAT preptest. Retreived from http://www.lsac.org/docs/default-source/jd-docs/sampleptjune.pdf

Livingston, J. A. (1997). *Metacognition: An Overview.* [ONLINE] Available at: http://gse.buffalo.edu/fas/shuell/cep564/Metacog.htm. [Last Accessed 21 May 2012].

Nielsen-Bohlman, L., Panzer, A. M., & Kindig, D. A. (2004). *Health literacy: A prescription to end confusion*. Washington, DC: Institute of Medicine.

Paulhus, D. L. (1998). Interpersonal vs. intrapsychic adaptiveness of trait self-enhancement: A mixed blessing? *Journal of Personality and Social Psychology, 74(5)*, 1197-1208.

Sedikides, C., Berbst, K. C., Harding, D. P., & Daris G. J. (2002). Accountability as a deterrent to self-enhancement: The search for mechanisms. *Journal of Personality and Social Psychology, 83,* 592-605.

Taylor, S. E., & Brown, J. D. (1988). Illusion and well being: A social psychological perspective on mental health. *Psychological Bulletin, 103(2)*, 193-210.

Weinstein, N. D. (1980). Unrealistic optimism about future life events. *Journal of Personality and Social Psychology*, *58(5)*, 806–820.

APPENDIX A: PERMISSION DOCUMENTS

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Humanities
Office of the Deputy Dean

1 October 2012

Dear Prof Maree

Project:	**You're not as smart as you think: an alternative account of the Dunning-Kruger effect**
Researcher:	**T Nunes**
Supervisor:	**Prof D Maree**
Department:	**Psychology**
Reference:	**10455508**

The above application was **approved (with comment)** by the **Postgraduate Committee** on 11 September 2012. The application was reviewed by the **Research Ethics Committee** on 27 September 2012, and is pending a decision due to the following:

- The questionnaire is outstanding
- Permission from the Registrar is required as students will be involved.

Once the questionnaire is submitted, the application will be forwarded to the Registrar for recommendation. Please note that data collection may not commence prior to final approval by this committee. To facilitate the administrative process, please respond to Ms Tracey Andrew, Room HB 7-27, at your earliest possible convenience.

Sincerely

Prof. John Sharp
Chair: Postgraduate Committee &
Research Ethics Committee
Faculty of Humanities
UNIVERSITY OF PRETORIA
e-mail: john.sharp@up.ac.za

APPENDIX B: INSTRUMENTS

Student Number: ______________

Race: _______________

Gender: ________

Age: ____

I hereby grant permission to the researcher, Mr T. Nunes, to use the data I have supplied as part of his research project. I agree that none of my personal information will be shared and understand that I may decide to from this this study at any time and have absolute right to do so. Furthermore if I wish to receive further information about the research and results I will include my e-mail address and the researcher will contact me upon the completion of his study. Any further queries I have will be directed to the researcher via his phone number, which he provided me.

Signed: ____________________ on ____/____/_____

DO NOT TURN PAGE UNTIL INSTRUCTED TO DO SO

SECTION I

Time—35 minutes

23 Questions

Directions: Each group of questions in this section is based on a set of conditions. In answering some of the questions, it may be useful to draw a rough diagram. Choose the response that most accurately and completely answers each question and blacken the corresponding space on your answer sheet.

Questions 1–5

A company employee generates a series of five-digit product codes in accordance with the following rules:

The codes use the digits 0, 1, 2, 3, and 4, and no others.
Each digit occurs exactly once in any code.
The second digit has a value exactly twice that of the first digit.
The value of the third digit is less than the value of the fifth digit.

1. If the last digit of an acceptable product code is 1, it must be true that the

(A) first digit is 2
(B) second digit is 0
(C) third digit is 3
(D) fourth digit is 4
(E) fourth digit is 0

2. Which one of the following must be true about any acceptable product code?

(A) The digit 1 appears in some position before the digit 2.
(B) The digit 1 appears in some position before the digit 3.
(C) The digit 2 appears in some position before the digit 3.
(D) The digit 3 appears in some position before the digit 0.
(E) The digit 4 appears in some position before the digit 3.

3. If the third digit of an acceptable product code is not 0, which one of the following must be true?

(A) The second digit of the product code is 2.
(B) The third digit of the product code is 3.
(C) The fourth digit of the product code is 0.
(D) The fifth digit of the product code is 3.
(E) The fifth digit of the product code is 1.

4. Any of the following pairs could be the third and fourth digits, respectively, of an acceptable product code, EXCEPT:

(A) 0, 1
(B) 0, 3
(C) 1, 0
(D) 3, 0
(E) 3, 4

5. Which one of the following must be true about any acceptable product code?

(A) There is exactly one digit between the digit 0 and the digit 1.
(B) There is exactly one digit between the digit 1 and the digit 2.
(C) There are at most two digits between the digit 1 and the digit 3.
(D) There are at most two digits between the digit 2 and the digit 3.
(E) There are at most two digits between the digit 2 and the digit 4.

GO ON TO THE NEXT PAGE.

Questions 6–10

Exactly three films—*Greed*, *Harvest*, and *Limelight*—are shown during a film club's festival held on Thursday, Friday, and Saturday. Each film is shown at least once during the festival but never more than once on a given day. On each day at least one film is shown. Films are shown one at a time. The following conditions apply:

On Thursday *Harvest* is shown, and no film is shown after it on that day.

On Friday either *Greed* or *Limelight*, but not both, is shown, and no film is shown after it on that day.

On Saturday either *Greed* or *Harvest*, but not both, is shown, and no film is shown after it on that day.

6. Which one of the following could be a complete and accurate description of the order in which the films are shown at the festival?

(A) Thursday: *Limelight*, then *Harvest*; Friday: *Limelight*; Saturday: *Harvest*
(B) Thursday: *Harvest*; Friday: *Greed*, then *Limelight*; Saturday: *Limelight*, then *Greed*
(C) Thursday: *Harvest*; Friday: *Limelight*; Saturday: *Limelight*, then *Greed*
(D) Thursday: *Greed*, then *Harvest*, then *Limelight*; Friday: *Limelight*; Saturday: *Greed*
(E) Thursday: *Greed*, then *Harvest*; Friday: *Limelight*, then *Harvest*; Saturday: *Harvest*

7. Which one of the following CANNOT be true?

(A) *Harvest* is the last film shown on each day of the festival.
(B) *Limelight* is shown on each day of the festival.
(C) *Greed* is shown second on each day of the festival.
(D) A different film is shown first on each day of the festival.
(E) A different film is shown last on each day of the festival.

8. If *Limelight* is never shown again during the festival once *Greed* is shown, then which one of the following is the maximum number of film showings that could occur during the festival?

(A) three
(B) four
(C) five
(D) six
(E) seven

9. If *Greed* is shown exactly three times, *Harvest* is shown exactly twice, and *Limelight* is shown exactly once, then which one of the following must be true?

(A) All three films are shown on Thursday.
(B) Exactly two films are shown on Saturday.
(C) *Limelight* and *Harvest* are both shown on Thursday.
(D) *Greed* is the only film shown on Saturday.
(E) *Harvest* and *Greed* are both shown on Friday.

10. If *Limelight* is shown exactly three times, *Harvest* is shown exactly twice, and *Greed* is shown exactly once, then which one of the following is a complete and accurate list of the films that could be the first film shown on Thursday?

(A) *Harvest*
(B) *Limelight*
(C) *Greed*, *Harvest*
(D) *Greed*, *Limelight*
(E) *Greed*, *Harvest*, *Limelight*

GO ON TO THE NEXT PAGE.

Questions 11–17

A cruise line is scheduling seven week-long voyages for the ship *Freedom*. Each voyage will occur in exactly one of the first seven weeks of the season: weeks 1 through 7. Each voyage will be to exactly one of four destinations: Guadeloupe, Jamaica, Martinique, or Trinidad. Each destination will be scheduled for at least one of the weeks. The following conditions apply to *Freedom*'s schedule:

Jamaica will not be its destination in week 4.
Trinidad will be its destination in week 7.
Freedom will make exactly two voyages to Martinique, and at least one voyage to Guadeloupe will occur in some week between those two voyages.
Guadeloupe will be its destination in the week preceding any voyage it makes to Jamaica.
No destination will be scheduled for consecutive weeks.

11. Which one of the following is an acceptable schedule of destinations for *Freedom*, in order from week 1 through week 7?
    (A) Guadeloupe, Jamaica, Martinique, Trinidad, Guadeloupe, Martinique, Trinidad
    (B) Guadeloupe, Martinique, Trinidad, Martinique, Guadeloupe, Jamaica, Trinidad
    (C) Jamaica, Martinique, Guadeloupe, Martinique, Guadeloupe, Jamaica, Trinidad
    (D) Martinique, Trinidad, Guadeloupe, Jamaica, Martinique, Guadeloupe, Trinidad
    (E) Martinique, Trinidad, Guadeloupe, Trinidad, Guadeloupe, Jamaica, Martinique

12. Which one of the following CANNOT be true about *Freedom*'s schedule of voyages?
    (A) *Freedom* makes a voyage to Trinidad in week 6.
    (B) *Freedom* makes a voyage to Martinique in week 5.
    (C) *Freedom* makes a voyage to Jamaica in week 6.
    (D) *Freedom* makes a voyage to Jamaica in week 3.
    (E) *Freedom* makes a voyage to Guadeloupe in week 3.

13. If *Freedom* makes a voyage to Trinidad in week 5, which one of the following could be true?
    (A) *Freedom* makes a voyage to Trinidad in week 1.
    (B) *Freedom* makes a voyage to Martinique in week 2.
    (C) *Freedom* makes a voyage to Guadeloupe in

14. If *Freedom* makes a voyage to Guadeloupe in week 1 and a voyage to Jamaica in week 5, which one of the following must be true?
    (A) *Freedom* makes a voyage to Jamaica in week 2.
    (B) *Freedom* makes a voyage to Trinidad in week 2.
    (C) *Freedom* makes a voyage to Martinique in week 3.
    (D) *Freedom* makes a voyage to Guadeloupe in week 6.
    (E) *Freedom* makes a voyage to Martinique in week 6.

15. If *Freedom* makes a voyage to Guadeloupe in week 1 and to Trinidad in week 2, which one of the following must be true?
    (A) *Freedom* makes a voyage to Martinique in week 3.
    (B) *Freedom* makes a voyage to Martinique in week 4.
    (C) *Freedom* makes a voyage to Martinique in week 5.
    (D) *Freedom* makes a voyage to Guadeloupe in week 3.
    (E) *Freedom* makes a voyage to Guadeloupe in week 5.

16. If *Freedom* makes a voyage to Martinique in week 3, which one of the following could be an accurate list of *Freedom*'s destinations in week 4 and week 5, respectively?
    (A) Guadeloupe, Trinidad
    (B) Jamaica, Guadeloupe
    (C) Martinique, Trinidad
    (D) Trinidad, Jamaica
    (E) Trinidad, Martinique

17. Which one of the following must be true about *Freedom*'s schedule of voyages?
    (A) *Freedom* makes a voyage to Guadeloupe either in week 1 or else in week 2.
    (B) *Freedom* makes a voyage to Martinique either in week 2 or else in week 3.
    (C) *Freedom* makes at most two voyages to Guadeloupe.
    (D) *Freedom* makes at most two voyages to Jamaica.
    (E) *Freedom* makes at most two voyages to Trinidad

Questions 18–23

There are exactly three recycling centers in Rivertown: Center 1, Center 2, and Center 3. Exactly five kinds of material are recycled at these recycling centers: glass, newsprint, plastic, tin, and wood. Each recycling center recycles at least two but no more than three of these kinds of material. The following conditions must hold:

Any recycling center that recycles wood also recycles newsprint.

Every kind of material that Center 2 recycles is also recycled at Center 1.

Only one of the recycling centers recycles plastic, and that recycling center does not recycle glass.

18. Which one of the following could be an accurate account of all the kinds of material recycled at each recycling center in Rivertown?

(A) Center 1: newsprint, plastic, wood; Center 2: newsprint, wood; Center 3: glass, tin, wood
(B) Center 1: glass, newsprint, tin; Center 2: glass, newsprint, tin; Center 3: newsprint, plastic, wood
(C) Center 1: glass, newsprint, wood; Center 2: glass, newsprint, tin; Center 3: plastic, tin
(D) Center 1: glass, plastic, tin; Center 2: glass, tin; Center 3: newsprint, wood
(E) Center 1: newsprint, plastic, wood; Center 2: newsprint, plastic, wood; Center 3: glass, newsprint, tin

19. Which one of the following is a complete and accurate list of the recycling centers in Rivertown any one of which could recycle plastic?

(A) Center 1 only
(B) Center 3 only
(C) Center 1, Center 2
(D) Center 1, Center 3
(E) Center 1, Center 2, Center 3

20. If Center 2 recycles three kinds of material, then which one of the following kinds of material must Center 3 recycle?

(A) glass
(B) newsprint
(C) plastic
(D) tin
(E) wood

21. If each recycling center in Rivertown recycles exactly three kinds of material, then which one of the following could be true?

(A) Only Center 2 recycles glass.
(B) Only Center 3 recycles newsprint.
(C) Only Center 1 recycles plastic.
(D) Only Center 3 recycles tin.
(E) Only Center 1 recycles wood.

22. If Center 3 recycles glass, then which one of the following kinds of material must Center 2 recycle?

(A) glass
(B) newsprint
(C) plastic
(D) tin
(E) wood

23. If Center 1 is the only recycling center that recycles wood, then which one of the following could be a complete and accurate list of the kinds of material that one of the recycling centers recycles?

(A) plastic, tin
(B) newsprint, wood
(C) newsprint, tin
(D) glass, wood
(E) glass, tin

S T O P

IF YOU FINISH BEFORE TIME IS CALLED, YOU MAY CHECK YOUR WORK ON THIS SECTION ONLY. DO NOT WORK ON ANY OTHER SECTION IN THE TEST.

SECTION II

1. How would you rate your Logical Thinking ability on scale of 0% to 100%?

____

2. How would you rate your performance on this test compared to your peers on a scale of 0% to 100%?

____

3. How many questions do you believe you answered correctly of the 23?

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If you have any further questions please write them here:

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Please provide an e-mail wherein I can respond to your question(s).

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END

SECTION II

1. How would you rate your Computational Mathematical ability on scale of 0% to 100%?

____

2. How would you rate your performance on this test compared to your peers on a scale of 0% to 100%?

____

3. How many questions do you believe you answered correctly of the 23?

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If you have any further questions please write them here:

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