INTEGRATING PHYSICS AND PHYSICAL EDUCATION: EFFECTS ON HIGH SCHOOL STUDENTS' LEARNING

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Abstract

The interdisciplinary approach has risen in the modern curricula as it is considered an important and challenging technique. Integrating core subjects with physical activity can be very beneficial to student learners in all levels of Education. This research not only includes contributions from different disciplines, but also focuses on theoretical work and empirical evidence from Physics and Physical Education, in an attempt to identify how the method of interdisciplinary within the teaching and learning process between Physics and Physical Education could be effective in student learning.

Specifically, the purpose of the present study was to investigate how the interdisciplinary approach between Physics and Physical Education could–improve high school students' conceptual understanding in the field of "Forces"; stretch, friction/stopping distance, air resistance, up thrust, and weight, as well as performance in P.E.: transfer of ball, air resistance, flexibility, aerobic exercise, energy balance/Body Mass Index. A total of 147 hypotheses were examined. Hypotheses 1 to 83 examined each individual question of PHYSICS knowledge test, while Hypotheses 94 to 123 examined the question groups belonging to each PHYSICS subtopic. Hypotheses 84 to 93 and 114 to 133 were focused on P.E. fields test activities. Hypotheses 134 to 147 involved the aggregation of all question variables for PHYSICS and P.E. to assess the potential impact of group and gender variables on each.

The entire experimental project, on which the empirical quantitative research was based, lasted 16 weeks, and was carried out in three private schools located in different regions around Cyprus and owned by the same company. It involved a particular sample of 180 7th-grade 13-year-old students equally divided into two groups: the experimental (n=90) and the control group (n=90). The specific age group was selected because of the same background that the children had in elementary schools. During this period, an 80-minute teaching period was dedicated twice a week on Physics and once a week on Physical Education. The experimental group went through the procedure of the interdisciplinary learning, according to which Physics was taught through examples and activities of Physical Education and vice versa. On the contrary, the control group followed the default syllabus.

For the evaluation of cognitive understanding in Physics a questionnaire was created with 5 factors representing the five subtopics, and 50 questions. Through the process of performing a reliability test and calculating the difficulty and discrimination indices, 39 questions remained in the final version of the questionnaire of Physics knowledge test. On the other hand, for the evaluation of performance in Physical Education, a test was given to students, involving five multiple choice questions, which also required answer justification.

Several statistical methods and tests, including correlations, cross-tabulation, t-tests and three-way repeated measures General Linear Model (GLM) were used for data analysis. Based on the results, there was a significant improvement in the experimental group students' performance and understanding between "pre" and "post" phases of the trial, regarding 32 out of 42 questions in the Physics Knowledge Test. A distinctive examination of students' overall performance in each Physics subtopic per test group (experimental – control) and per trial phase (pre – post) showed that the experimental group students significantly outperformed the control group students in subtopics 1 – 4, regarding "Friction/Stopping Distance", "Air Resistance", "Up Thrust" and "Stretch", while there was no significant difference between the two groups in subtopic 5 regarding "Weight/Gravity". On the other hand, in the post-trial test, students from the experimental group had a significantly better overall performance in all five subtopics. The same conclusion was reached when investigating the impact of group on the overall performance of students in the Physics' topic of Forces. In other words, experimental group students had a significantly more improved overall performance than control group students in the Physics' topic of Forces. Also, the experimental group had a significantly better improvement than the control group in the P.E. subtopics "Transfer of the Ball" and "Air Resistance", and "Energy Balance/Body Mass Index". On the contrary, there was no significant difference between the performances of two genders in any of the disciplines' subtopics, in any measure.

It seems that through the interdisciplinary approach, more clear processes and rules are attained, favoring the real understanding and consolidation of notions which often remain more vague when delivered in a "traditional learning environment".

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I. Introduction

1.1. Research Scope

Education is organized traditionally around the idea that students will focus their learning on at least one specific academic field of study, a specialization known commonly as a "major" (Pajewski, 2006). Specializations can range from the traditional academic disciplines such as those in the liberal arts and sciences (such as music, art, philosophy, physics and chemistry), to majors that prepare students for "professional" or "applied" fields of study (such as engineering, business administration and nursing) (Pajewski, 2007). Each discipline requires students to focus on specific phenomena. Organizing education based on a discipline or field of study accomplishes a number of pedagogical and curricular objectives. One would be to approach with specific analytical and descriptive methodologies, another, to have specific aims and a third, to employ specific conceptual frameworks and vocabularies (Marion, 2003). It has been supported though that student education has suffered the inferior pedagogy of traditional methodologies that concentrate specifically on only one discipline.

In this context, the interdisciplinary approach has risen in the modern curriculum as it is considered an important and challenging technique. Bammer (2010; 2013) suggests that this field, which she calls 'integration and implementation', has become increasingly significant in recent years and that a community of researchers has emerged with a shared interest in this field. It has been suggested that a new specialist field might be emerging which includes most of the terms and issues normally grouped under the heading of interdisciplinary education by synthesizing more than one discipline and creating teams of teachers and students that enrich the overall educational experience.

The interdisciplinary or cross-thematic approach has been variously defined (Klein, 1990). A general description refers to "the process of answering a question, solving a problem, or addressing a topic that is too broad or complex to be dealt with by a discipline or specialization" (Newell, 1996).

Interdisciplinary studies have many advantages, as well as disadvantages. There are educators who advocate the concept of interdisciplinary study, based on the view that the world itself does not exist as separate disciplines or fields of study, and that all knowledge is systematically integrated. Moreover, interdisciplinary study is considered a means of framing and solving problems that cannot be addressed using single methods or approaches (Klein, 1990).

Also, the interdisciplinary approach provides many benefits that develop into much needed lifelong learning skills that are essential to a student's future learning. The foundation of interdisciplinary techniques will lead to a future of discovery and innovation. For example, the chemist Willard Libby who discovered radiocarbon dating, applied his findings in Chemistry to the discipline of Archaeology, winning the Nobel Prize for the discovery in 1960 (Youngblood, 2007).

In general, it is widely believed and proven that interdisciplinary teaching is the ideal way of approaching a specific area of study as it brings together expertise from different fields in a way that retains and clarifies the fundamental building blocks of a given discipline. Tracing a common thread (a theme or issue) through these different viewpoints leads to valuable synergies among the disciplines and professional skills. At its best, by utilizing the strengths of each area, interdisciplinary cooperation leads to the optimal creation of something far greater than any one area could produce alone (Petrie, 1992).

Nevertheless, educators (and specialists) continue to debate the effectiveness of organizing knowledge into disciplinary categories, as well as the definitions of, and boundaries between, these categories (Klein & Newell, 1997). Also, Burton (2001) supports that the interdisciplinary approach should not be considered a panacea for solving the problems of the modern educational system. Cooperation and the value of teamwork can be achieved utilizing conventional teaching methods and not necessarily through interdisciplinarity.

Despite the extensive examination of the interdisciplinary approach (Klein, 1996; Lattuca, 2001; Newell, 1996), literature shows that little attention has been paid to the instructional methods used in such programs, and to the effect of such programs or teaching methods on student learning. As interdisciplinary education claims to have pedagogies and curricula that are distinctly different from the non-interdisciplinary or “traditional” disciplines this should result in different instructional strategies between interdisciplinary and traditional disciplinary programs.

Interdisciplinary teaching helps to advance critical thinking and cognitive development, engaging students and helping them to develop knowledge, insight, problem solving skills, self-confidence, self-efficacy and passion for learning. These are the common goals that educators bring to the classroom and interdisciplinary instruction and exploration promotes towards the realization of these objectives (Riggs & Gholar, 2008).

Most of the researches were done in primary and preschool, less in secondary education and the least on higher education. All of them showed how interdisciplinary programs have a positive impact on improving students’ different skills (language, mathematical, movement) (Placek, 2003).

With regards to the combination of physics with physical education particularly in secondary education, more research is required (Downing & Lander, 1997). Since there is lack of research between interdisciplinary lessons of Physics and Physical Education, it is necessary to have a deeper insight of a specific project and the disciplines to involve, in conjunction with the benefits of an interdisciplinary approach, the extent of integration required and how this integration will be achieved.

The present study considered how the method of interdisciplinarity of teaching and learning process between Physics and Physical Education could be effective in student learning. It was an attempt to cross the boundaries of the two disciplines involved. Specifically, the purpose of the present study was to examine how the interdisciplinary approach between Physics and Physical Education can improve high school students’ conceptual understanding in the field of “Forces” (the effects of forces, stretch, friction/stopping distance, air resistance, up thrust and weight).

1.2. Research Hypotheses

As explained thoroughly in the chapter of Methodology (Chapter III), the present study intended to examine a series of hypotheses, in order to reach specific conclusions concerning the potential relationship between the factors of group and gender and the improvement in the participants’ understanding of the two disciplines. These hypotheses are presented below:

1. There should be no statistically significant difference between the experimental and control group, regarding the improvement of understanding of each individual question of PHYSICS knowledge test.
2. There should be no statistically significant difference between male and female participants, regarding the improvement of understanding of each individual question of PHYSICS knowledge test.
3. There should be no statistically significant difference between the experimental and control group, regarding the improvement of understanding of each individual question of P.E. fields test.
4. There should be no statistically significant difference between male and female participants, regarding the improvement of understanding of each individual question of P.E. fields test.
5. There should be no statistically significant difference between the experimental and control group, regarding the understanding of each subtopic of PHYSICS knowledge test in the pre-trial phase.
6. There should be no statistically significant difference between the experimental and control group, regarding the understanding of each subtopic of PHYSICS knowledge test in the post-trial phase.
7. There should be no statistically significant difference between male and female participants, regarding the understanding of each subtopic of PHYSICS knowledge test in the pre-trial phase.
8. There should be no statistically significant difference between male and female participants, regarding the understanding of each subtopic of PHYSICS knowledge test in the post-trial phase.
9. There should be no statistically significant difference between the experimental and control group, regarding the understanding of each subtopic of P.E. fields test in the pre-trial phase.
10. There should be no statistically significant difference between the experimental and control group, regarding the understanding of each subtopic of P.E. fields test in the post-trial phase.
11. There should be no statistically significant difference between male and female participants, regarding the understanding of each subtopic of P.E. fields test in the pre-trial phase.

12. There should be no statistically significant difference between male and female participants, regarding the understanding of each subtopic of P.E. fields test in the post-trial phase.
13. There is no statistically significant difference between the experimental and control group, regarding the improvement of understanding of each subtopic of PHYSICS knowledge test.
14. There should be no statistically significant difference between male and female participants, regarding the improvement of each understanding of subtopic of PHYSICS knowledge test.
15. There should be no statistically significant difference between the experimental and control group, regarding the improvement in the understanding of PHYSICS.
16. There should be no statistically significant difference between male and female participants, regarding the improvement in the understanding of "FORCES" in PHYSICS.
17. There should be no statistically significant difference between the experimental and control group, regarding the improvement in the understanding of "FORCES" in P.E.
18. There should be no statistically significant difference between male and female participants, regarding the improvement in the understanding of "FORCES" in P.E.

1.3. Operational Definitions

Interdisciplinarity in the specific research could be defined as the design and implementation of the integration of Physics and Physical Education curricula, through a range of actions and options that move away from the traditional individual teaching of each discipline and towards the fusion of both disciplines with the purpose of optimizing students' conceptual understanding of common topics.

1.4. Delimitations of the Study

The two main delimitations of the present study involve the small number of sample students as well as the short time of intervention. In particular, the non-representative sample is highlighted as a limiting element of this research, since the number of pupils in schools is relatively small, not allowing the generalization of results,. At the same time, the constraint of available space and time refers to the reduced duration of activities and execution in unfavorable spatial environments.

Furthermore, targeting a very specific age group (13 year old students) coming from three different cities in Cyprus (Larnaka, Nicosia and Limassol) could also be considered as a constraint, while [the lack of a control group as there was another class at school].

Finally, an important factor that affected this research was the lack of funding.

II. Literature Review

Interdisciplinary work in science has been viewed as a natural phase in the development of new disciplines (Klein, 1996; Lemaine, et al., 1976; Lenoir, 1993), suggesting that scientists branch out beyond the limitations of their existing field and work with others for a period of time until a new discipline or sub-discipline becomes established.

In any case, the interdisciplinary approach employs experience and application as critical elements of the teaching-learning process; learning by "doing" rather than through theory addresses the needs of a significant percentage of students (for instance, in secondary education) who will soon need to put these skills to practice. Also, the interdisciplinary model's emphasis on cooperative learning and the use of critical thinking skills speaks to a national educational priority that affects all levels of teaching and learning (Gabbard & McBride, 1990; Schwager & Labate, 1993; Stier, et al., 1994). In turn, interdisciplinary cooperation facilitates student engagement and active learning encourages student involvement by providing a variety of ways to learn, which are appropriate to their discipline and incorporate an experiential component where appropriate. Besides, according to Leblanc (1998) and Hartmann, et al. (2014), effective interdisciplinary teaching and learning employs and applies the common principles of all high-quality teaching and learning, promoting critical thinking and rendering students more engaged and disciplines more applicable, meaningful and noteworthy.

2.1. Interdisciplinary Learning & Physical Education

Placek (1992) criticizing conventional teaching programs of physical education, claims that their main objective is the development of fundamental skills, the practicing of sports and games and the development of students’ fitness. Cognitive and emotional development, such as the implementation of rules may be of secondary importance to the course. The main priority is for students to be trained in such a way, so they can perform well and become competitive in various sports, regardless of the allegations of physical education teachers that unless these goals are taught simultaneously to students, they will not be able to develop their critical thinking and problem solving skills.Both Placek and O' Sallivan (1997) taking into consideration the typical physical education programs, believe that it is left to chance and support that these objectives are served only through multidisciplinary approach considering the internal and external integration as the most appropriate form of integration. Derri, Aggelousis & Pateraki (2004) examining 10-12 year olds, investigated the effectiveness of a nutrition educational program through the development of students' fitness. The results of the investigation showed that the program had a positive impact on pupils' eating habits.

Similar were the results of the survey conducted by Zervou, Derri and Pateraki (2004). They found that students attending grade D in a primary school, who were taught topics relating to the ancient Olympic Games, through interdisciplinary approach which combined motor activities, they both acquired and maintained good knowledge compared to their classmates, who were taught the same subject but in a theoretical framework in the classroom.

Milosis and Papaioannou (2005) unified themes from the Greek language and physical education in a six-month collaborative project. Their aim was to investigate the impact of the project on various aspects such as how the students approached their objectives, how strong their motivation was, the satisfaction received from the different classes and the feeling that they succeeded in coping with difficult tasks. In addition, self-concept, the development of personal and social responsibility and academic achievement, were some more of the project's aspects investigated. The survey results confirmed the expectations of the researchers since they revealed positive effects on all aspects of the research.

The impact of an interdisciplinary physical education program integrated with themes from Greek language in language learning from pre-school students was the research topic of Goti, Derri, and Kioumourtzoglou (2006) through which the positive effects the program had in learning the language were verified.

The increase in interest and internal motivation of ' indifferent ' pupils was the result of an interdisciplinary physical education program integrated with concepts from the scientific field of natural sciences practiced by Gotzarides,Papaioannou, Antoniou and Almpanides (2007).

Filippou, Bebetsos, Vernadakis, Zetou and Derri (2015) investigated the effect of an interdisciplinary program of Greek traditional dance with issues from music and sociology, on high school students' anxiety levels. From the analysis of the results it seems that there was a significant reduction of the percentage of both the somatic and cognitive anxiety of the experimental team students after each measurement. On the contrary, although the control team students also showed a reduction in their percentage, this was of minor significance statistically. On the other hand, the results showed an important increase, after each measurement, in the percentage of the self - confidence of the experimental team members, while the relevant percentage of self-confidence of the control team students were insignificant statistically. The results of the research come into contrast with the results of Kaprinis, Diggelidis and Papaioannou (2009), in which the students of the experimental team showed increased percentages of somatic and cognitive anxiety. This differentiation of results might possibly stem from the different objects of the research, folk dance for the present research and Physical education in the research of Kaprinis, Diggelidis and Papaioannou (2009). Probably, this differentiation is due the content of the interdisciplinary approach which in this investigation was consisted of music and sociology issues, while in the research of Kaprinis, Diggelidis and Papaioannou (2009) came from mathematics. Moreover, dance constitutes an activity which contributes to the socialization process of a person (Mihaltsi, 2008) to the banishment of boredom and monotony (Kipourou, 2009).

Kaprinis, Diggelidis, and Papaioannou (2009), taking into consideration elementary school students who attended grade D, investigated the effect of an interdisciplinary physical education program on the development of mathematics skills, on motivation, on the objectives and on the degree of satisfaction the students received. His work verified what Usnick, Johnson, & White (2003), had also previously concluded.

The results of their research highlighted the positive impact of the program on the development of mathematical skills, the increase of internal motivation and of students' satisfaction. The same learning outcomes had the research that Tsapatori, Pollatou, Gerodimos & Mavromatis (2009) conducted, who applied a music-movement program on first graders of elementary school.

The most recent application of interdisciplinary approach was that of Arapitsa (2014) who investigated the effect of an interdisciplinary program on students' satisfaction, motivation and on their objectives, having as her object of study 1st grade high school students. She integrated the teaching of Greek dances with concepts of music, anthropology, history and sociology. The survey resulted in showing the positive impact of the program as it increased students' satisfaction and intrinsic motivation while it reduced any external motivational factors.

According to Ellis and Fouts (2001), the interdisciplinary integration of grammatical and historical issues with physical activities had better and more positive results than teaching them through conventional curricula. The remarkable thing is that the students who participated in the interdisciplinary teaching, though they recognized that their opinions are greater and more difficult than those of conventional programs, were much satisfied with the course and loved the teaching process more than those who were involved in conventional teaching methods.

Cone and Cone (2001), as well as Sperling and Head (2002), share the same view. The former showed that the interdisciplinary teaching has a positive impact on improving the language skills of students and the latter, praised the effectiveness of an interdisciplinary physical education program on learning letters and recognizing words by pre-school and primary school students through the formation of letters using their bodies

2.2. Integrating Physics & Physical Education in Elementary & High school

Moore (1992) and Stevens (1994) suggested the use of Physical Education skills to reinforce concepts in academic disciplines such as physics, mathematics, history, or art. This method provides students and teachers with increased opportunities for exploration, problem solving, and concept application while providing an additional medium for cooperative learning and mutual understanding of each other's goals and objectives. Also, according to Rasch (1989), the relationship between scientific principles and Physical Education and Sport movement skills is well established.

The laws of Physics, especially those relating to mechanics and motion, have strong parallel relationships with the principles that dictate the foundations of psychomotor movement. For instance, the increased popularity of weight training at the secondary level, and its integral role in programs that advocate wellness and fitness for life make it an appropriate choice from the perspective of physical education.

Therefore, students should be provided with opportunities to apply concepts and principles of Physics acquired through formal classroom teaching to Physical Education environment or/and vice versa, and also to establish collaboration and other social skills that are of crucial importance in life.

Furthermore, many researchers claim that the interdisciplinary teaching of Physical Education could be the answer to students' lack of interest in participating to the course (Gotzaridis, et al., 2007) and as a consequence, to their reduced effort during the course as well as to the absence of satisfaction to gain from that (Diggelidis & Papaioannou, 1999).

However, when it comes to interdisciplinary between Physics and Physical Education too little research has been done and one can find even less concerning the secondary education (Gilbert, 1987; House & Coxford, 1995).

Both the interdisciplinary teaching models that include Physical Education as an integral part of the learning process and the way in which these have been implemented in high schools, emphasize the use of critical thinking, decision making and cooperative learning skills as these are considered prominent strengths of interdisciplinary education (Ivanitskaya, et al., 2002). Such skills will also help the teaching profession meet the demands of a complex and changing world (Downing & Lander, 1997).

Therefore, more programs of this nature are needed in high schools. There are three reasons for this imperative: The success of this technique is apparent in literature. Team teaching approaches that have been implemented in Physical Education (Faucette, 1989; Gabbard, et al., 1989; Ritson, 1989) helped to integrate it into the curriculum; fostered the development of critical thinking skills; and nurtured cooperative implementation of fitness programs. Tenoschok (1993) designed a "Jog Around the World" interdisciplinary school wide activity in which classes collaborated to jog the equivalent of the earth's circumference during the school year while learning mathematical applications and elements of geography. Markle (1991) formulated a cross-curricular activity program designed to teach the scientific bases of physical and health fitness. Crall (1994), Guthrie and Perea (1995), and Jones (1996) have developed integrated curriculum models that focus on interdisciplinary cooperation and the development of critical thinking processes across grade levels. All these models include Physical Education as an integral to the learning process.

2.3. The Interdisciplinary Approach in Higher Education

Interdisciplinary study has had an increasing presence in undergraduate education in the past three decades as colleges and universities have added interdisciplinary programs in areas such as Women's Studies, Information Systems, and International Relations. Colleges and universities continue to be encouraged by educators to offer courses, curricula, and major programs that are interdisciplinary in nature. Edwards (1996) suggests that inventory of academic programs in the U.S. show that about half of the colleges and universities have interdisciplinary components to their liberal arts programs.

A curriculum requiring students to cross disciplinary boundaries can present complex learning objectives. These may include the use of multiple methodologies for learning problem-solving skills, and the need to integrate or synthesize knowledge claims taken from two or more disciplines. These objectives may be different from the objectives of the curricula of individual traditional disciplines. In their research in understanding the way knowledge is structured and how experts think in specific disciplines, Middendorf and Pace (2004) wrote : "Thus, we have only begun to understand what kinds of thinking goes on in different disciplines, nor do we know the similarities and differences across the disciplines" (p. 2).

The extensive examination of interdisciplinary education in the past decades has focused on these curricular and pedagogical differences (Newell, 1996; Klein, 1996; Lattuca, 2001). Guiding students by way of academic advising is crucial to meeting these complex learning objectives of interdisciplinary study. Payne (1998) writes that the types of faculty who are attracted to interdisciplinary study tolerate ambiguity, are self-motivated, broadly educated, and dissatisfied with the constraints placed on their intellectual work. These defining characteristics may be found in mature adults who are teachers and researchers, but are undergraduate students prepared for this type of learning model? Are students made aware of the challenges, the goals, and structures of such programs from their advisors, their college admissions staff, or their high school programs? Interdisciplinary study is often described in terms of hardship and journeying, as these article and book titles suggest: "Barriers to Interdisciplinarity" (Bradbeer, 1999), "Negotiating a Passage Between Disciplinary Borders (Wissoker, 2000), and "Crossing Boundaries" (Klein, 1996).

Writing about the barriers to interdisciplinary study, the Boyer Commission (1998) found that “Students who find that existing majors do not suit their interests often encounter discouraging barriers; advisors will likely first try to fit those interests into one of the existing patterns” (p. 23). Klein (1999) offers a list of administrative strategies for supporting students, such as loosening structural barriers and clustering programs. Haynes (2002) writes that interdisciplinary study is “concerned primarily in fostering in students a sense of self-authorship and a notion of knowledge that they can use to respond to complex questions, issues, or problems.”

Elsley (2002) recognized that the expression of such goals are quite lofty, and surmises that not all undergraduate students can rise to this challenge. To what extent are students prepared to achieve such learning outcomes from interdisciplinary study? A criticism of interdisciplinary programs is that the quality of interdisciplinary study can be a concern (Lattuca, 2001). Klein (1996) points out, that departments fail to develop the integrative skills students need for dealing with complex problems and issues. Institutions that expect interdisciplinary study to thrive on their campus need to do more than support their scholarship; they need to “create flexible spaces” for exploration and collaboration (Lattuca, 2001). In addition to producing scholarship and teaching, programs need to offer personal guidance to students for establishing their educational and professional goals in these interdisciplinary fields of study. The advising of these students plays a key role in the students’ achievement of these interdisciplinary learning outcomes.

2.4. Conceptual Change in Learning in Science

Constructivism dominated the teaching of natural sciences in recent decades, the basic principle of which is that knowledge is not given and that the students construct their own new knowledge based on the stimuli received from the environment.

According to Vosniadou et al. (2001) the term “conceptual change indicates that the conceptual development includes not only the enrichment of existing structures but also the substantial reorganization and their complete reformation'.

The process of conceptual change is doubted by some researchers, mainly because it is rather considered a slow and gradual process rather than a sudden change of theory.

It is also very important to identify the process of conceptual change from its final outcome (Vosniadou, et al., 2001). Generally there are two types of conceptual change:

a) the weak cognitive restructuring, incorporation or conceptualization , and

b) the strong /radical cognitive restructuring, compliance or conceptual exchange (Harrison & Treagust, 1996).

However, the conceptual change is, nowadays, considered responsible for indicating learning paths from the children's perceptions before teaching the scientific concepts, which must be built. This is the perspective upon which, this research is based on (Duit, 1999).

The teaching model of conceptual change was first proposed by Hewson (1981) and by Nussbaum and Novick a year later. Strike in cooperation with Posner in 1982 and then Hewson tried to describe the most favourable conditions for conceptual change. Initially, students need to feel, to some extent, the shortcomings of their original ideas. Then, the new idea must seem smart, fair and fruitful in this context. The role of the teacher is to create the climate of trust necessary to activate the process of change.

Given the fact that this type of teaching approach, in order to be effective, requires major changes in traditional views. They also formulate new beliefs about the role and responsibilities of both the teacher and the students. The teacher is not the one who teaches something but he, who inspires the students to do their best to discover what they already know and bring it to the surface through the approach of questioning. "What the students already know has been proven to be the key to learning."

2.5. Conceptual Change Models

Some researchers have expressed different views about the nature of alternative concepts or their organization and use by children. DiSessa (1988, 1993) expressed the view that the initial perceptions of the physical world are composed of an unstructured collection of small and individual knowledge «Knowledge in pieces» elements, which he called «phenomenological primitives» (p-prims). These small pieces of knowledge are simple and small structures of consciousness, which derive from the shallow, early or original interpretations of experience and from the observations of the various phenomena that children make.

When people form an alternative interpretation, they try to maintain as much of the existing beliefs as possible, without coming into conflict with those taught by adults (Vosniadou & Brewer, 1992). Through this process, the children create the so-called synthetic models that represent their efforts to merge their intuitive perceptions with the scientific information presented through teaching. This process of conceptual restructuring is said to be long and difficult and can also become the cause of formation of alternative concepts (Vosniadou, 1994).

The intuitive perceptions formed by personal experiences are so well established, that they are difficult to change through teaching. They are maintained, in parallel course, with the scientific views taught in the context of conventional teaching (DiSessa, 1982; White, 1983; Beveridge, 1985; Cros, et al., 1988).

Vosniadou and Brewer (1992, 1994), supported the view, that students, before they even receive systematic instruction in elementary school and mainly based on the experiences of everyday life, form their own mental models (mental models) to explain the different physical phenomena. Ritchie, Tobin and Hook (1997) define mental models as cognitive structures used by individuals to describe and explain the phenomena that cannot be directly perceived. These constructions are personal efforts of individuals to interpret the world around them (Judson, 1980), but also to express their views to others (Harrison & Treagust, 1996).

Vosniadou (2002) also mentions two other important functions of mental models in the human cognitive system. Mental models act as processing aids to form explanations as intermediaries in the interpretation and acquisition of new pieces of information.

According to Vosniadou (2002), when people think of the natural world, they often use mental models, especially in cases where the answer cannot be produced from previously stored knowledge or cannot easily be expressed through verbal information. Mental models can help people to gain information from the implicit knowledge of physical reality, information which then can be used to answer questions, solve problems, interpret natural phenomena, etc. In this way, the implicit knowledge about the physical world becomes clear and is introduced into the conceptual system. In other words, these mental models become the vehicles, through which, the implicit knowledge about the physical world becomes clear and is introduced into the conceptual system.

Once this non-verbal knowledge enters the conceptual system, it can be encoded and made available for further use. So mental models are important knowledge resources to produce new knowledge and to form theories. At the same time, mental models act as strong constraints on how people interpret the comments and information into the conceptual system, leading through every mental model built to arise many alternative conceptions (Vosniadou, 2001).

Driver et al. (1985) reasoned that the mental models that students have already formed, prevent the effective integration of new concepts. This is because, in the process of learning the various scientific concepts, students need to reorganize their intuitive or prior knowledge, in order to harmonize with the current scientific opinions. But, two epistemological types of restrictions seem to define the concepts of children: (a) the belief that ontological beliefs represent the true state of world affairs and (b) the belief that adults are usually right.

According to what reported by Piaget, children, until the age of 11-12 years old, cannot comprehend the action power unless the objects move. But children find it difficult to leave their intuitive ideas and so, by trying to interpret the information of adults, they form alternative concepts, in such a way as not to contradict their ontological beliefs.

Conceptual change research has shown that this process of integration is by no means a sudden shift from a naive explanation to a scientifically adequate view but rather a gradual process of restructuring interrelated concepts, in the course of which misconceptions may reoccur depending on the particular context (Caravita, 2001; Tyson, et al., 1997; Harrison & Treagust, 1996; Vosniadou, et al., 2001). Why and under what conditions does successful conceptual change occur? According to the pioneering work of Posner, Strike, Hewson, and Gertzog (1982), an essential condition of conceptual change is for learners to become dissatisfied with the conceptions they have, thus experiencing the need for new explanatory mechanisms. Central to this notion is the induction of cognitive conflict as a motor of conceptual change, starting with the initial conceptions a child may hold (Chinn & Brewer, 1993). According to surveys (Posner, et al., 1982), in order for a conceptual change to take place, four essential requirements are needed:

1. The old knowledge to be unsatisfactory.

2. The new knowledge to be understood.

3. The new knowledge must be initially plausible, in order to make an original approach.

4. New knowledge must contain research value. That is, to provide the feeling that can assist in the solution of new problems.

Models and modelling: Each model describes and explains a certain area and certain aspects of reality. The continuous "dialogue " between reality and model, both in the phase of construction and the subsequent use make difficult concepts easier to understand (Stavridou, 1995). The process of modelling helps students build knowledge, because of their involvement in the construction process of conceptual schemes. The structure of the solar system and its operation can be easily understood in a physical representation instead of through a text in a book.

Cognitive conflict and Socratic dialogues facilitate recognition of contradictory knowledge a person has on a field (Kanuka & Anderson, 1999; Champagne & Klopfer, 1982; Limon, 2001).

Possible procedures for achieving conceptual change could be:

• Insubstantial reorganization: Add abstract knowledge on poor foundations, whose structure is amended (Chi, et al., 1982).

• Radical reorganization: It is necessary when the information given is incompatible with existing ideas and can be done either in theory level, or on a general framework level, in which a theory is formed. The reorganization refers to the creation of new structures (Chinn & Brewer, 1993).

The process of conceptual change appears to be a gradual and complex case in which the information coming through observation and teaching are embodied in the already existing knowledge and can produce different results (Vosniadou, et al., 2001).

Learning in science can be characterized as a kind of questioning (inquiry). Students should criticize on the basis of the available data to reach the desired result (Posner, et al., 1982). The students themselves argue that learning is based on the ideas of the individuals, their structure and the evidence for them. It’s not just about the acquisition of correct answers, a verbal repertoire or a 'set' of behaviours. Thus, learning, more specifically, inquiry learning may be regarded as a conceptual change process (Posner, et al., 1982).

III. Methodology

3.1. Sample

The sample, which falls into the category of convenience samples, consists of 180 7^{th}-grade 13-year-old students from three private schools located in different regions around Cyprus and owned by the same company. The specific age group was selected because of the same background that the children had in elementary schools.

In detail, the school in Larnaka provided the experimental group, comprising of 90 students (40 in the class of 2017 and 50 in the class of 2018), while the control group was formed by the two schools in Nicosia and Limassol and also included 90 students (20 students per school in the class of 2017 and 25 students per school in the class of 2018).

The following tables and figures depict the sample's distribution per group (experimental, control), per region (Larnaka, Nicosia, Limassol), per year, as well as per gender.

Table 1: Distribution of Sample per Region

Region

	Frequency	Percent	Cumulative Percent
Larnaka	90	50,0	50,0
Nicosia	45	25,0	75,0
Limassol	45	25,0	100,0
Total	180	100,0	

Table 2: Distribution of Sample per Group

Group

	Frequency	Percent	Cumulative Percent
Experimental	90	50.0	50.0
Control	90	50.0	100.0
Total	180	100.0	

Table 3: Distribution of Sample per Gender

Gender			
	Frequency	Percent	Cumulative Percent
Male	85	47.2	47.2
Female	95	52.8	100.0
Total	180	100.0	

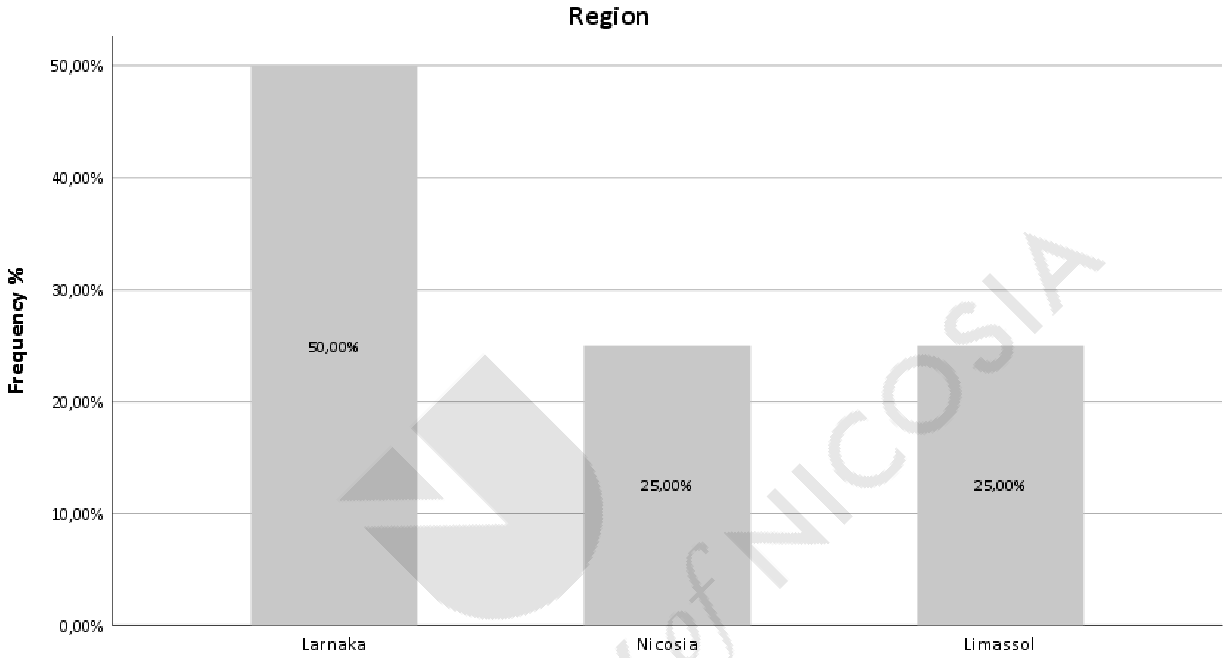


Figure 1: Distribution of Sample per Region

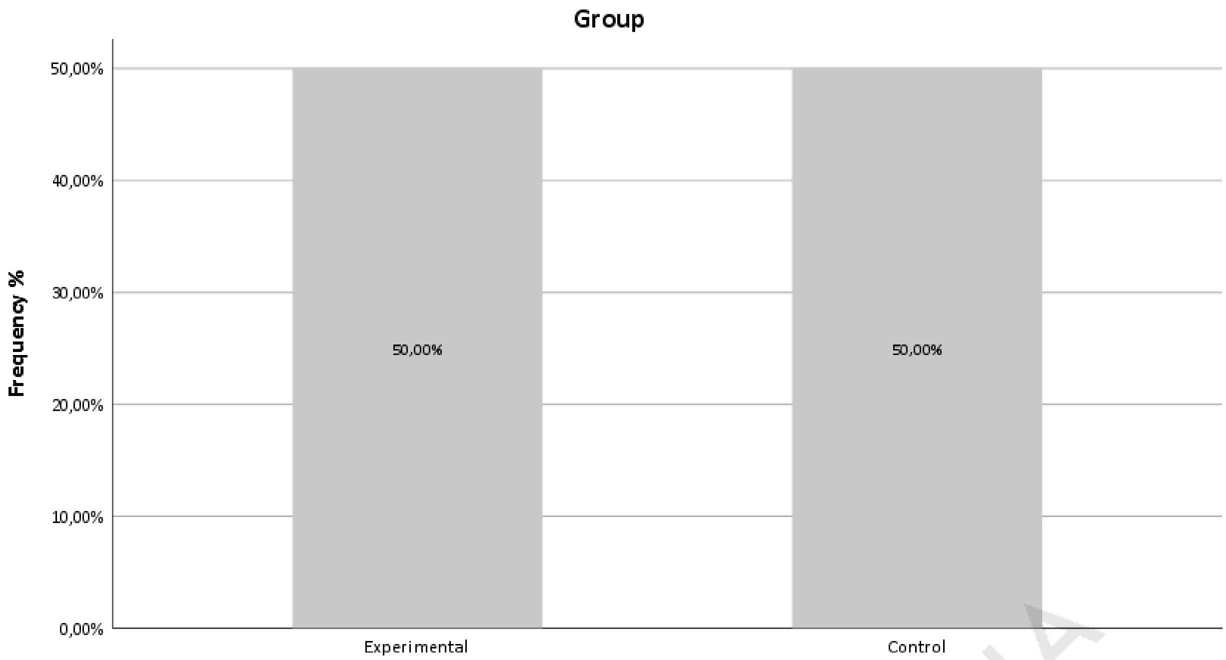


Figure 2: Distribution of Sample per Group

Figure 3: Distribution of Sample per Gender

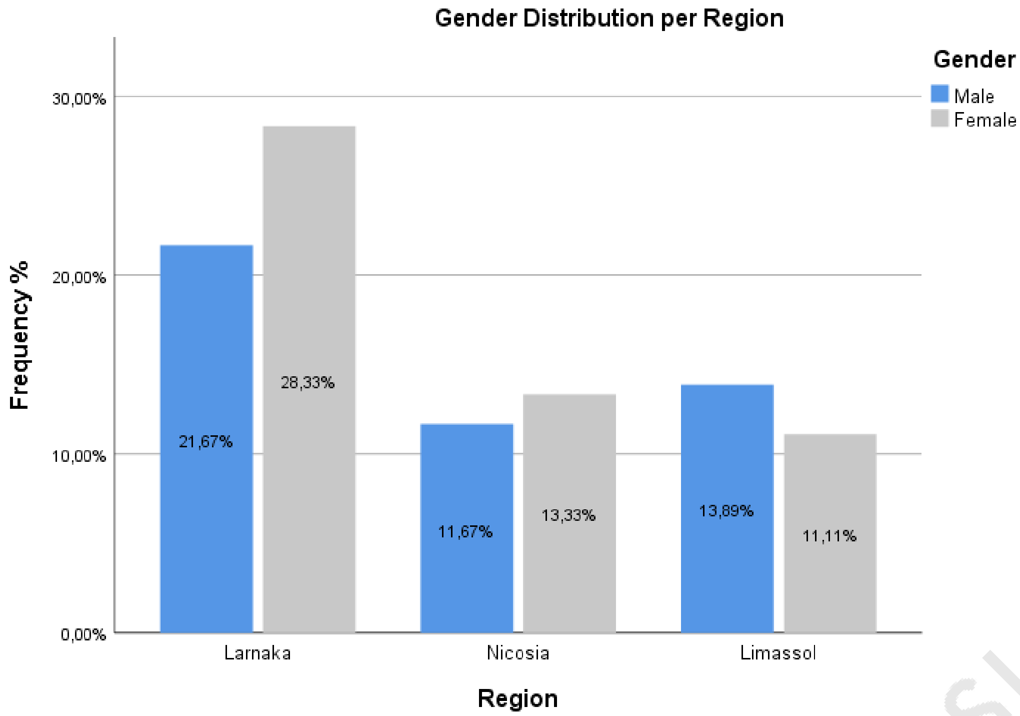


Figure 4: Percentage per Gender and Region (out of Sample Total)

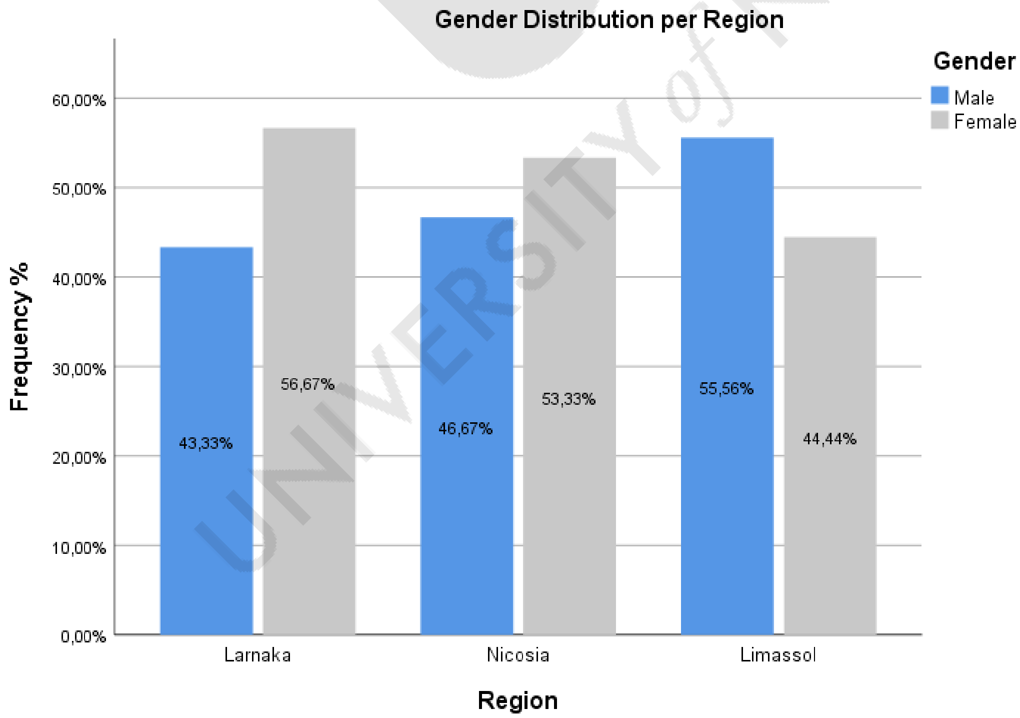


Figure 5: Percentage per Gender and Region (out of Region Total)

3.2. Experimental Design

The overall design of the project took a quantitative approach where the data were utilized to test whether the interdisciplinary learning in education yields better student learning outcomes than individual approach on physics and physical education.

The implementation lasted 16 weeks, twice a week on an eighty minute teaching period for physics and once a week eighty minutes for Physical Education.

The pre-test was given to all participants. The pre and post-test measured students understanding of the concepts before the intervention (both in P+P.E). The experimental group went through the procedure of the interdisciplinary learning. Physics was taught through examples and activities of Physical Education and vice versa.

Therefore, a 2(groups) x 2(measures) design was followed. The independent variable was the experimental design used for the teaching implementation (use of the physics lab). The dependent variable was the conceptual understanding of the students (which was the difference in students' performance before and after the implementation and covariate was the understanding of students on pretests before the implementation. In this way they were examined in the influence of different experimental methods used during the implementation while checked the influence of the previous knowledge and experience of the students which was count as the results on the pretest in conceptual understanding on the five subtopics of the Forces as well as the basic skills in P.E.

3.3. Instrumentation

After finishing the intervention post-test was given to all groups to check the difference and the improvement in understanding.

More specifically ten tests were implemented (five pre and five posts) which were given to all groups.The teaching material consists of five chapters. For each chapter one pre and one post-test are going to be designed. Apart from that a bigger pre and posttest will be designed for the whole unit. Tests were consisted of exercises and questions, which will be referring to the relevant experiments, exercises and terms of the specific chapter at hand.

Different materials and different teaching environments were used during our intervention. The traditional Physics Classroom (Lab) including all materials needed for Physics lessons (newton meters, light gates, graph paper, scales). Interactive whiteboard was also used in the Physics lab.

Regarding the Physical Education lesson the materials used were: the football pitches, basketball court, medicine balls, football and basketball, elastic bands of different resistance, tape measure, stopwatches and parachutes. The lessons concerning up thrust were held in the swimming pool.

3.4. Teaching Approach

Traditional classrooms tend to be closed systems where information is filtered through layers to students. In general, the use of resources is limited to what is available in the classroom or within the school. The use of technology is more focused on learning about the technology rather than its application to enhance learning. Lesson plans are used to organize the various steps in the learning process for the whole-class approach.

The experimental group followed the interdisciplinary lesson plans which were created based on both P+P.E. The control group followed the individual lesson plan for each subject separately. Both groups were given the same pre and posttest before and after the implementation.

Pre and post tests given to all participants, were consisting of multiple choice questions and closed end questions, based on both subjects.

The teaching methods which support the inquiry approach are mainly focused on direct experience with phenomena introducing cognitive conflict while encouraging students to develop new reasoning patterns, which are better adapted to their experiences (Gerber & Edmund, 2001)

The inquiry approach is more focused on using and learning content as a means to develop information-processing and problem-solving skills. The system is more student-centered, with the teacher as a facilitator of learning. Students are more involved in the construction of knowledge through active involvement. The more interested and engaged students are by a subject or project, the easier it will be for them to construct in-depth knowledge of it. Learning becomes almost effortless when something fascinates students and reflects their interests and goals. The choice of using an inquiry based environment is based on the scientific validity which can support effectively learning in science (McDermott, Shaffer &Constantinou, 2000). Furthermore, it is a dynamic learning environment which includes interactions in different levels, between learners, teacher, learning material, instruments and materials giving the opportunity to focus and analyze on those, in more depth.

Students in the control group will follow their syllabus. Participants of the control group will be taught separately each lesson with the convenient so far way.

The topic selected from year 7 syllabus of Physics is “Forces” (separated into five subtopics: the effects of forces, friction, stopping distance, up thrust, weight). For every sub topic, the experimental group, followed a lesson plan which created based on the requirements, aims and goals for Physical Education program, of the Ministry of Education of the country.

After finishing the implementation students were able to know how to use a force meter to measure forces carefully. That a newton is a unit of force. That there is a force between two objects that may prevent them from moving. That the force between two moving objects is called friction. That friction can be useful. That air resistance is a force that slows objects moving through air. As well as the relevant concepts in Physical Education (briefly shown on the table below).

Table 4: Summary of Teaching Approach

PHYSICS CONCEPTS	P.E CONCEPTS	AIMS / GOALS PHYSICS	AIMS / GOALS PHYSICAL EDUCATION	ACTION TAKEN / MATERIALS USED
Friction/ Stopping distance	Transfer of the ball	To identify and control key variables and make predictions of possible outcomes. That friction is a force that opposes motion and about the factors that affect frictional forces. Describe ways in which friction can be reduced between an object and a solid surface and some situations in which friction is useful.	Basic football skills/improvement in stopping distance.	Running on various fields with different surface materials, use of football, light gates, stopwatch, and tape measure.
Air resistance	Air Resistance	To understand how forces are related.	Correct position of head. Correct movement of the arms and hands (Air resistance is relatively related to small surface area)	Use of parachutes/Running with and without the parachute a specific distance
Up thrust	Aerobic ercise	When objects are immersed in a solution, there is upthrust acting on them and that the size of this force will affect the buoyancy of an object.	Basic Swimming skills.	Swimming pool (In which position they are able to float?)
Stretch	Flexibility	To identify anomalous results from a graph and understand the importance of repeat readings. How the size of a force affects the extension of elastic materials	Stretching techniques(flexibility test)	Elastic bands of different thickness and length/stretching of specific muscle units
Weight gravity	Energy balance/ body mass index	That mass is the amount of matter in an object and is measured in kilograms; weight is a force caused by gravity acting on a mass and is measured in newtons.	The body weight is equally divided into two legs	Scales, Newton meter, graph paper, basketball, medicine ball,

3.5. Data Collection: The Questionnaires

For the assessment of the knowledge of the participants a questionnaire was used which was developed for the requirements of the study. The questionnaire consisted of 50 multiple choice questions. Each question had three answers.

For the construction and development of the questionnaire the following procedure was followed:

The content of the questions was chosen based on the material of the syllabus covered for the specific age group, eliminations came based on the criteria of development of the Framework Science Syllabus -key stage 7- upon (which, the physics teaching part is based and developed), IGCSE Physics exams and International Baccalaureate exams and the final form deduced based on the relevant bibliography (Brigham Young University 2001, Annual University Conference, Collins, J., 2005).

The questionnaire was then checked for its validity and reliability in two pilot studies.

At the beginning five physics teachers (four of them having masters degree in Physics and one having PhD in Physics) studied the questionnaire and gave feedback regarding the content, on how appropriate the questions were, mostly on the language and the precision. After the corrections the questionnaire had to be filled in by random selection of students.

Item analysis: The 50-questions questionnaire was filled in by 15 students of the same age group (12-13 years old) and the data collected were used for item analysis (see Table 5).

Results showed that questions 37 and 46 had no variance so the questions were removed.

After checking the difficulty index, 9 questions were removed. Difficulty index is related to the percentage of the correct answers and it is calculated by the quotient R/N where R is the number of correct answers and N the total number of participants to the pilot study, getting as accepted values .30 to .70 (Safrit & Wood, 1995).

The remaining 39 questions were then checked using the discrimination index.

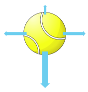
- Discrimination index is related to the level each question discriminates the participants to those who did well or not. For the calculation of the total of the answers of the specimen the scale was divided into three parts (easy, medium, difficult) based on the answers and were measured the difference of the number answering correct and easily and those who answered correct according to the formula $(R_u-R_l)/N_u$ having R_u=the number of correct and easily,

- $R_{l=}$ the number of correct but difficulty answers and $N_{u=}$ the total number of participants who said it was easy. Values ≥ .40 are considered to be very good and >.20 accepted. Below .20 are very poor and subject to be rejected (Kirkendall, 1987; Safrit & Wood, 1995).

After the reliability test, internal correlation was satisfactory since the accepted values are >.50 for questionnaires having less than 50 questions (Field, 2005; Kehoe, 1995). The Cronbach was a=.63 for all questions (Table 5).

Table 5: Item-Total Statistics and internal correlation for each question of the knowledge questionnaire

#	Question	Difficulty index	Discrimination index	Corrected Item-Total Correlation
Q1	The force that one surface exerts on another when the two rub against each other is called: A. friction B. acceleration C. inertia	0.86	0.92	0.195
Q2	Which of the following is an example of increasing friction intentionally? A. waxing skis B. adding grease to gears on a bike C. throwing sand on an icy driveway	0.46	0.43	0.729
Q3	To keep a heavy box sliding across a carpeted floor at constant speed, a person must continually exert a force on the box. This force is used primarily to overcome which of the following forces? A. Air resistance B. The weight of the box C. The frictional force exerted by the floor on the box	0.40	0.33	0.423
Q4	When do I stop more abruptly? A. To stop using both legs B. To stop with the one foot facing straight forward C. To stop with the one foot facing to the side	**0.20**	**REMOVED**	-
Q5	Galileo proposed a thought experiment where a sphere would be rolled down a U-shaped incline. In an “ideal scenario,” the sphere would move along the incline until it returned to its original height. Why will this not occur in real life? A. The force of gravity prevents the sphere from moving upward B. The friction between the sphere and the incline reduces the sphere’s energy C. The momentum of the sphere increases as it moves, causing it to rise above its original height	**0.20**	**REMOVED**	-
Q6	Which driving surface would provide the greatest friction? A. ice B. wet concrete C. dry pavement	0.46	0.44	0.475
Q7	In an accident, the distance a passenger is thrown from a moving car is related to A. the mass of the car B. the size of the object that the car collides with C. the speed of the car before it collided with another object	0.60	0.57	0.203

Q8	A person walking on a level surface moves forward because the forces of A. his feet pushing backward on the ground B. the ground pushing forward on his feet C. the ground pushing backward on his feet	0.66	0.58	0.532
Q9	A ball rolling across the floor slows to a stop because A. there are unbalanced forces acting on it. B. the force that started it moving wears out. C. all the forces are balanced.	**0.06**	**REMOVED**	-
Q10	The Force opposing the movement of one surface over another is called A. Frozen B. Fiction C. Friction	0.40	0.55	0.471
Q11	Objects falling through air experience a type of friction called A. terminal velocity B. air resistance C. inertia	0.53	0.41	0.118
Q12	A person from parachute falls slowly to ground due to A. thrust B. air resistance C. air friction	0.33	0.30	0.499
Q13	When it is harder for me to run? A. Using 1 parachute B. Using 2 parachutes together C. Using 3 parachutes together	0.53	0.75	0.742
Q14	Ignoring air resistance, a bullet fired horizontally has how many forces acting on it after leaving the rifle? A. One, from the gunpowder explosion B. Two, one from the gunpowder explosion and one from gravity C. Three, one from the gunpowder explosion, one from gravity, and one from the motion of the bullet	0.73	0.46	0.274
Q15	Two objects are released from the same height at the same time, and one has twice the weight of the other. Ignoring air resistance, A. the heavier object hits the ground first. B. the lighter object hits the ground first. C. they both hit at the same time	**0.06**	**REMOVED**	-
Q16	Tom is riding his bicycle he wants to go faster without pedalling faster. In addition to achieve it he must: A. Wear a jacket B. Bend near the steering wheel C. Ask Jenna to ride with him	0.80	0.81	0.324
Q17	To reduce air and water resistance objects are shaped in A. streamlined B. oblongata C. rectangular	0.26	0.14	0.017
Q18	The arrows in this diagram represent the sizes of forces acting on a stationary tennis ball. What will happen to the tennis ball? A. it will stay still B. it will start to move upwards C. it will start to move downward 	0.66	0.71	0.116
Q19	What happens to the air resistance on a car as the car goes faster? A. it decreases B. it stays the same C. it increases	0.53	0.5	0.266

Q20	A football, a hockey puck, and a tennis ball all fall down in the absence of air resistance. Which of the following is true about their acceleration? A. The acceleration of the football is greater than the other two B. The acceleration of the hockey puck is greater than the other two C. They all fall down with the same constant acceleration	0.26	0.33	0.687
Q21	Up thrust and weight act in A. same direction B. opposite direction C. upward	0.60	0.62	0.324
Q22	A stone stays less heavy in water than in A. mud B. soil C. air	0.60	0.55	0.357
Q23	Upward force acting on an object when it is submerged into a fluid either liquid or solid it is called A. thrust B. up thrust C. drag	0.40	0.44	0.460
Q24	When do I float easier? A. When using board B. When using exercise weights in the water C. Using pool pipes	0.53	0.66	0.300
Q25	When up thrust is equal to weight of object then it A. floats B. sinks C. moves	0.40	0.60	0.637
Q26	Any substance will float on water or gas if its density is less than that of A. liquid B. gas C. both a and b	0.53	0.69	0.743
Q27	Up thrust depends on: A. The depth of the pool/sea B. Shape of the object submerged C. The density of the fluid	0.60	0.55	0.778
Q28	A ship is travelling from the equator to the north pole. During the trip: A. The up thrust of the ship decreases B. The up thrust of the ship gets increases C. The up thrust of the ship doesn't change	0.40	0.38	0.260
Q29	The up thrust a tanker experiences is more when: A. The tanks are empty B. The tanks are full C. In both cases up thrust is the same	0.20	0.22	0.216
Q30	When the same body is submerged in different fluids the force of up thrust : A. Is the same B. Is different C. Is friction	0.26	0.30	0.690
Q31	If a spring is stretch when it is A. pulled B. pushed C. both a and b	0.73	0.69	0.269
Q32	A spring can be stretched by hanging weights on it. Which of the following is true? A. The larger the force, the greater the stretch B. The smaller the force, the greater the stretch C. The spring does not exert a force on the weight	0.53	0.58	0.118

Q33	A student carried out an experiment by putting weights on the end of a spring. After each weight was added, the length of the spring was carefully measured. The results are summarised below. Weight added to spring (N) 2 4 6 8 10 Length of spring (cm) 23 27 31 35 39 From the data, what would be the spring length with a weight of 15N on? A. 51 cm B. 47 cm C. 49 cm	0.20	0.23	0.713
Q34	In science, a push or a pull is called a(n) A. force B. acceleration C. inertia	0.53	0.5	0.203
Q35	If you are launching a matchstick rocket, the action force is the rocket pushing the gases down. What is the reaction force? A. The table pushing the rocket down B. The gases pushing the rocket up C. The gases pushing the rocket down	0.53	0.2	0.018
Q36	Two boys wearing in-line skates are standing on a smooth surface with the palms of their hands touching and their arms bent, as shown above. If Boy X pushes by straightening his arms out while Boy Y holds his arms in the original position, what is the motion of the two boys? A. Boy X does not move and Boy Y moves backward B. Boy Y does not move and Boy X moves backward C. Boy X and Boy Y both move backward	0.26	0.2	0.674
Q38	Stretching happens when the material or object is A. Pulled B. Pushed C. Both	0.60	0.62	0.024
Q39	Which of the following would you recommend to prevent inflammation of the joints during or after physical activity? A. Rub massage oil into your joints before and after exercise B. Use carbo-loading to increase energy levels C. Stretch your muscles thoroughly before exercise	0.33	0.3	0.145
Q40	Which one of the following is the best example of flexibility training? A. Bounding and hopping exercises B. A mixture of sprinting and walking C. A number of stretching activities	**0.80**	**REMOVED**	0.390
Q41	The force that pulls falling objects toward Earth is called A. gravity B. free fall C. acceleration	0.73	0.76	0.706
Q42	Gravitational force is influenced by object's A. weight B. shape C. size	**0.80**	**REMOVED**	-
Q43	When you jump up you feel a force pulling you back on Earth it is A. magnetic force B. frictional force C. gravitational force	0.53	0.81	0.343
Q44	Force is measured in SI unit A. Newton B. Ampere C. Watt	**0.86**	**REMOVED**	0.598

Q45	What is the unit of weight in the metric system? A. kilogram B. newton C. meters per second squared	0.26	0.25	0.392
Q47	If the forces on an object are balanced, the object will A. remain at rest if initially at rest. B. continue moving in a straight line if initially moving in a straight line. C. both A and B	0.33	0.23	0.303
Q48	Ignoring air resistance, an object falling toward the surface of the earth has an acceleration that is A. constant B. increasing C. decreasing	0.46	0.77	0.260
Q49	You are riding fast on a skateboard when your wheel suddenly gets stuck in a crack on the sidewalk. Why does your body go flying forward? A. there is a net force pushing you off your skateboard B. your inertia keeps you moving forward C. someone pushed you	0.53	0.63	0.364
Q50	You just collected a huge bag of leaves in your yard, and you need to move it out to the curb. How could you get the bag to move faster? A. use more force (push harder) B. take some leaves out to make it weigh less (make it lighter) C. both of the above would work (both pushing harder and making it lighter)	0.46	0.38	0.692

3.6. Data Processing & Analysis Methodology

Data processing and analysis is an important part statistical analysis consisting of the rearrangement and reorganization of collected information with the purpose of generating results that will constitute the basis of research findings. This process involves a series of steps (Sufian, 2015; Krzywinski & Altman, 2013; Laerd Statistics, 2018):

- Primary data gathered from questionnaires is first organized and screened out to remove any invalid questionnaires.
- If the researcher is present when the questionnaires are answered, then field editing is possible, otherwise post-field editing may be carried out as soon as all the questionnaires are collected and revised.
- Raw data is then coded by assigning the possible answers of each question with a numerical code, when necessary. For example, the answers of all demographic questions are coded with numbers 1, 2, 3, etc. while Likert scale questions do not further coding.

- The coded data is then imported into an appropriate statistical package, such as SPSS, where additional data processing and analysis is performed.
- Data classification may also be necessary, where categorizing large amounts of per groups of similar responses facilitates comparisons among classes or groups of observations.
- Data is usually depicted in tabular, statistical or cartographic form. Tabular presentation enables classification and/or comparison of data originating from different variables and is used for summarization of data, thus facilitating the analysis of relationships, trends and other data traits. Simple tabulation answers single-variable questions, while complex (two-way or three-way) tabulation depicts multiple interrelated attributes. Cartographic presentation refers to the generation of graphs, diagrams, charts and maps visualizing the results.
- Statistical analysis involves sampling techniques, regression analysis, factor analysis, correspondent analysis and multidimensional analysis.
- Data analysis techniques depend on the structure of available variables and range from simple univariate description to complex multivariate procedures. Univariate analysis, is applied for all variables and generates frequency distributions and summary measures to provide descriptive statistics. Then, bivariate analysis for nominal, ordinal or scale variables is carried to test for specific relationships between pairs of variables and potentially identify causality.
- If and when reliability analysis is required, Cronbach alpha is calculated for a particular set of variables.
- In order to test the validity of hypotheses, certain correlation coefficients are examined, such as Pearson's r (product-moment correlation) for continuous variables and Spearman's rho (rank-order correlation), which is the nonparametric version of Pearson's r and can be used for continuous, ordinal or nominal variables. Spearman's rho examines the strength and direction of a monotonic relationship between two variables, whereas Pearson's r requires that the relationship is also linear.
- The probability value (p-value) is also used to examine validity and refers to the probability of obtaining a value of the sample that is very different from the expected or observed value. It entails formulating a null hypothesis and determining the probability of the null hypothesis being true based on the statistical significance of the

p-value, according to which the null hypothesis will be accepted or rejected against the alternate hypothesis. The statistical significance level “α”, which refers to the margin of error in the probability of falsely rejecting the null hypothesis, must also be defined. It is usually equal to $\alpha = 0.05$, implying that the probability of rejected the null hypothesis in favor of the alternative hypothesis should be less or equal than 5%.

In the context of this research, data from the collected “questionnaires”, i.e. knowledge and fields tests, was first inserted in Excel, where an initial stage of coding into variables was performed. The variables of questions were assigned the values 0 and 1, representing the wrong and correct answers to the questions of each test. The variable “group” was assigned the values 0 (experimental) and 1 (control). Similarly, the variable “gender” was assigned the values 0 (male) and 1 (female). Finally, the variable “region” was assigned the values 0 (Larnaka), 1 (Nicosia) and 2 (Limassol).

Then, the pre-processed data was imported into SPSS for further processing and analysis. For each question of the two tests (on Physics and P.E.) two variables were created to match the answers of students at the “pre” and “post” stages. Additional variables included group, region and gender, referring to the experimental and control groups and basic demographics of students.

Furthermore, to facilitate the process of data analysis, new variables were computed:

- 41 variables named “diff_pqX” (where X={1-3, 6-8, 10-14, 16-39, 41, 43, 46-50) represented the existence of different performance per question and student between the pre and post PHYSICS knowledge tests.
- 5 variables named “diff_peqX” (where X=1,2, …, 5) represented the existence of different performance per question and student between the pre and post P.E. field tests.
- 10 variables named “mean_subjectX_pre” and “mean_subjectX_pre” (where X=1,2, …, 5) represented the average performance of each student in the pre and post knowledge tests on the 5 subtopics of PHYSICS.

The statistical analysis carried out in SPSS aimed to answer specific research questions regarding the students’ understanding of topics related to PHYSICS and P.E.

The statistical analysis regarding PHYSICS knowledge test followed a bottom-up approach, starting from the investigation of factors potentially influencing students' understanding of each individual question of the test, then continuing with the examination of factors affecting students' understanding of each of the five subtopics (Friction/Stopping Distance, Air Resistance, Up thrust, Stretch and Weight/Gravity) and ending with the study of the relationship between the understanding of the entire topic of Forces and each of the two independent factors (group and gender).

On the other hand, the statistical analysis related with P.E. fields test was more straightforward, since the test consisted of five questions, one per exercise-goal (Transfer of the Ball, Air Resistance, Aerobic Exercise, Flexibility and Energy Balance/Body Mass Index).

To this end, the following Null Hypotheses were formed, along with their respective Alternative Hypotheses. Hypotheses 1 to 83 examined each individual question of PHYSICS knowledge test, while Hypotheses 94 to 123 examined the question groups belonging to each PHYSICS subtopic. Hypotheses 84 to 93 and 114 to 133 were focused on P.E. fields test activities. Hypotheses 134 to 147 involved the aggregation of all question variables for PHYSICS and P.E. to assess the potential impact of group and gender variables on each.

- Null Hypotheses: $H_1^0 \dots H_{41}^0$

  There is no statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question X of PHYSICS knowledge test. (where X={1-3, 6-8, 10-14, 16-39, 41, 43, 46-50)

- Null Hypotheses: $H_{42}^0 \dots H_{83}^0$

  There is no statistically significant difference between male and female participants, regarding the improvement of understanding of Question X of PHYSICS knowledge test. (where X={1-3, 6-8, 10-14, 16-39, 41, 43, 46-50)

- Null Hypotheses: $H_{84}^0 \dots H_{88}^0$

There is no statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question X of P.E. fields test. (where X=1,2, …, 5)

- Null Hypotheses: $H_{89}^{0} \dots H_{93}^{0}$

There is no statistically significant difference between male and female participants, regarding the improvement of understanding of Question X of P.E. fields test. (where X=1,2, …, 5)

- Null Hypotheses: $H_{94}^{0} \dots H_{98}^{0}$

There is no statistically significant difference between the experimental and control group, regarding the understanding of Subtopic X (<titleX>) of PHYSICS knowledge test in the pre-trial phase. (where X=1,2, …, 5)

- Null Hypotheses: $H_{99}^{0} \dots H_{103}^{0}$

There is no statistically significant difference between the experimental and control group, regarding the understanding of Subtopic X (<titleX>) of PHYSICS knowledge test in the post-trial phase. (where X=1,2, …, 5)

- Null Hypotheses: $H_{104}^{0} \dots H_{108}^{0}$

There is no statistically significant difference between male and female participants, regarding the understanding of Subtopic X (<titleX>) of PHYSICS knowledge test in the pre-trial phase. (where X=1,2, …, 5)

- Null Hypotheses: $H_{109}^{0} \dots H_{113}^{0}$

There is no statistically significant difference between male and female participants, regarding the understanding of Subtopic X (<titleX>) of PHYSICS knowledge test in the post-trial phase. (where X=1,2, …, 5)

- Null Hypotheses: $H_{114}^{0} \dots H_{118}^{0}$

There is no statistically significant difference between the experimental and control group, regarding the understanding of Subtopic X (<titleX>) of P.E. fields test in the pre-trial phase. (where X=1,2, …, 5)

- Null Hypotheses: $H^0_{119} \ldots H^0_{123}$

  There is no statistically significant difference between the experimental and control group, regarding the understanding of Subtopic X (<titleX>) of P.E. fields test in the post-trial phase. (where X=1,2, …, 5)

- Null Hypotheses: $H^0_{124} \ldots H^0_{128}$

  There is no statistically significant difference between male and female participants, regarding the understanding of Subtopic X (<titleX>) of P.E. fields test in the pre-trial phase. (where X=1,2, …, 5)

- Null Hypotheses: $H^0_{129} \ldots H^0_{133}$

  There is no statistically significant difference between male and female participants, regarding the understanding of Subtopic X (<titleX>) of P.E. fields test in the post-trial phase. (where X=1,2, …, 5)

Hypotheses 1 to 133 were investigated using several statistical methods and tests, including correlations, cross-tabulation and t-tests.

- Null Hypotheses: $H^0_{134} \ldots H^0_{138}$

  There is no statistically significant difference between the experimental and control group, regarding the improvement of understanding of Subtopic X of PHYSICS knowledge test. (where X=1,2, …, 5)

- Null Hypotheses: $H^0_{139} \ldots H^0_{143}$

  There is no statistically significant difference between male and female participants, regarding the improvement of understanding of Subtopic X of PHYSICS knowledge test. (where X=1,2, …, 5)

- Null Hypothesis: H^0_{144}

There is no statistically significant difference between the experimental and control group, regarding the improvement in the understanding of PHYSICS.

- Null Hypothesis: H_{145}^{0}

  There is no statistically significant difference between male and female participants, regarding the improvement in the understanding of "FORCES" in PHYSICS.

- Null Hypothesis: H_{146}^{0}

  There is no statistically significant difference between the experimental and control group, regarding the improvement in the understanding of "FORCES" in P.E.

- Null Hypothesis: H_{147}^{0}

  There is no statistically significant difference between male and female participants, regarding the improvement in the understanding of "FORCES" in P.E.

Hypotheses 133 – 147 were examined using correlations, t-tests and three-way repeated measures GLM.

Therefore, the main statistical methods applied during the statistical analysis and the respective statistics examined per method are described below in detail.

3.6.1. Correlations

Correlations measure how variables or rank orders are related. Pearson's correlation coefficient is a measure of linear association. Two variables can be perfectly related, but if the relationship is not linear, Pearson's correlation coefficient is not an appropriate statistic for measuring their association. Pearson's r is suitable for quantitative, normally distributed variables, whereas Spearman's rho is appropriate for variables which are not normally distributed or have ordered categories. Correlation coefficients range in value from –1 (a perfect negative relationship) and +1 (a perfect positive relationship). A value of 0 indicates no relationship. However, it is important to avoid drawing any cause-and-effect conclusions due to a significant correlation. Finally, when examining bivariate correlations, one-tailed or two-tailed tests of significance are performed, depending on whether the direction of the association is known or not (IBM Knowledge Center, 2017).

3.6.2. Cross-Tabulation

The Crosstabs procedure in SPSS forms two-way and multi-way tables and provides a variety of tests and measures of association for two-way tables. The structure of the table and whether categories are ordered determine what test or measure to use (IBM Knowledge Center, 2017).

For nominal data with no intrinsic order (such as male/female gender and experimental/control group) suitable statistics include (IBM Knowledge Center, 2017):

- Contingency coefficient. A measure of association based on chi-square. The value ranges between 0 and 1, with 0 indicating no association between the row and column variables and values close to 1 indicating a high degree of association between the variables. The maximum value possible depends on the number of rows and columns in a table.
- Phi (coefficient) and Cramér's V. Phi is a chi-square-based measure of association that involves dividing the chi-square statistic by the sample size and taking the square root of the result. Cramer's V is a measure of association based on chi-square.
- Lambda (symmetric and asymmetric lambdas and Goodman and Kruskal's tau). A measure of association that reflects the proportional reduction in error when values of the independent variable are used to predict values of the dependent variable. A value of 1 means that the independent variable perfectly predicts the dependent variable. A value of 0 means that the independent variable is no help in predicting the dependent variable.
- Uncertainty coefficient. A measure of association that indicates the proportional reduction in error when values of one variable are used to predict values of the other variable. For example, a value of 0.83 indicates that knowledge of one variable reduces error in predicting values of the other variable by 83%. The program calculates both symmetric and asymmetric versions of the uncertainty coefficient.

When one variable is categorical, coded numerically, and the other is quantitative, Eta is the appropriate statistic. It is a measure of association that ranges from 0 to 1, with 0 indicating no association between the row and column variables and values close to 1 indicating a high degree of association. Eta is appropriate for a dependent variable measured on an interval scale and an independent variable with a limited number of categories (for example, gender). Two eta values are computed: one treats the row variable as the interval variable, and the other treats the column variable as the interval variable (IBM Knowledge Center, 2017).

Finally, McNemar is a useful nonparametric test for two related dichotomous variables, which tests for changes in responses using the chi-square distribution. It can detect changes in responses due to experimental intervention in "before-and-after" designs (IBM Knowledge Center, 2017).

3.6.3. Independent-Samples vs. Paired-Samples T-Test

The Independent-Samples T Test procedure compares means for two groups of cases. Ideally, for this test, the subjects should be randomly assigned to two groups, so that any difference in response is due to the treatment (or lack of treatment) and not to other factors. For each quantitative test variable, the statistics computed include: sample size, mean, standard deviation, and standard error of the mean. For the difference in means, mean, standard error, and confidence interval (you can specify the confidence level) are calculated. Statistical tests involve Levene's test for equality of variances and both pooled-variances and separate-variances t tests for equality of means. For the equal-variance t test, the observations should be independent, random samples from normal distributions with the same population variance. For the unequal-variance t test, the observations should be independent, random samples from normal distributions. The two-sample t test is fairly robust to departures from normality (IBM Knowledge Center, 2017).

On the other hand, the Paired-Samples T-Test procedure compares the means of two quantitative variables for a single group. The procedure computes the differences between values of the two variables for each case and tests whether the average differs from 0. For each variable, the calculated statistics are mean, sample size, standard deviation, and standard error of the mean, while for each pair of variables, statistics include correlation, average difference in means, t test, and confidence interval for mean difference (usually a 95% confidence interval), as well as standard deviation and standard error of the mean difference. Observations for each pair should be made under the same conditions. The mean differences should be normally distributed. Variances of each variable can be equal or unequal. This procedure is often used for before-after measures (IBM Knowledge Center, 2017).

3.6.4. Three-way Repeated Measures

In SPSS, the GLM Repeated Measures procedure provides analysis of variance when the same measurement is made several times on each subject or case. When between-subjects factors are specified, they divide the population into groups. Using this general linear model procedure, it is possible to test null hypotheses about the effects of both the between-subjects factors and the within-subjects factors, as well as to investigate interactions between factors and the effects of individual factors. Furthermore, the effects of constant covariates and covariate interactions with the between-subjects factors can be included (IBM Knowledge Center, 2017).

Commonly used a priori contrasts are available to perform hypothesis testing on between-subjects factors. Additionally, after an overall F test has shown significance, post hoc tests can be used to evaluate differences among specific means. Estimated marginal means provide estimates of predicted mean values for the cells in the model, and profile plots (interaction plots) of these means facilitate the visualization of certain relationships (IBM Knowledge Center, 2017).

Type I, Type II, Type III, and Type IV sums of squares can be used to evaluate different hypotheses. Type III is the default (IBM Knowledge Center, 2017).

Descriptive statistics include observed means, standard deviations, and counts for all of the dependent variables in all cells. When post-hoc range tests and multiple comparisons (for between-subjects factors) are applied, they involve the calculation of the following statistics: least significant difference, Bonferroni, Sidak, Scheffé, Ryan-Einot-Gabriel-Welsch multiple F, Ryan-Einot-Gabriel-Welsch multiple range, Student-Newman-Keuls, Tukey's honestly significant difference, Tukey's b, Duncan, Hochberg's GT2, Gabriel, Waller Duncan t test, Dunnett (one-sided and two-sided), Tamhane's T2, Dunnett's T3, Games-Howell, and

Dunnett's C. Finally, statistical tests that can be carried out under this procedure include the Levene test and Box's M for homogeneity of variance, and Mauchly's test of sphericity (IBM Knowledge Center, 2017).

The dependent variables should be quantitative. Between-subjects factors are categorical, can have numeric or string values and divide the sample into discrete subgroups, such as male and female or experimental and control group. Within-subjects factors are also defined and are not existing variables in the data. Covariates are quantitative variables that are related to the dependent variable. For a repeated measures analysis, these should remain constant at each level of a within-subjects variable (IBM Knowledge Center, 2017).

The data should contain a set of variables for each group of measurements on the subjects. The set has one variable for each repetition of the measurement within the group. A within-subjects factor is defined for the group with the number of levels equal to the number of repetitions (IBM Knowledge Center, 2017).

A repeated measures analysis can be approached in two ways, univariate and multivariate. The univariate approach (also known as the split-plot or mixed-model approach) considers the dependent variables as responses to the levels of within-subjects factors. The measurements on a subject should be a sample from a multivariate normal distribution, and the variance-covariance matrices are the same across the cells formed by the between-subjects effects. Certain assumptions are made on the variance-covariance matrix of the dependent variables. The validity of the F statistic used in the univariate approach can be assured if the variance-covariance matrix is circular in form. To test this assumption, Mauchly's test of sphericity can be used, which performs a test of sphericity on the variance-covariance matrix of an orthonormalized transformed dependent variable. Mauchly's test is automatically displayed for a repeated measures analysis. For small sample sizes, this test is not very powerful. For large sample sizes, the test may be significant even when the impact of the departure on the results is small. If the significance of the test is large, the hypothesis of sphericity can be assumed. However, if the significance is small and the sphericity assumption appears to be violated, an adjustment to the numerator and denominator degrees of freedom can be made in order to validate the univariate F statistic. Three estimates of this adjustment, which is called epsilon, are available in the GLM Repeated Measures procedure. Both the numerator and denominator degrees of freedom must be multiplied by epsilon, and the significance of the F ratio must be evaluated with the new degrees of freedom (IBM Knowledge Center, 2017).

The multivariate approach considers the measurements on a subject to be a sample from a multivariate normal distribution, and the variance-covariance matrices are the same across the cells formed by the between-subjects effects. To test whether the variance-covariance matrices across the cells are the same, Box's M test can be used (IBM Knowledge Center, 2017).

IV. Findings

This chapter aims to present the findings of the statistical analysis performed on the data gathered via the knowledge and fields tests that students filled in pre and post teaching the subject of Forces.

4.1. Improvement in the Understanding of Each Individual Question of PHYSICS Knowledge Test

As explained previously in Section 3.6 (Data Processing & Analysis Methodology), a new dichotomous variable was computed per each individual question of PHYSICS knowledge test, indicating whether there was a difference in the students' performance and understanding in the "pre" and "post" phases of the trial, with 0 representing the negative answer and 1 signifying a positive answer.

The first step was to apply nonparametric correlations between each of these variables and each of the two factors under consideration, i.e. group and gender, leading to the generation of Table 6, which summarizes the results (the entire output of Table 6, as calculated in SPSS, is available in Appendix C). Since the dichotomous variables are nominal, Spearman's rho was considered appropriate to test for statistically significant correlation. Table 6 also shows that there is no statistically significant relationship between group and gender at a significance level of $a = 5\%$.

Table 6 indicates the existence of statistically significant relationships between a few of the new dichotomous variables and group, at a significance level of either $a = 1\%$ or $a = 5\%$.

On the contrary, there were no statistically significant relationships between any of the new dichotomous variables and gender.

In detail, at a significance level of $a = 1\%$, there was a statistically significant difference in the students' performance and understanding in the "pre" and "post" phases of the trial, regarding the following questions:

- Question 2 (under subtopic "Friction/Stopping Distance")
- Question 17 (under subtopic "Air Resistance")
- Questions 21, 22, 23, 24, 27, 28, 30 (under subtopic "Up Thrust")
- Questions 30, 31, 32, 33, 34, 35, 36, 37, 38, 39 (under subtopic "Stretch")
- Questions 41, 43, 45, 46, 47, 48, 49, 50 (under subtopic "Weight/Gravity")

Similarly, at a significance level of $a = 5\%$, there was a statistically significant difference in the students' performance and understanding in the "pre" and "post" phases of the trial, regarding the following questions:

- Question 8 (under subtopic "Friction/Stopping Distance")
- Questions 18, 20 (under subtopic "Air Resistance")
- Question 26, 29 (under subtopic "Up Thrust")

On the contrary, there was no statistically significant difference in the students' performance and understanding in the "pre" and "post" phases of the trial, regarding the following questions:

- Questions 3, 6, 7, 10 (under subtopic "Friction/Stopping Distance")
- Questions 11, 12, 13, 14, 19 (under subtopic "Air Resistance")
- Question 25 (under subtopic "Up Thrust")

Table 6: Nonparametric Correlations Investigating the Association between Group / Gender and the Understanding of Individual Questions of PHYSICS Knowledge Test

Nonparametric Correlations (Calculation of Spearman's rho Correlation Coefficient)		
	Group	**Gender**
Difference in Performance in Question 2 of Physics Knowledge Test	-.192**	.071
Difference in Performance in Question 3 of Physics Knowledge Test	-.034	.034
Difference in Performance in Question 6 of Physics Knowledge Test	-.071	-.033
Difference in Performance in Question 7 of Physics Knowledge Test	-.045	.000
Difference in Performance in Question 8 of Physics Knowledge Test	-.175*	.052
Difference in Performance in Question 10 of Physics Knowledge Test	-.073	.012
Difference in Performance in Question 11 of Physics Knowledge Test	-.023	.018

Difference in Performance in Question 12 of Physics Knowledge Test	-.037	.024
Difference in Performance in Question 13 of Physics Knowledge Test	-.057	-.105
Difference in Performance in Question 14 of Physics Knowledge Test	.024	-.059
Difference in Performance in Question 17 of Physics Knowledge Test	.349**	-.061
Difference in Performance in Question 18 of Physics Knowledge Test	-.166*	-.057
Difference in Performance in Question 19 of Physics Knowledge Test	-.023	-.098
Difference in Performance in Question 20 of Physics Knowledge Test	-.190*	-.081
Difference in Performance in Question 21 of Physics Knowledge Test	-.317**	-.089
Difference in Performance in Question 22 of Physics Knowledge Test	-.211**	-.101
Difference in Performance in Question 23 of Physics Knowledge Test	-.214**	-.105
Difference in Performance in Question 24 of Physics Knowledge Test	-.264**	-.059
Difference in Performance in Question 25 of Physics Knowledge Test	.000	.000
Difference in Performance in Question 26 of Physics Knowledge Test	-.183*	.048
Difference in Performance in Question 27 of Physics Knowledge Test	-.285**	-.081
Difference in Performance in Question 28 of Physics Knowledge Test	-.272**	-.023
Difference in Performance in Question 29 of Physics Knowledge Test	-.172*	.054
Difference in Performance in Question 30 of Physics Knowledge Test	-.216**	-.103
Difference in Performance in Question 31 of Physics Knowledge Test	-.274**	-.047
Difference in Performance in Question 32 of Physics Knowledge Test	-.270**	.005
Difference in Performance in Question 33 of Physics Knowledge Test	-.321**	-.003
Difference in Performance in Question 34 of Physics Knowledge Test	-.292**	-.065
Difference in Performance in Question 35 of Physics Knowledge Test	-.284**	.011
Difference in Performance in Question 36 of Physics Knowledge Test	-.264**	.008
Difference in Performance in Question 37 of Physics Knowledge Test	-.298**	-.071
Difference in Performance in Question 38 of Physics Knowledge Test	-.298**	-.026
Difference in Performance in Question 39 of Physics Knowledge Test	-.271**	.046
Difference in Performance in Question 41 of Physics Knowledge Test	-.264**	.054
Difference in Performance in Question 43 of Physics Knowledge Test	-.312**	.037
Difference in Performance in Question 45 of Physics Knowledge Test	-.342**	-.024
Difference in Performance in Question 46 of Physics Knowledge Test	-.348**	-.052
Difference in Performance in Question 47 of Physics Knowledge Test	-.393**	-.031
Difference in Performance in Question 48 of Physics Knowledge Test	-.390**	-.026
Difference in Performance in Question 49 of Physics Knowledge Test	-.384**	-.064
Difference in Performance in Question 50 of Physics Knowledge Test	-.345**	.043

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

The above results of nonparametric correlations were supported by the results of crosstab and independent-sample t-test procedures, through which additional statistical tests were carried out with different statistics.

The results of crosstabs are summarized in Table 6(b), available in Appendix C. As explained in Chapter 3, since the examined variables are all nominal with two categories each, Phi coefficient and Cramer's V can be used to measure the strength of the association between each pair of variables and assess whether there is a statistically significant relationship between them. Since their values are identical, their results are merged. Figures 6 - 46 are also indicative of the results as they visualize the distribution of alternative values of the dichotomous question-related variables per group and per gender.

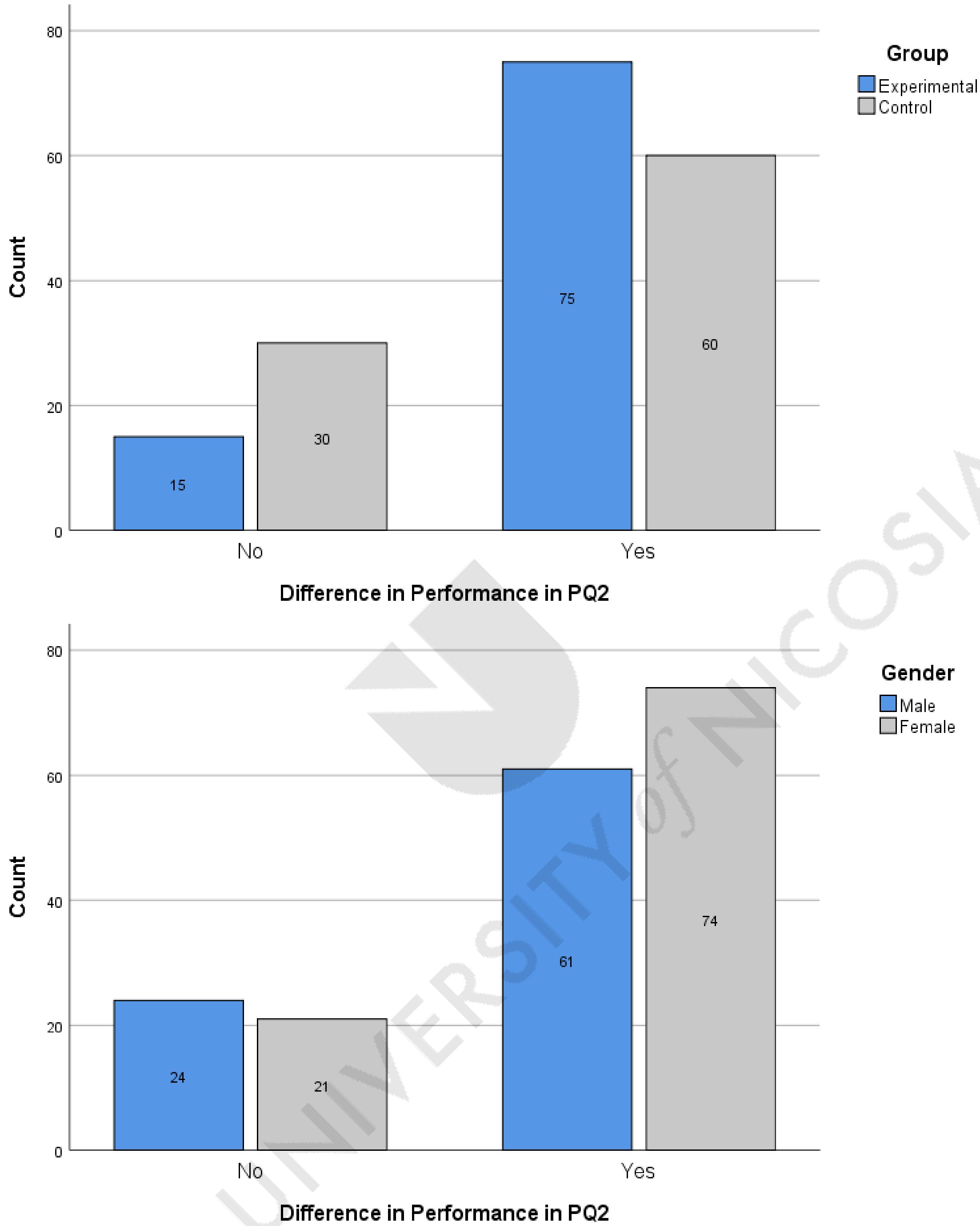


Figure 6: Investigating Potential Association between Group / Gender and Understanding of Question 2 of PHYSICS Knowledge Test

Figure 6 shows that when asked about an example of intentional friction increase in Question 2 of the Physics Knowledge Test, there were significantly more students in the experimental group that improved their answers post trial than those of the control group (Phi = -0.192, p=0.010<0.050). On the contrary, when investigating the role of gender in the improvement of understanding of Question 2, there was no significant difference between males and females (Phi = 0.071, p=0.343>0.050).

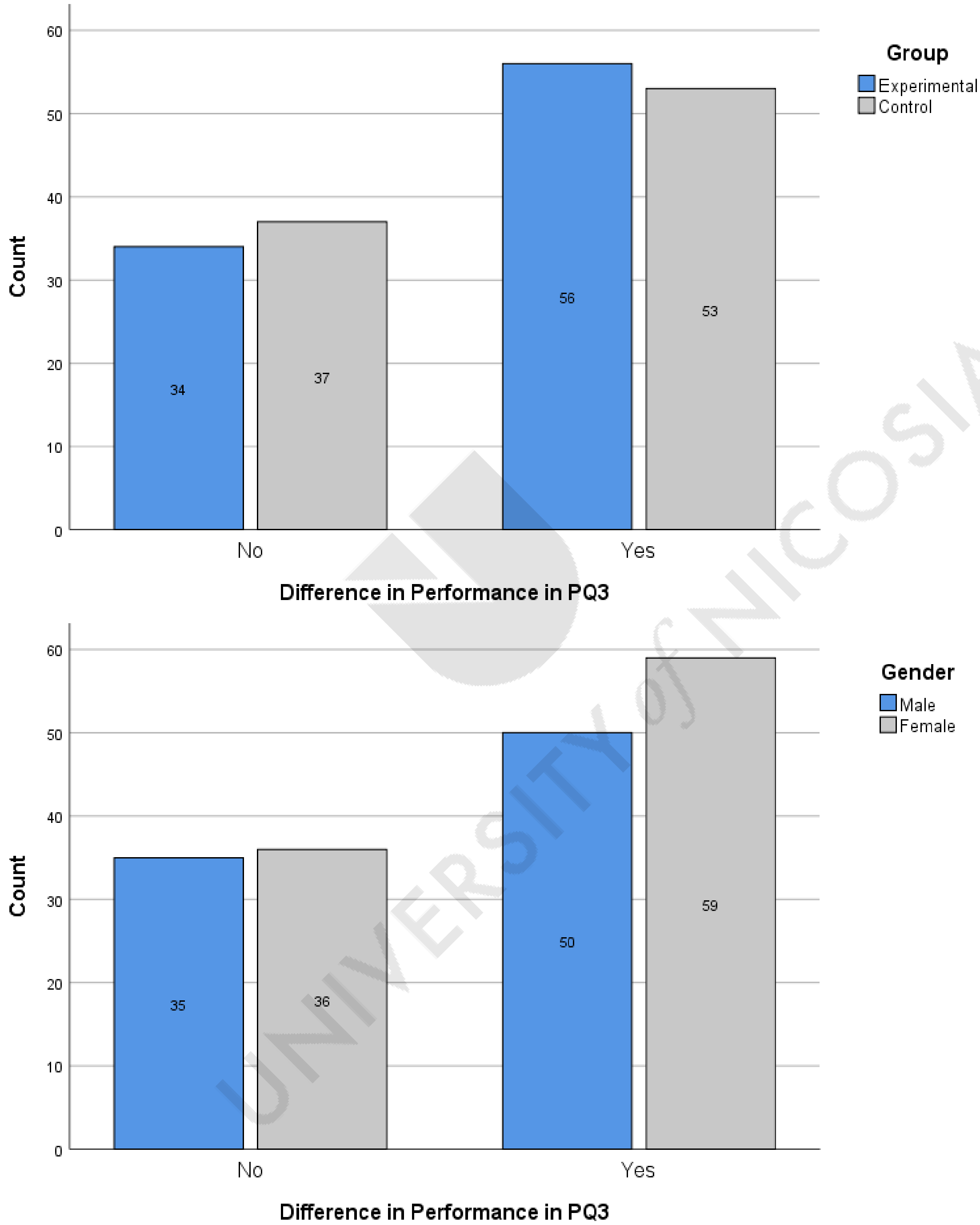


Figure 7: Investigating Potential Association between Group / Gender and Understanding of Question 3 of PHYSICS Knowledge Test

Figure 7 shows that the distribution of students with a different performance pre and post trial in Question 3, regarding frictional force, was neither affected by group (Phi = -0.034, p=0.647>0.050) nor by gender (Phi = 0.034, p=0.657>0.050).

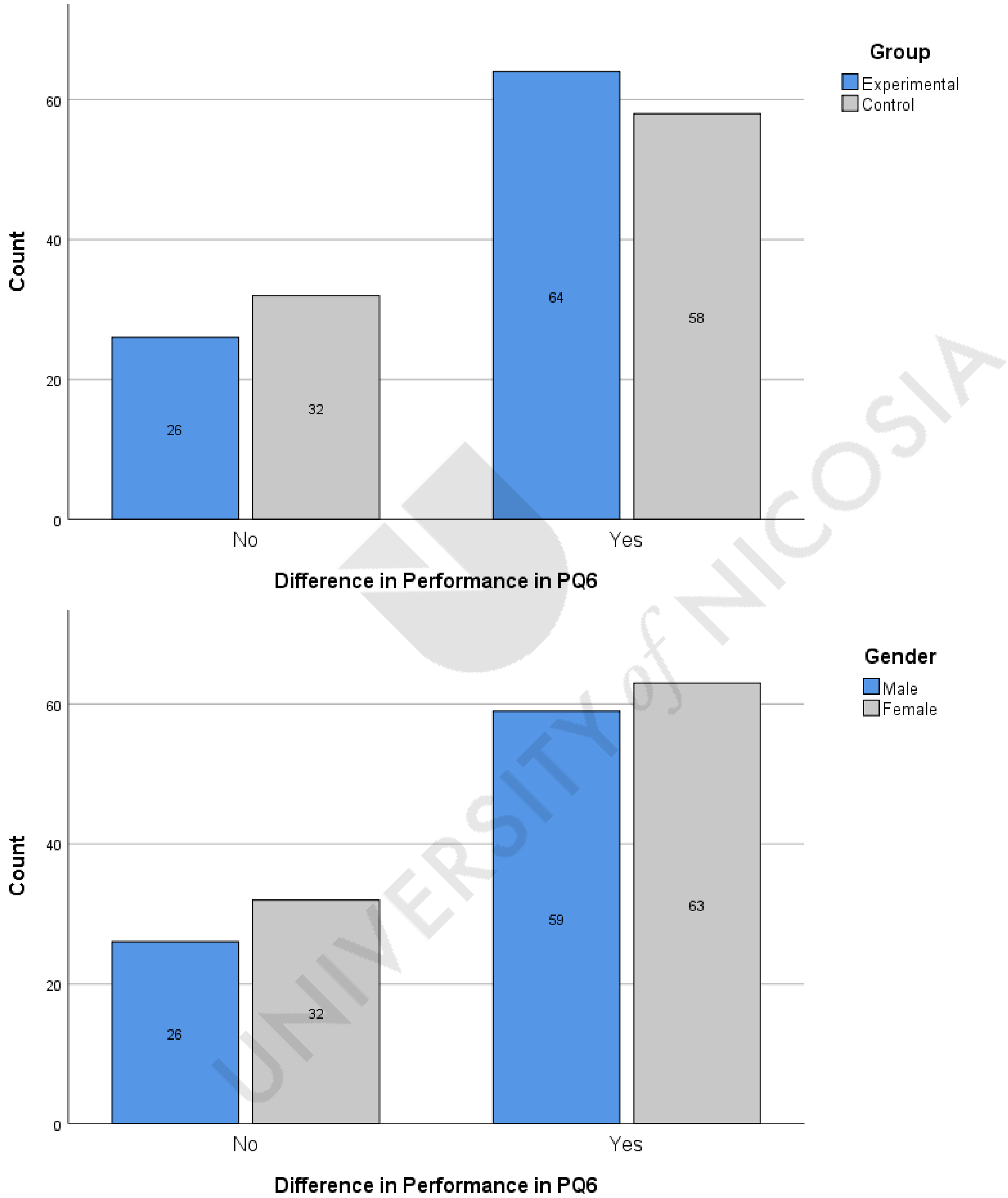


Figure 8: Investigating Potential Association between Group / Gender and Understanding of Question 6 of PHYSICS Knowledge Test

Similarly, Figure 8 shows that the same absence of statistical relationship was also observed between group (Phi = -0.071, p=0.339>0.050) and gender (Phi = -0.033, p=0.659>0.050) and the performance pre and post trial for Question 6 about friction levels among different surfaces.

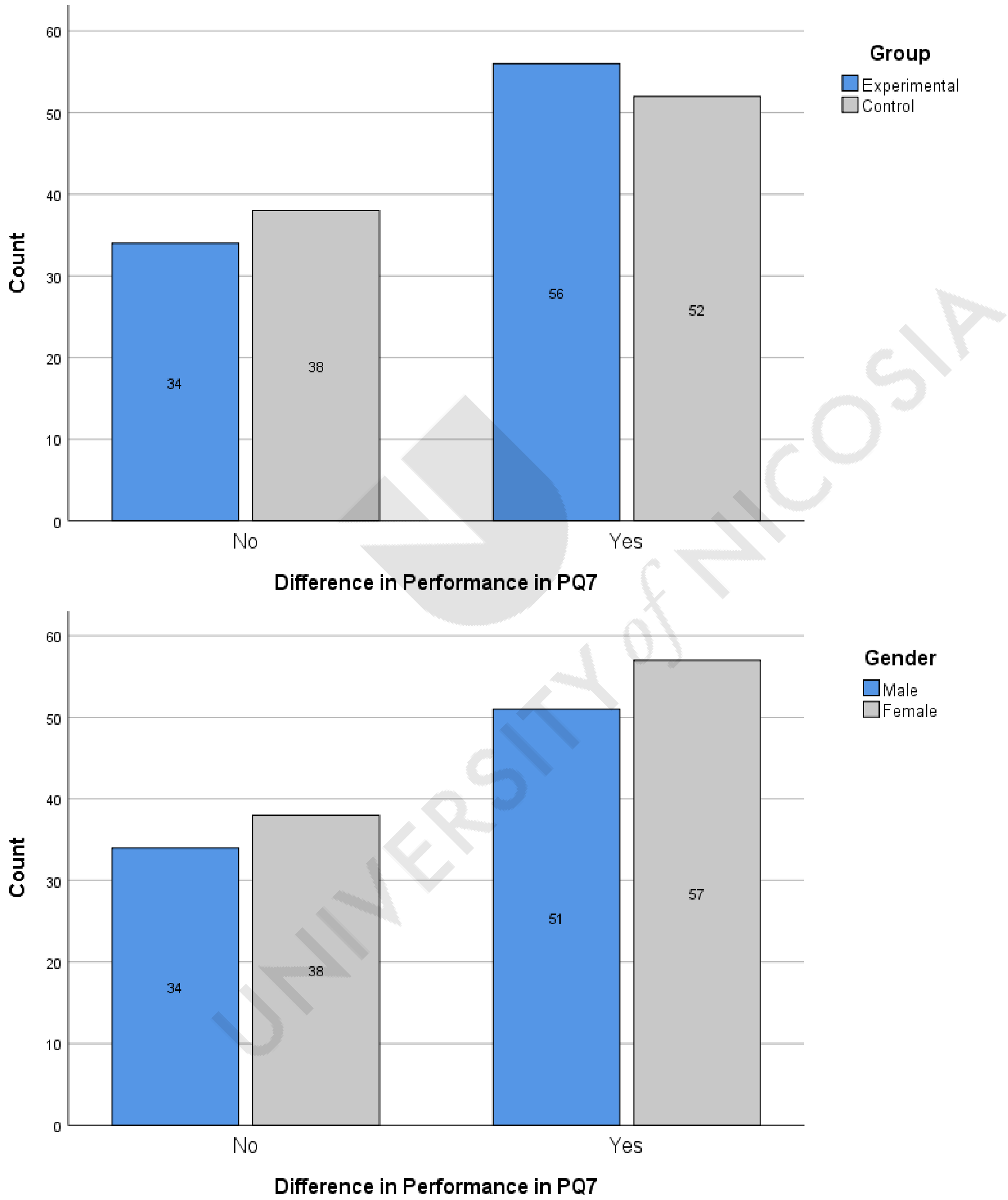


Figure 9: Investigating Potential Association between Group / Gender and Understanding of Question 7 of PHYSICS Knowledge Test

According to Figure 9, similar conclusions are reached about the impact of group (Phi = -0.045, p=0.543>0.050) and gender (Phi = 0.000, p=1.000>0.050) on the pre- and post-trial understanding of Question 7 about the factors affecting the distance a passenger is thrown from a moving car.

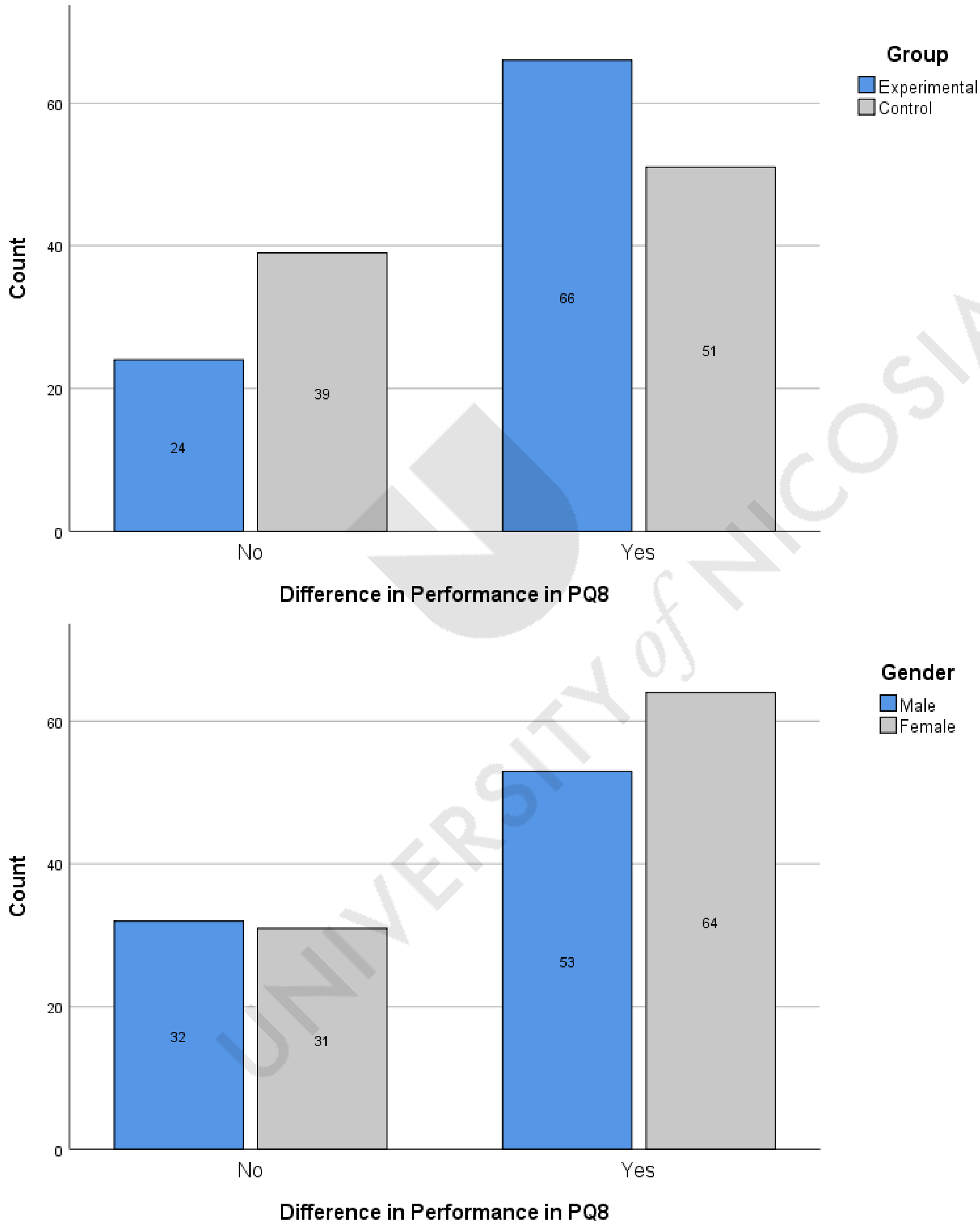


Figure 10: Investigating Potential Association between Group / Gender and Understanding of Question 8 of PHYSICS Knowledge Test

In contrast, Figure 10 shows that significantly more students in the experimental group improved their score in Question 8 about forces making a walking person move forward, than those in the control group (Phi = -0.175, p=0.019<0.050), while gender did not make any substantial difference (Phi = 0.052, p=0.481>0.050).

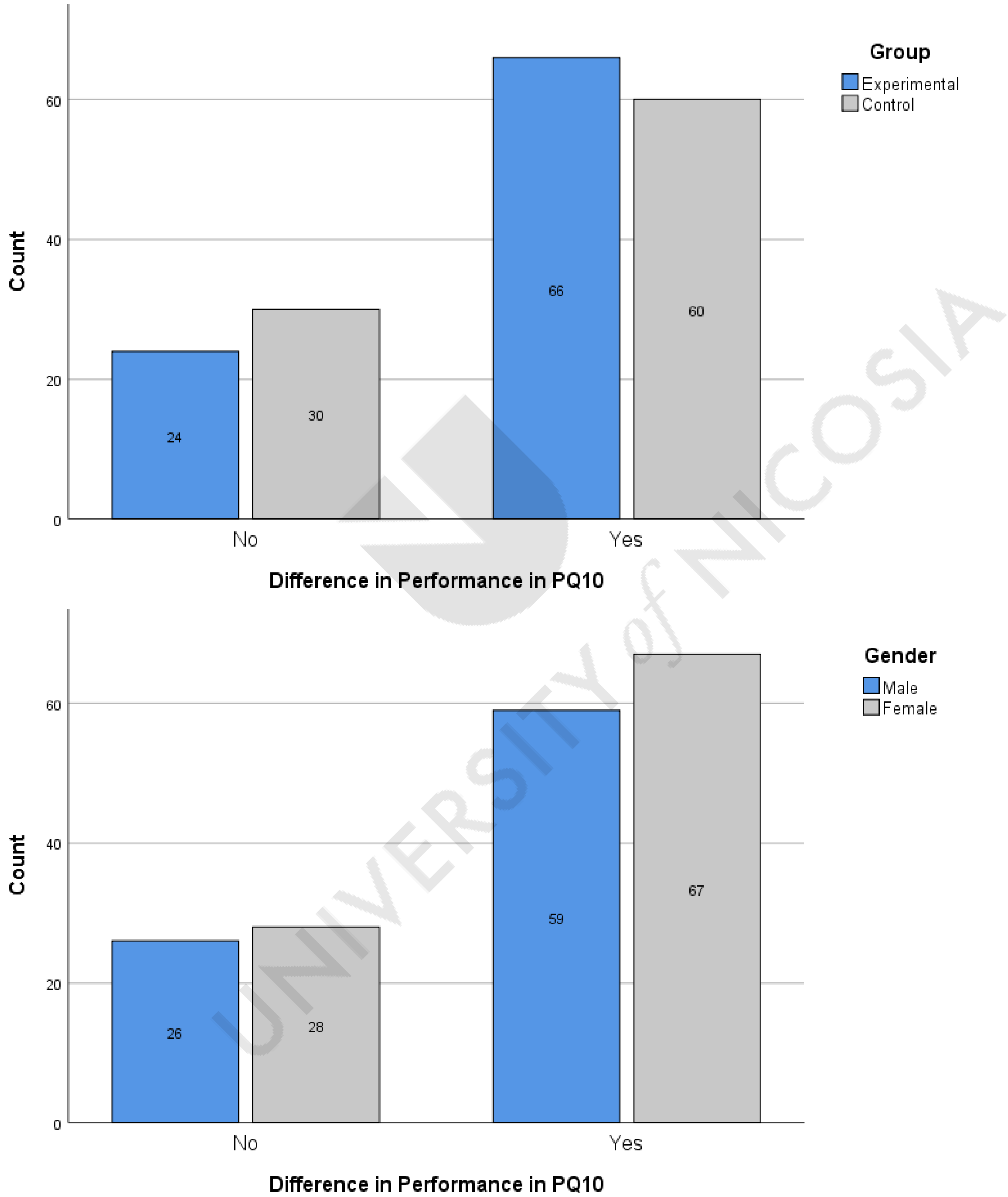


Figure 11: Investigating Potential Association between Group / Gender and Understanding of Question 10 of PHYSICS Knowledge Test

Figure 11 shows that in the last question of the first Physics subtopic (Friction/Stopping Distance), requiring the acknowledgement of friction from its definition, neither group (Phi = -0.073, p=0.329>0.050) nor gender (Phi = 0.012, p=0.871>0.050) led to statistically significant improvement in students' score pre and post trial.

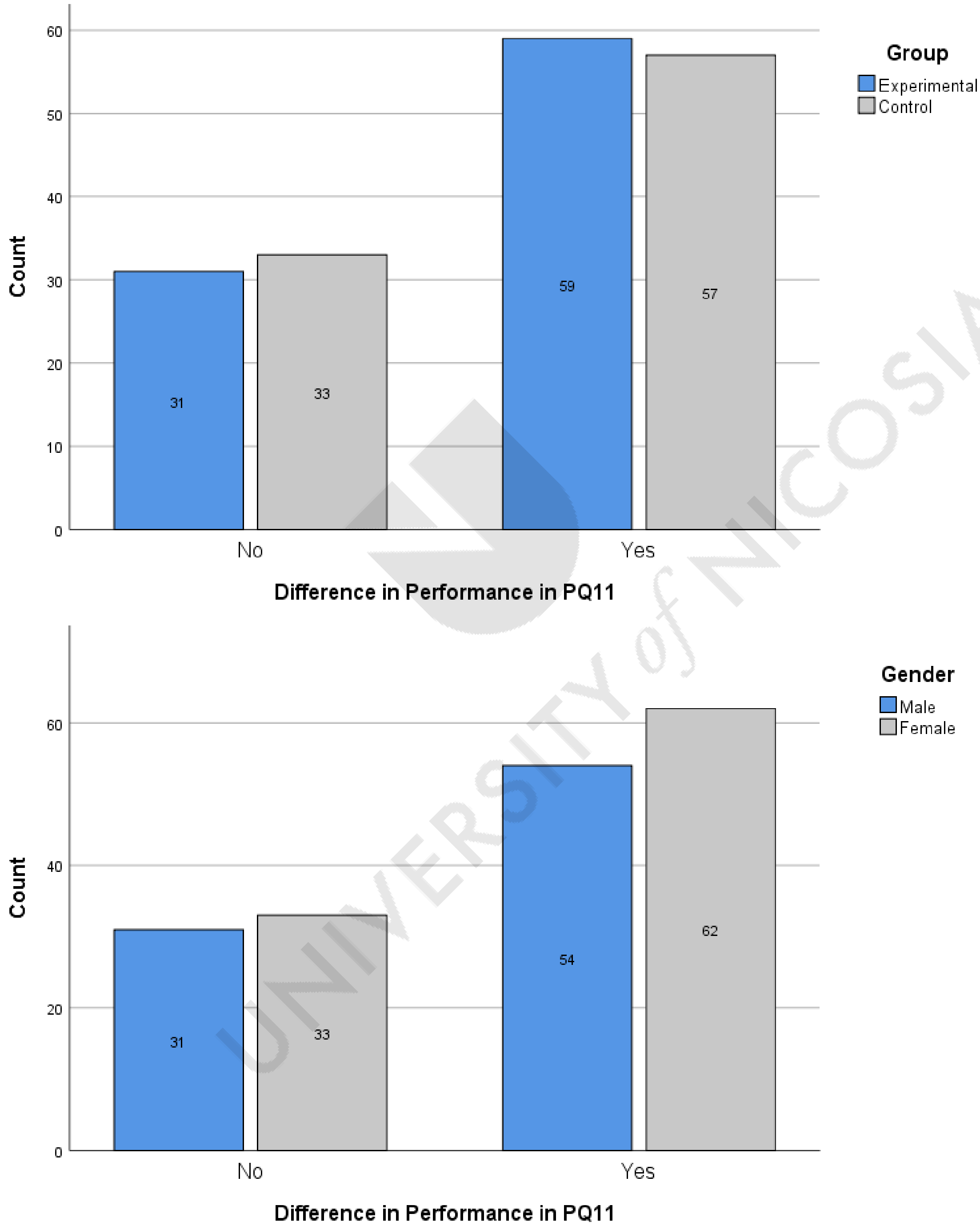


Figure 12: Investigating Potential Association between Group / Gender and Understanding of Question 11 of PHYSICS Knowledge Test

Again, Figure 12 graphically depicts the absence of significant association between group (Phi = -0.023, p=0.755>0.050) or gender (Phi = 0.018, p=0.808>0.050) and the difference in students' score in the first question of the Physics subtopic "Air Resistance", about the explanation of air resistance.

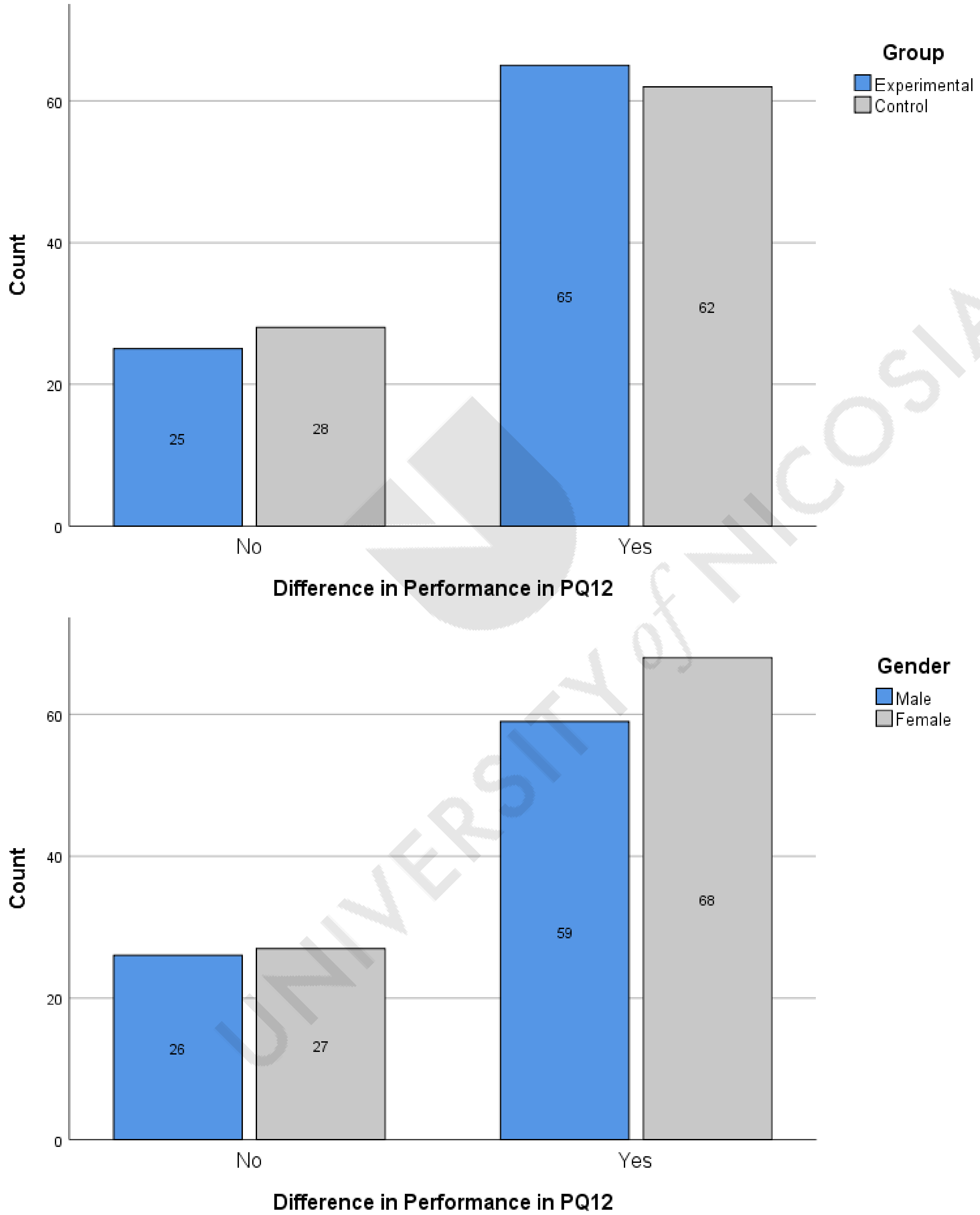


Figure 13: Investigating Potential Association between Group / Gender and Understanding of Question 12 of PHYSICS Knowledge Test

The same observations can be made when studying Figure 13 on Question 12 regarding the effects of air resistance on a person falling with a parachute, with neither group (Phi = -0.037, p=0.624>0.050) nor gender (Phi = 0.024, p=0.750>0.050) having a significant impact on students' understanding pre- and post-trial.

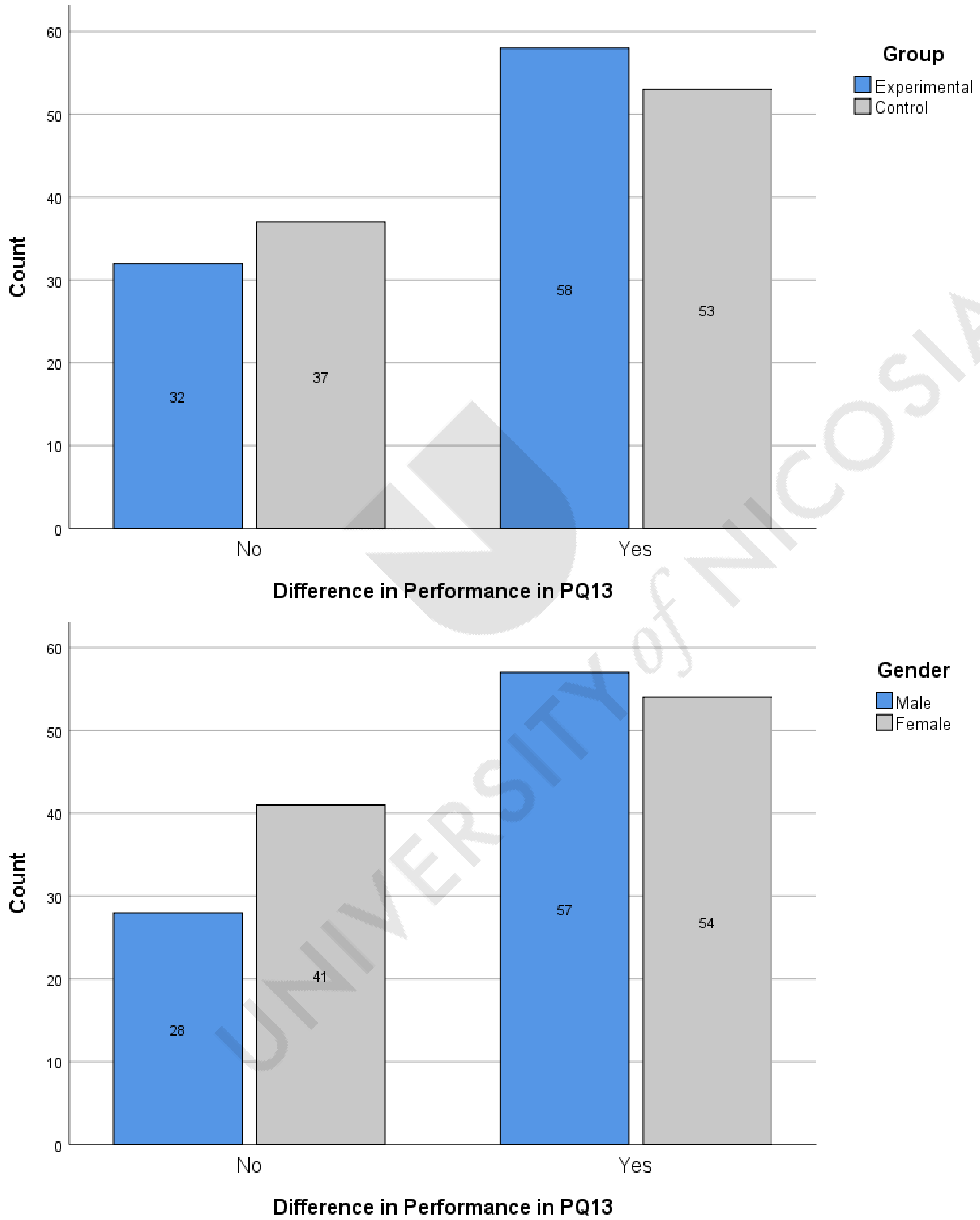


Figure 14: Investigating Potential Association between Group / Gender and Understanding of Question 13 of PHYSICS Knowledge Test

Likewise, Figure 14 confirms that group (Phi = -0.057, p=0.443>0.050) and gender (Phi = -0.105, p=0.159>0.050) did not affect students' understanding of Question 13, asking them to assess the difficulty of running with 1, 2 or 3 parachutes.

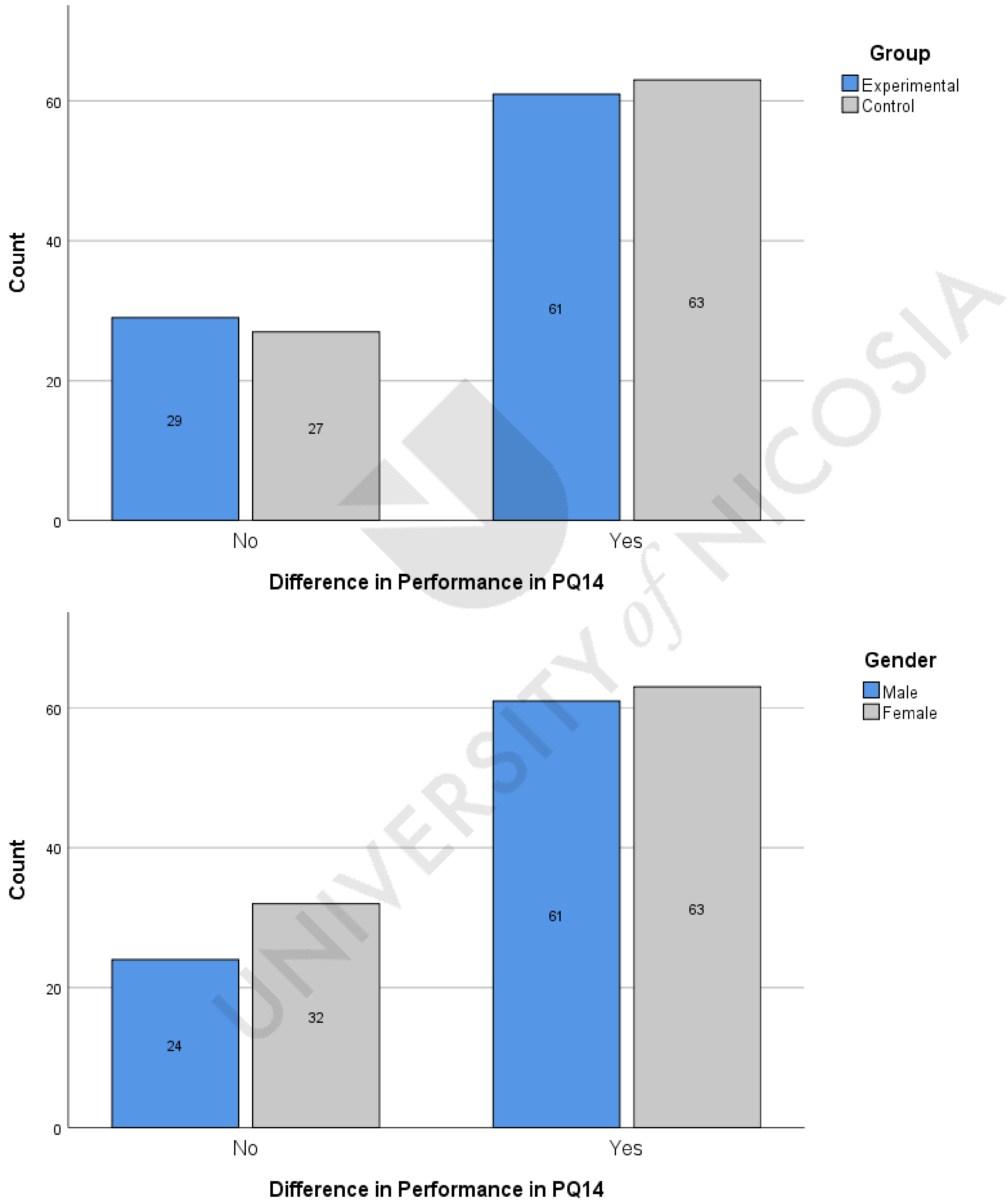
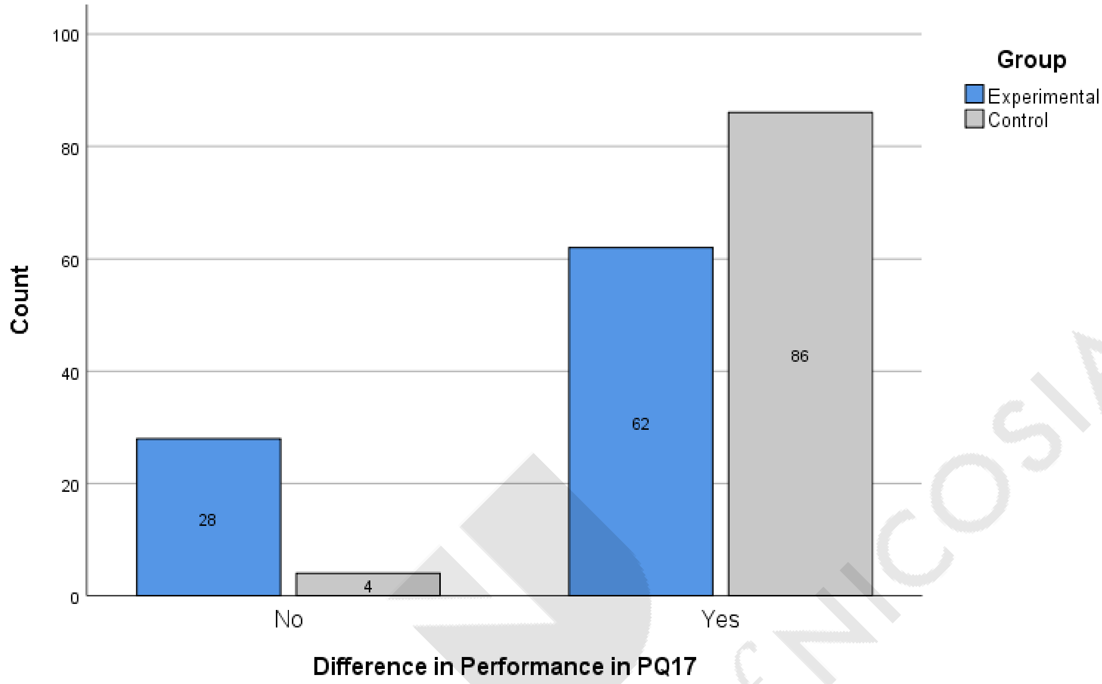


Figure 15: Investigating Potential Association between Group / Gender and Understanding of Question 14 of PHYSICS Knowledge Test

Question 14 asked students to identify the forces other than air resistance acting on a fired bullet. Figure 15 shows that although there were many students who improved their performance in this question post trial, neither group (Phi = 0.024, p=0.747>0.050) nor gender (Phi = -0.059, p=0.430>0.050) were associated with that improvement.



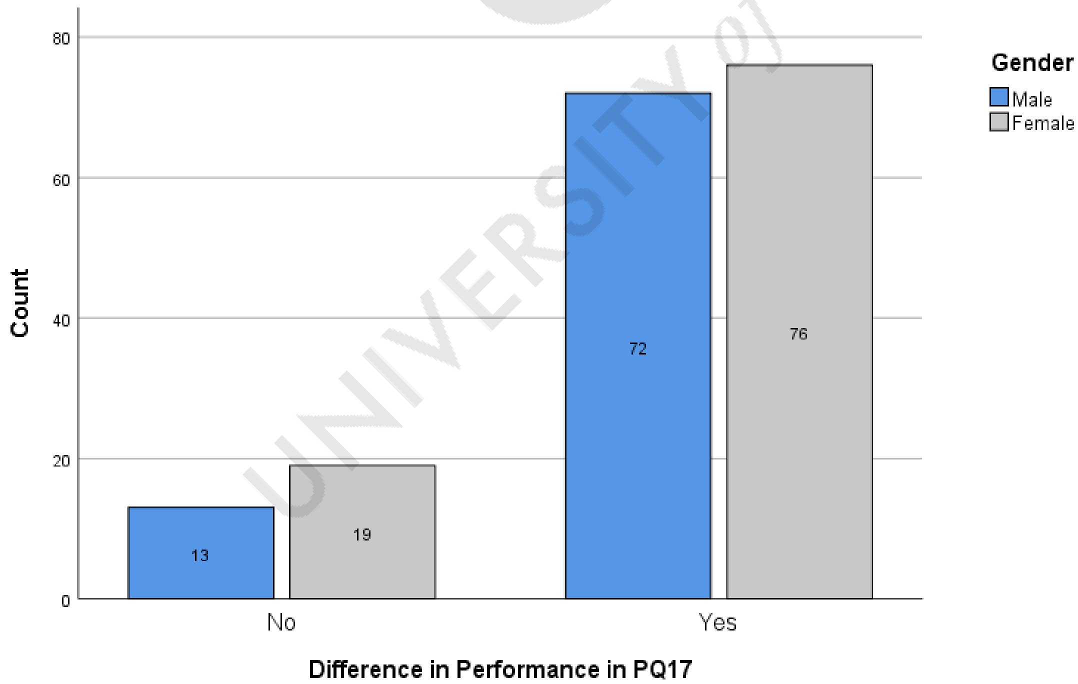


Figure 16: Investigating Potential Association between Group / Gender and Understanding of Question 17 of PHYSICS Knowledge Test

According to Figure 16, results about Question 17 on the shape of objects reducing air and water resistance surprisingly revealed a reverse association between group and post-trial performance improvement, with more students from the control group improving their performance than those from the experimental group (Phi = 0.349, p=0.000<0.050). Again, gender did not appear to affect students' performance (Phi = -0.061, p=0.410>0.050).

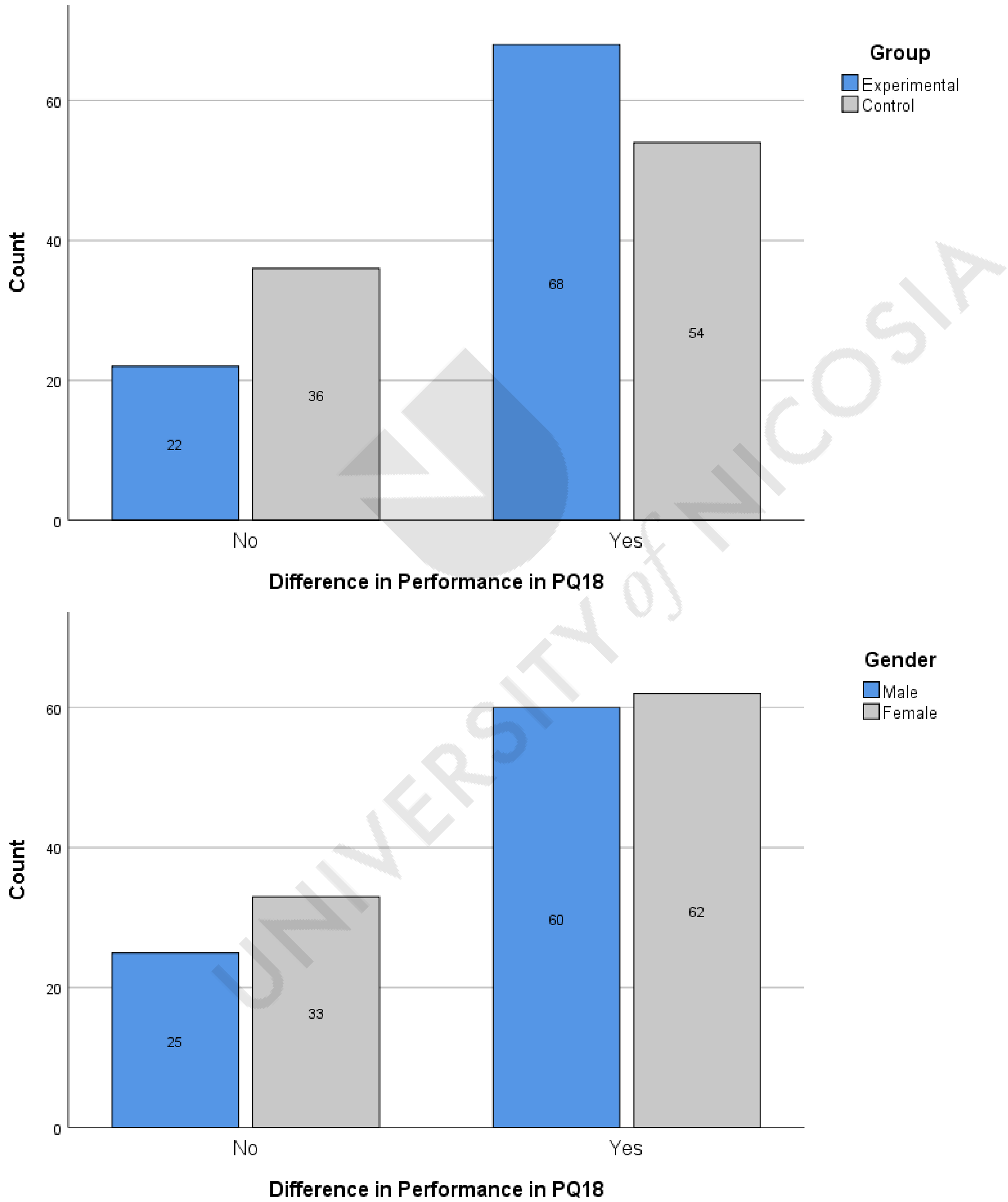


Figure 17: Investigating Potential Association between Group / Gender and Understanding of Question 18 of PHYSICS Knowledge Test

Figure 17 shows that students from the experimental group had a significantly higher performance improvement ratio than those from the control group in the case of Question 18 regarding the effects of multiple forces acting on a tennis ball (Phi = -0.166, $p=0.026<0.050$). On the contrary, gender was not a statistically significant factor (Phi = -0.057, $p=0.445>0.050$).

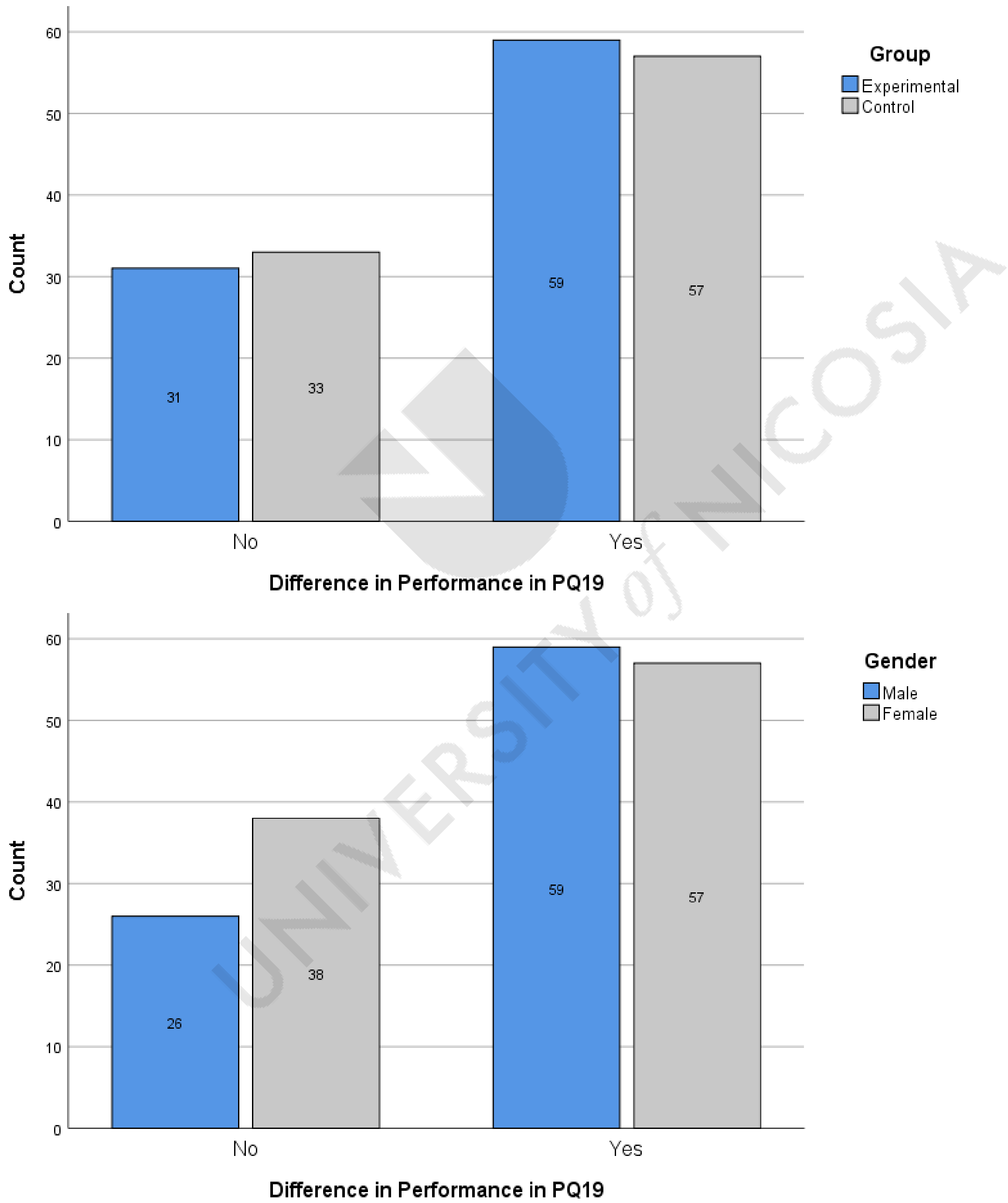


Figure 18: Investigating Potential Association between Group / Gender and Understanding of Question 19 of PHYSICS Knowledge Test

Figure 18 shows that neither group (Phi = -0.023, p=0.755>0.050) nor gender (Phi = -0.098, p=0.188>0.050) affected students' improvement in understanding Question 19 about the effect of car acceleration on air resistance.

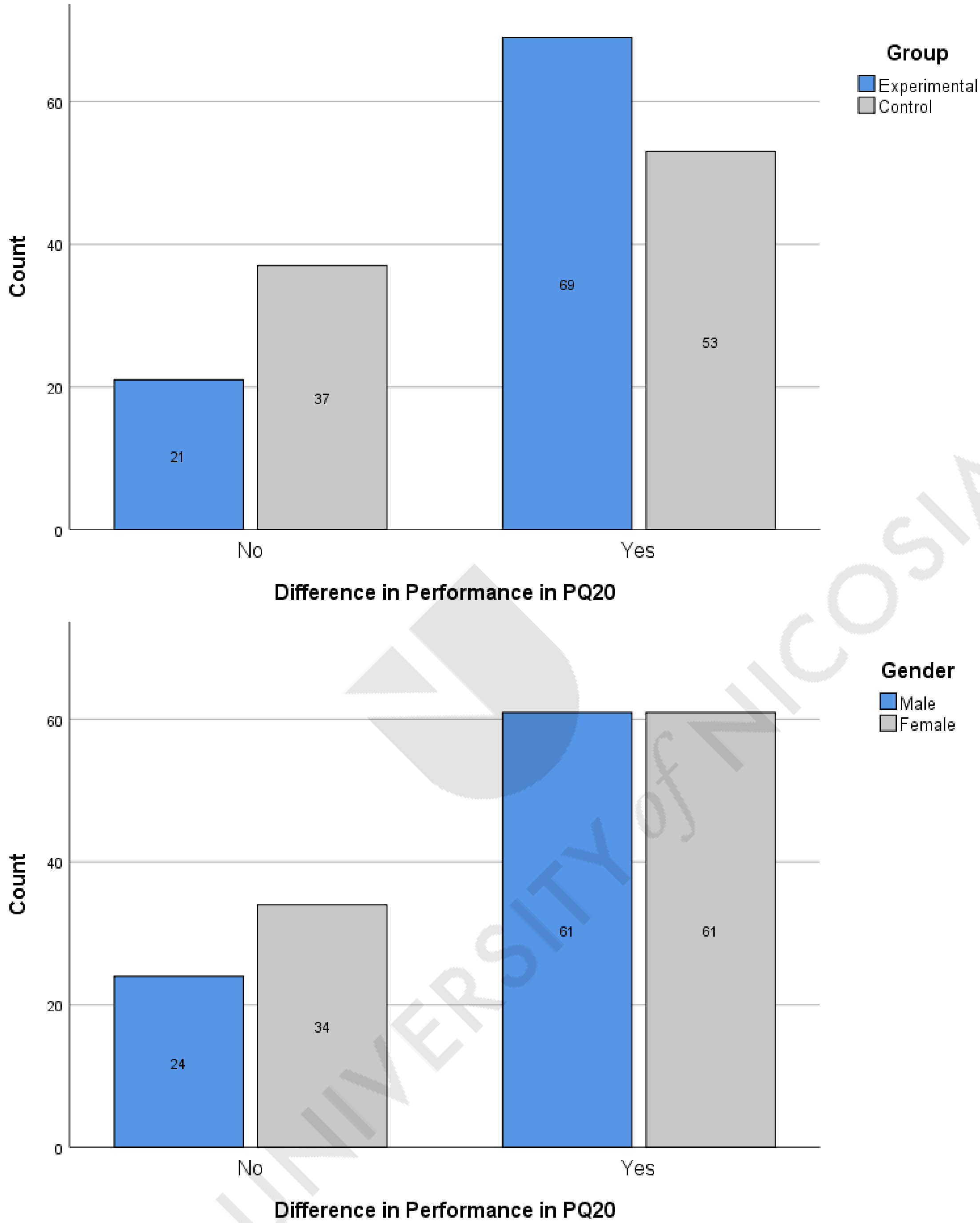


Figure 19: Investigating Potential Association between Group / Gender and Understanding of Question 20 of PHYSICS Knowledge Test

Figure 19 shows the significant effect of group on students' score improvement in the last question of the second Physics subtopic ("Air Resistance") about the relationship between different-shape and different-weight objects' acceleration in the absence of air resistance (Phi

= -0.190, p=0.011<0.050). Once more, gender was not a significant factor (Phi = -0.081, p=0.279>0.050).

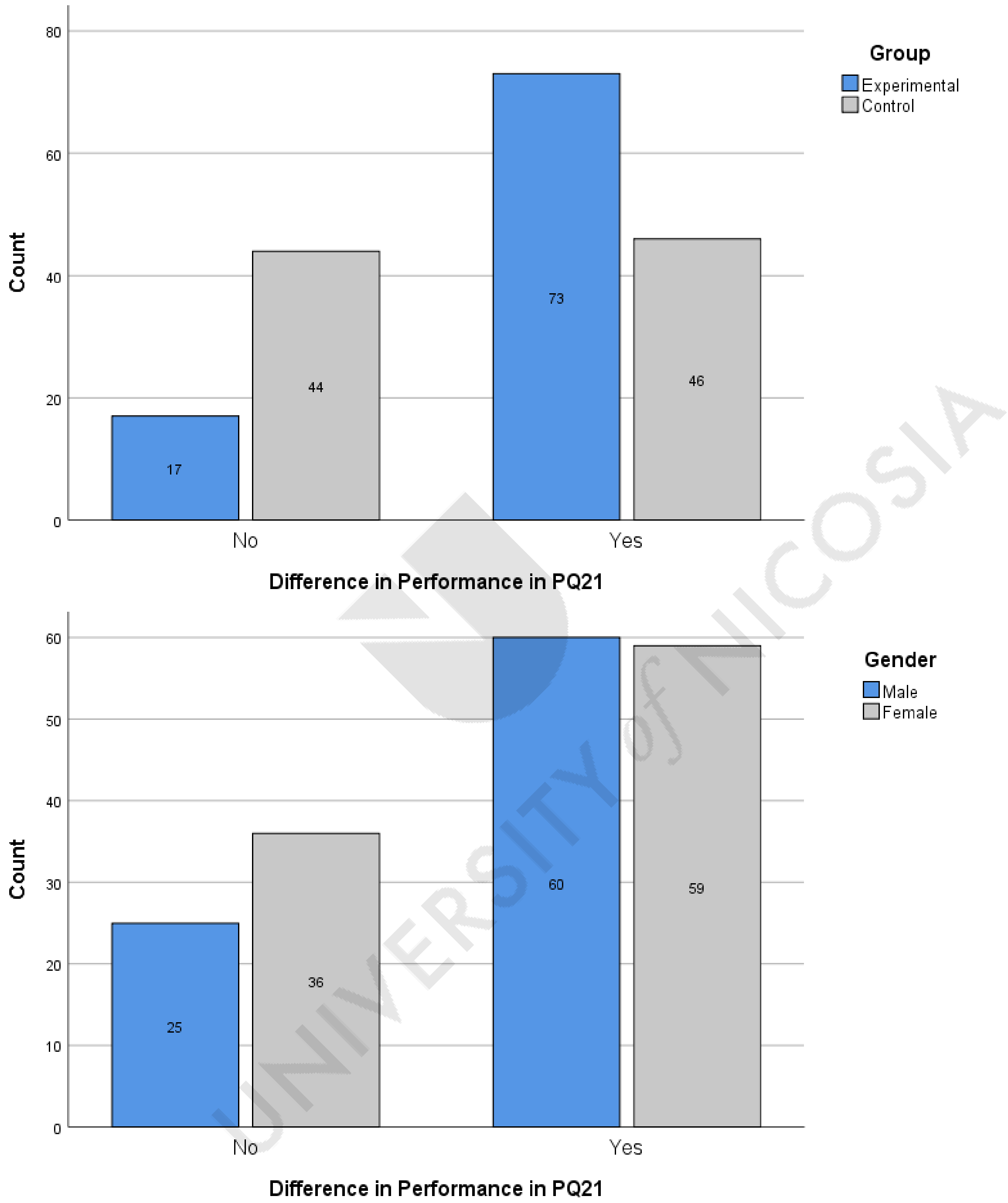


Figure 20: Investigating Potential Association between Group / Gender and Understanding of Question 21 of PHYSICS Knowledge Test

Figure 20 demonstrates the significant relationship between group and students' score improvement (Phi = -0.317, p=0.000<0.050) in the first question of the third subtopic, "Upthrust", about the direction of upthrust and weight, as well as the insignificance of gender (Phi = -0.089, p=0.230>0.050).

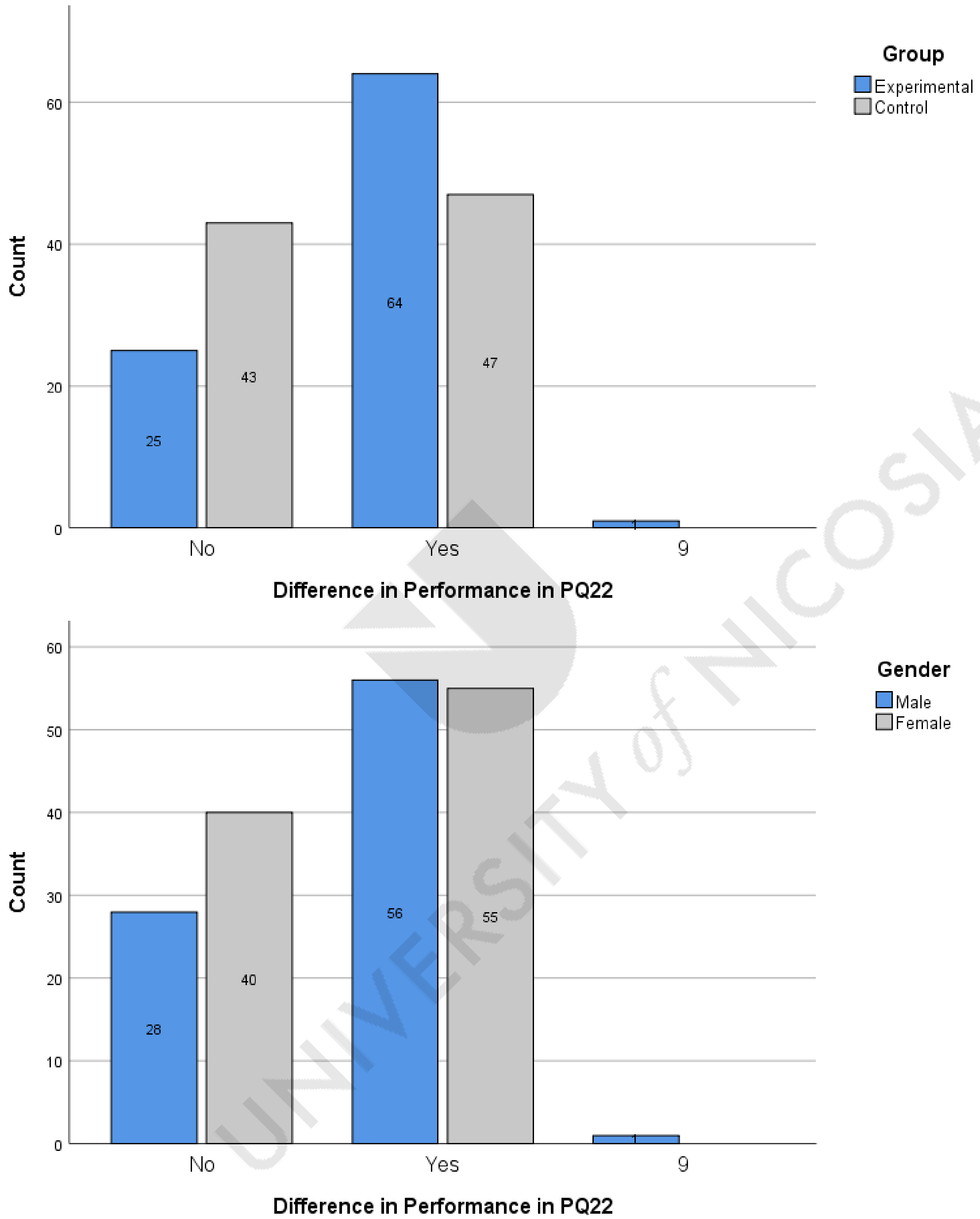


Figure 21: Investigating Potential Association between Group / Gender and Understanding of Question 22 of PHYSICS Knowledge Test

As shown in Figure 21, the same observations can be made for Question 22 about the effects of upthrust on a stone inside different fluids, with significantly more students in the experimental group improving their score (Phi = 0.216, p=0.015<0.050) while gender plays no role in students' performance (Phi = 0.120, p=0.275>0.050).

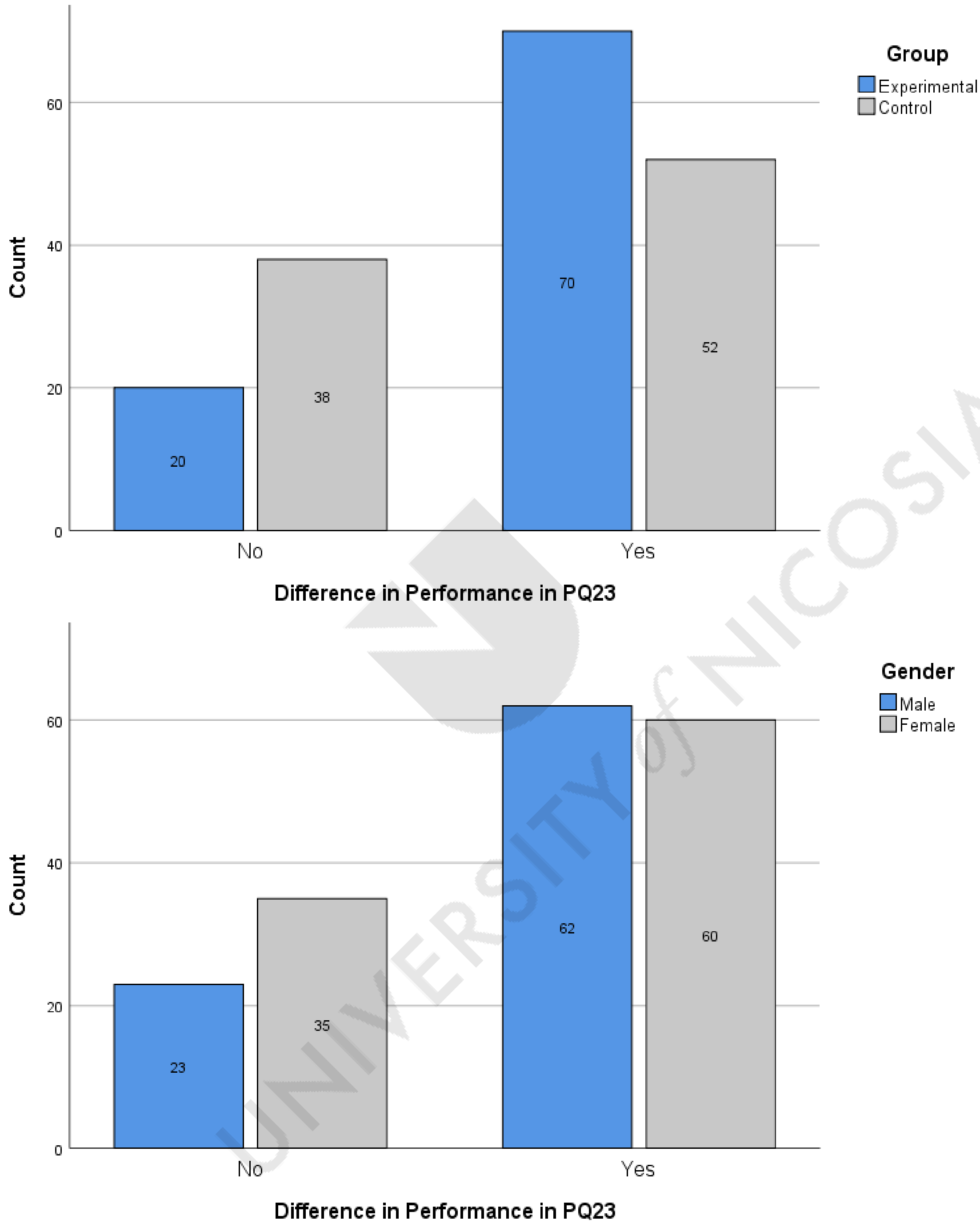


Figure 22: Investigating Potential Association between Group / Gender and Understanding of Question 23 of PHYSICS Knowledge Test

Again, group plays a significant role in students' score improvement in Question 23 about the identification of upthrust's definition (Phi = -0.214, p=0.004<0.050), while gender has no significant impact (Phi = -0.105, p=0.161>0.050), as depicted in Figure 22.

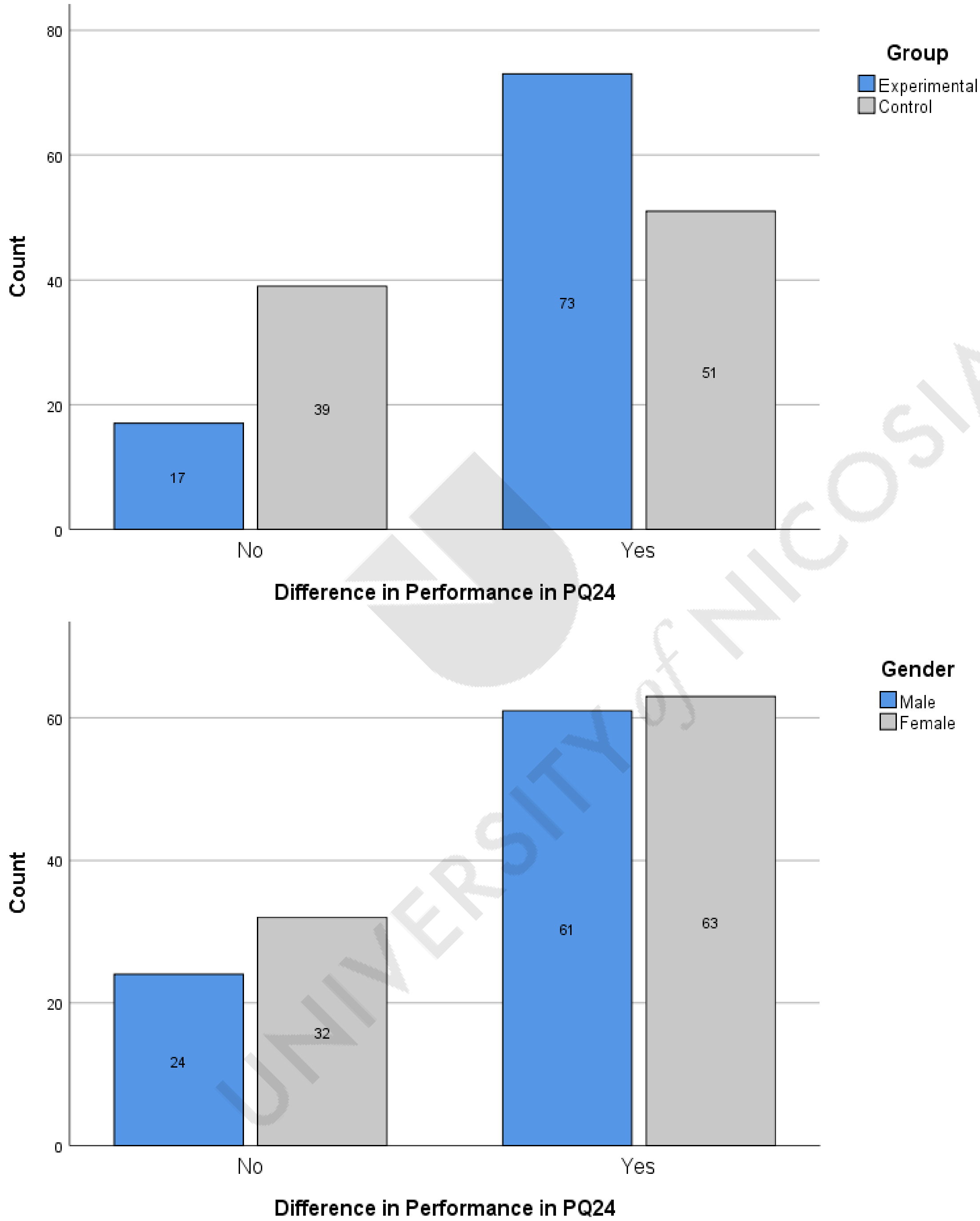


Figure 23: Investigating Potential Association between Group / Gender and Understanding of Question 24 of PHYSICS Knowledge Test

Similarly, students achieved a better understanding of Question 24, regarding the easiest way to float using different objects, when going through the experimental interdisciplinary approach than those taught via the traditional method (Phi = -0.264, p=0.000<0.050), as shown in Figure 23, where gender appears to have no effect (Phi = -0.059, p=0.430>0.050).

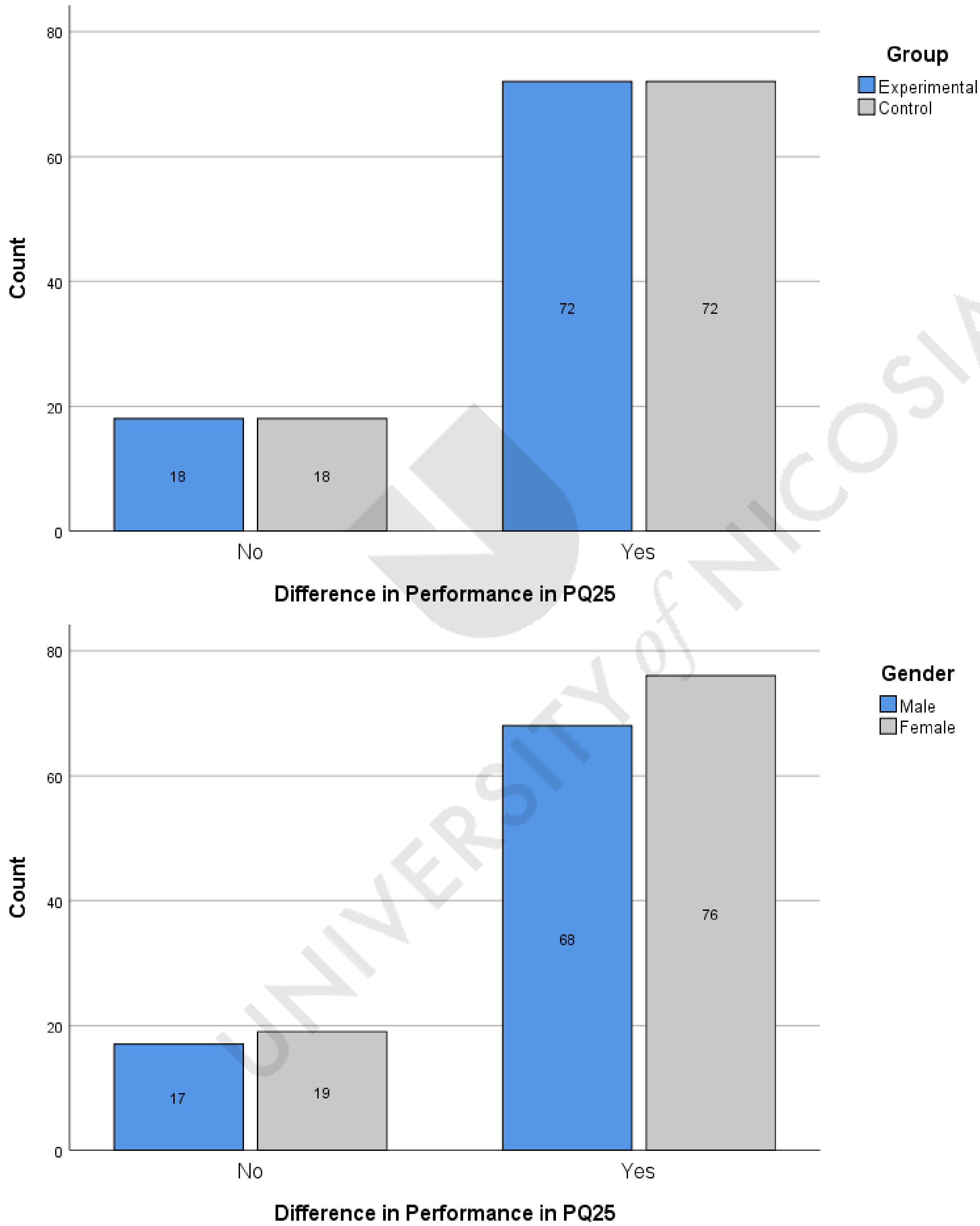


Figure 24: Investigating Potential Association between Group / Gender and Understanding of Question 25 of PHYSICS Knowledge Test

On the contrary, Figure 24 shows that in Question 25 about the effect of equal upthrust and weight, students vastly improved their score post trial, however, this improvement was not related to either group (Phi = 0.000, p=1.000>0.050) or gender (Phi = 0.000, p=1.000>0.050).

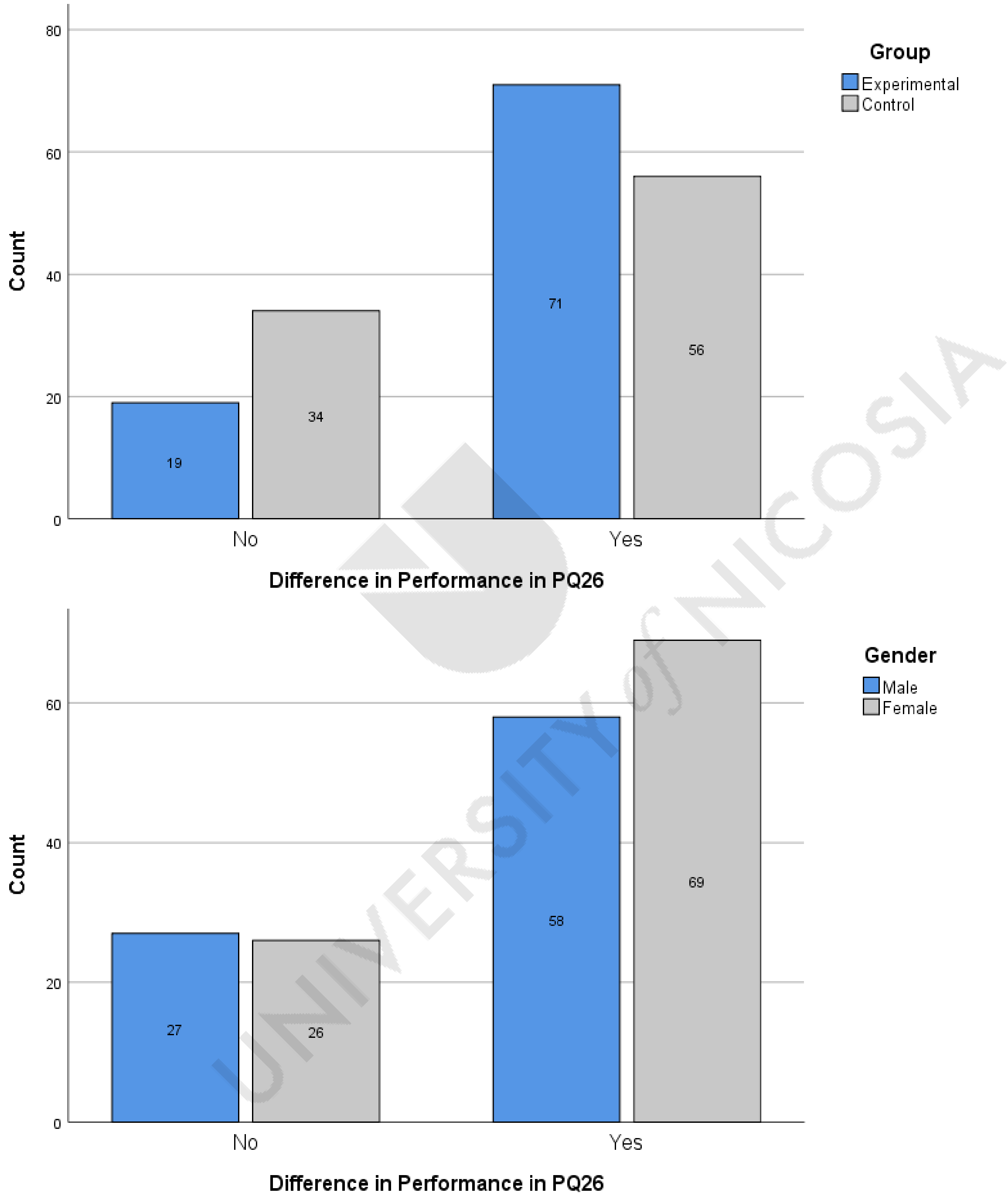


Figure 25: Investigating Potential Association between Group / Gender and Understanding of Question 26 of PHYSICS Knowledge Test

According to Figure 25, in Question 26 about the effect of objects' density on their ability to float, students' score improvement post trial was significantly related to group (Phi = -0.183, p=0.014<0.050) but not to gender (Phi = 0.048, p=0.518>0.050).

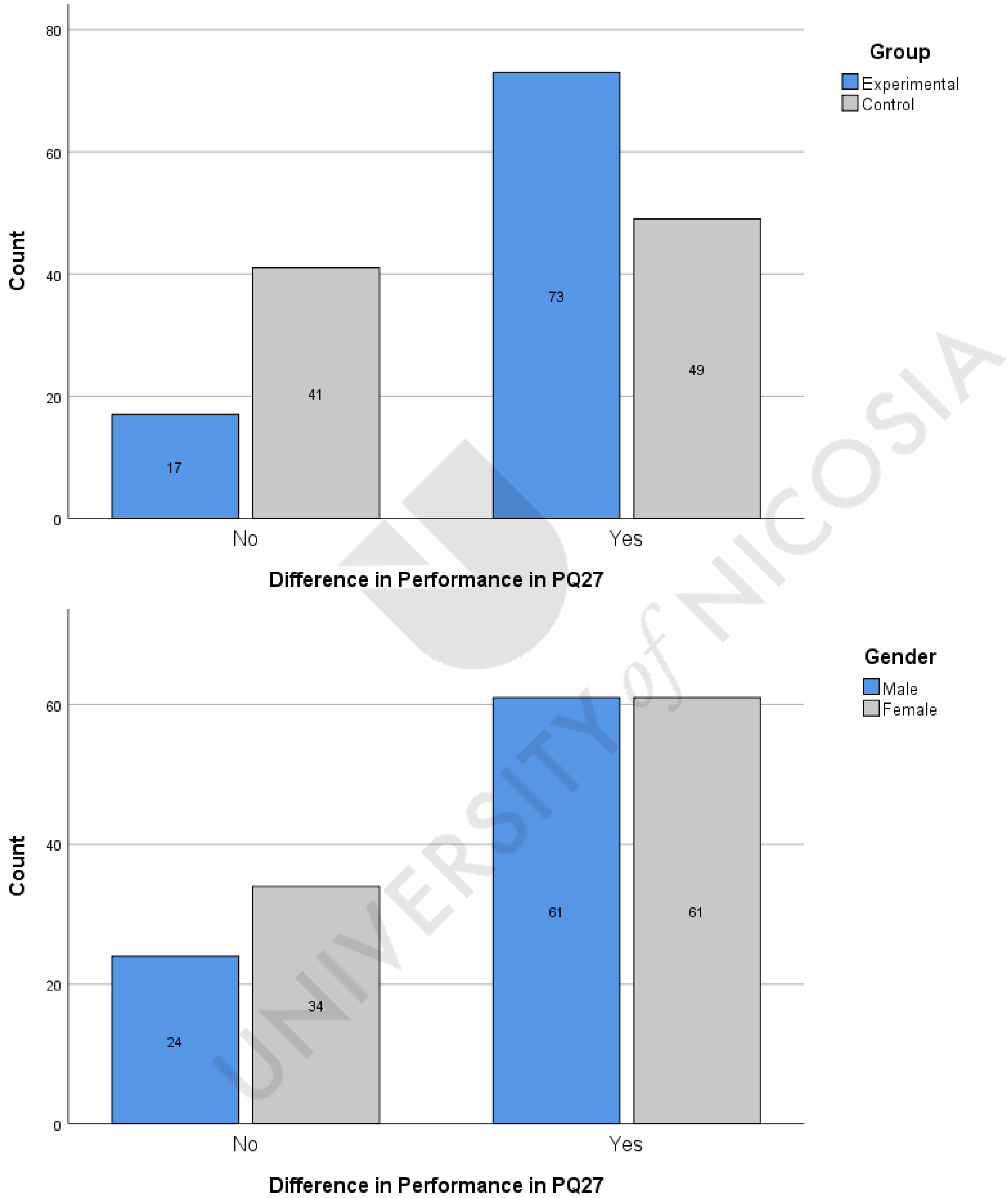


Figure 26: Investigating Potential Association between Group / Gender and Understanding of Question 27 of PHYSICS Knowledge Test

According to Figure 26, in Question 27 inquiring on what upthrust depends, students' score improvement post trial was significantly associated with group (Phi = -0.285, p=0.000<0.050) but not with gender (Phi = -0.081, p=0.279>0.050).

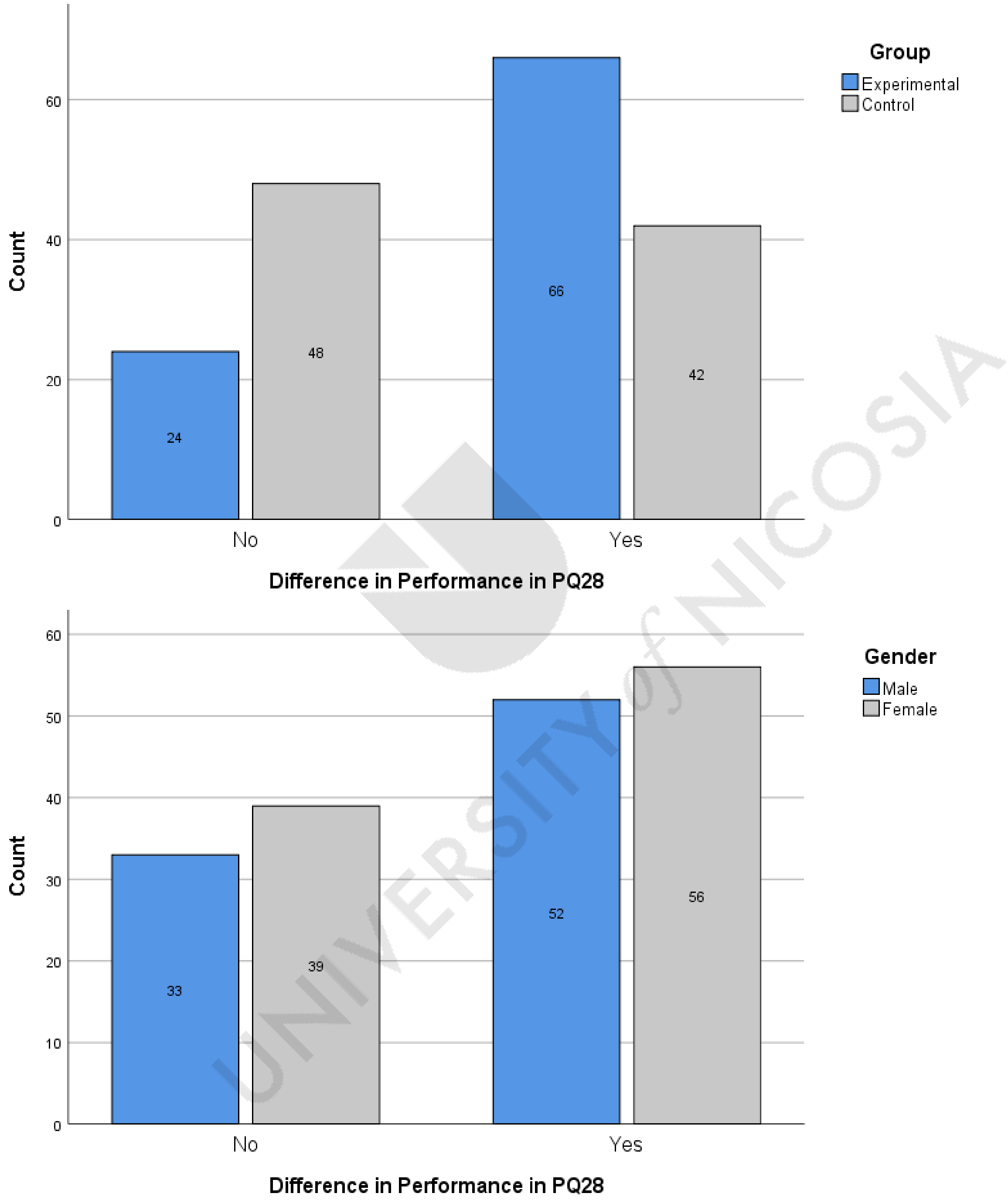


Figure 27: Investigating Potential Association between Group / Gender and Understanding of Question 28 of PHYSICS Knowledge Test

Figure 27 shows that the improvement in students' understanding of Question 28, about the relationship between upthrust and an object's geographic location, was significantly associated with group (Phi = -0.272, $p=0.000<0.050$) but not with gender (Phi = -0.023, $p=0.761>0.050$).

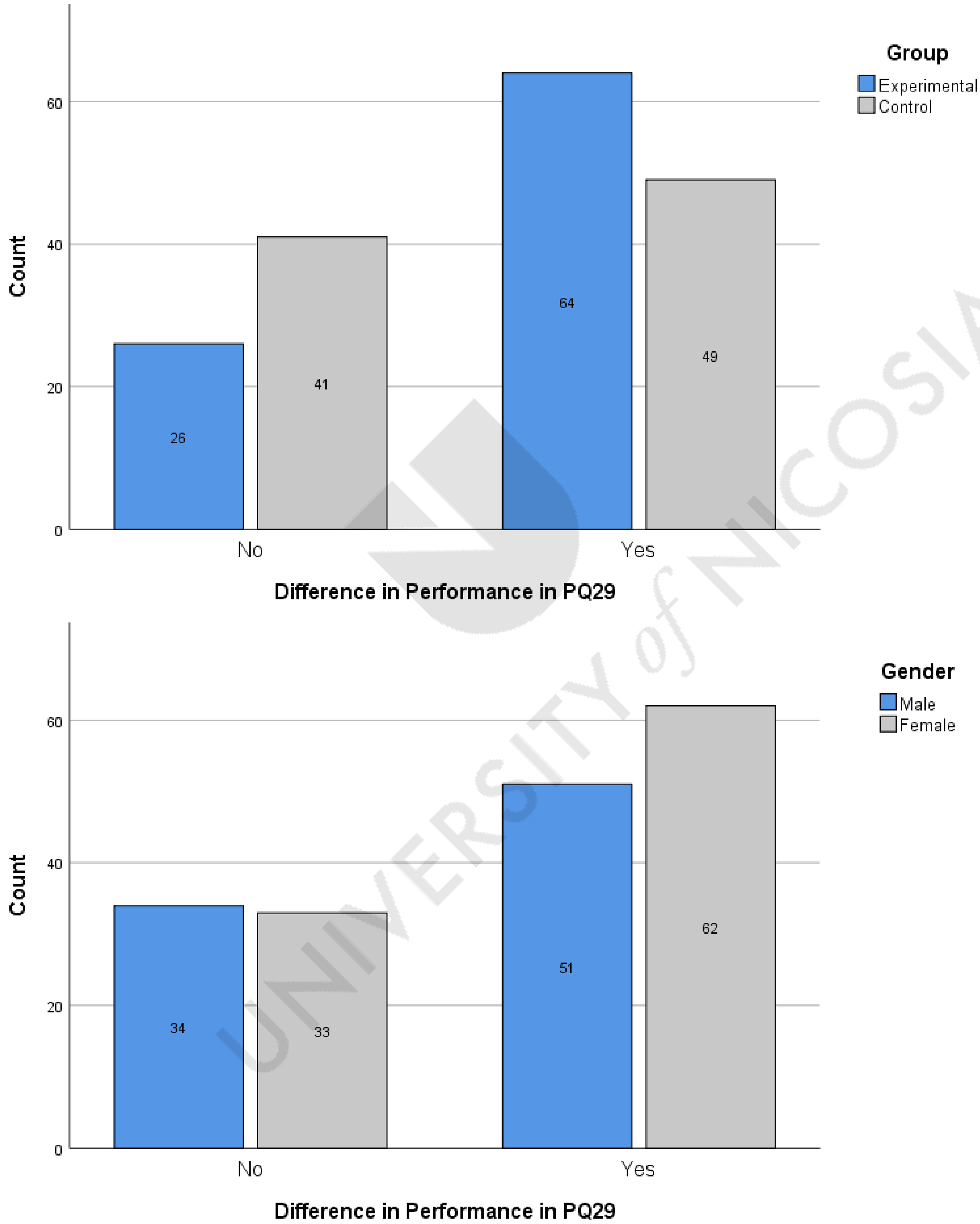


Figure 28: Investigating Potential Association between Group / Gender and Understanding of Question 29 of PHYSICS Knowledge Test

Again, Figure 28 shows that the improvement in students' understanding of Question 29, regarding the relationship between upthrust and an object's weight, was significantly related with group (Phi = -0.172, p=0.021<0.050) but not with gender (Phi = 0.054, p=0.466>0.050).

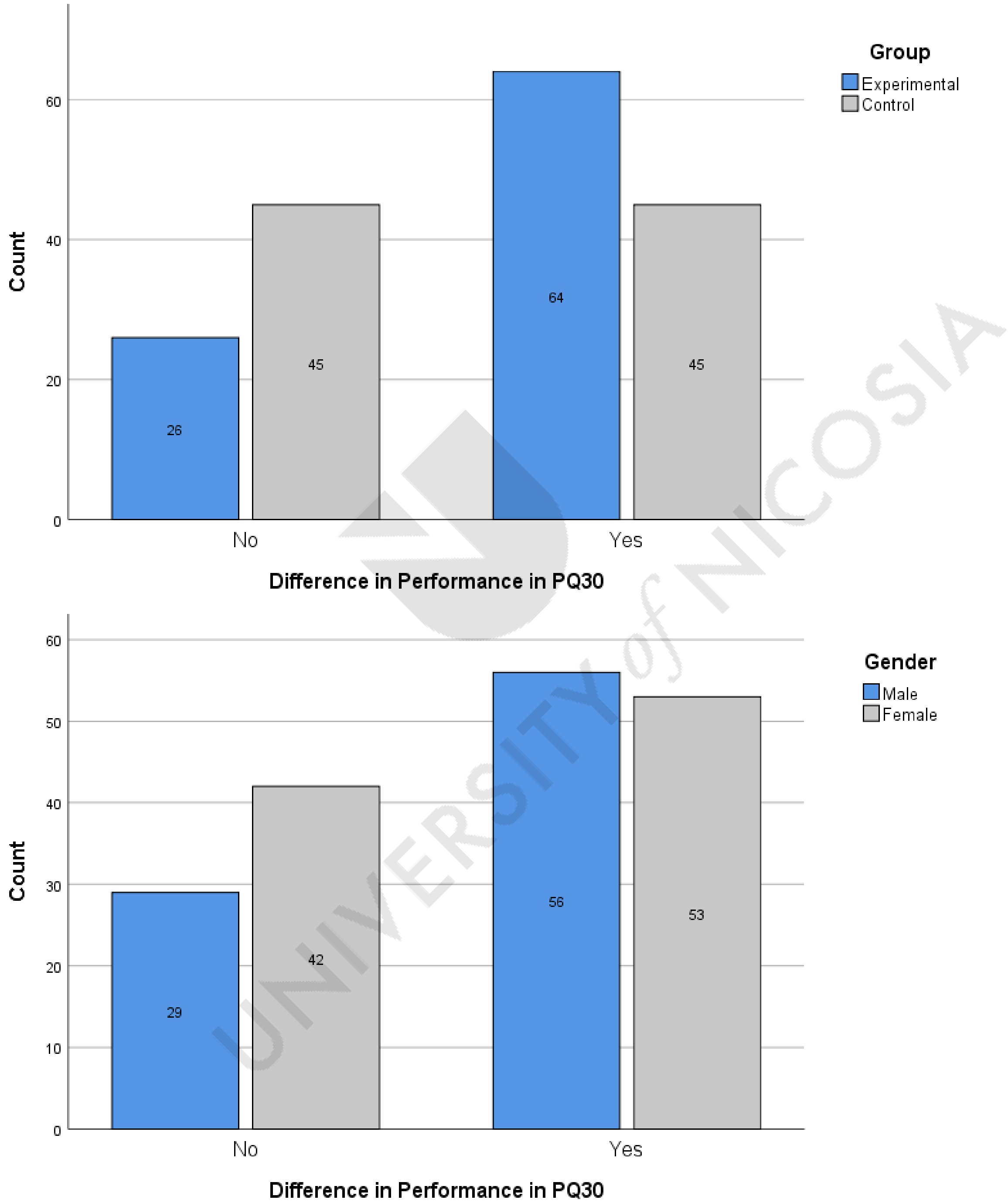
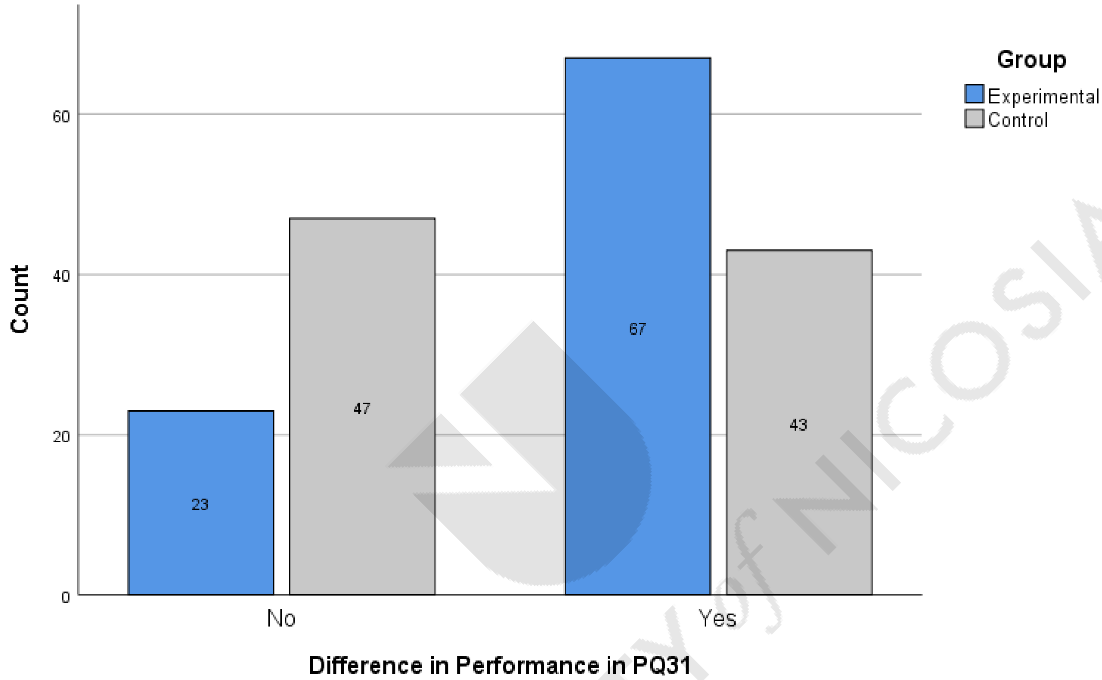


Figure 29: Investigating Potential Association between Group / Gender and Understanding of Question 30 of PHYSICS Knowledge Test

Figure 29 shows that the improvement in students' score in Question 30, about the relationship between upthrust and the fluid where the object is submerged, was significantly related with group (Phi = -0.216, $p=0.004<0.050$) but not with gender (Phi = -0.103, $p=0.167>0.050$).

Next, Figures 30 - 38 are dedicated to the potential association between students' understanding of all the questions in the subtopic of "Stretch" and group/gender.



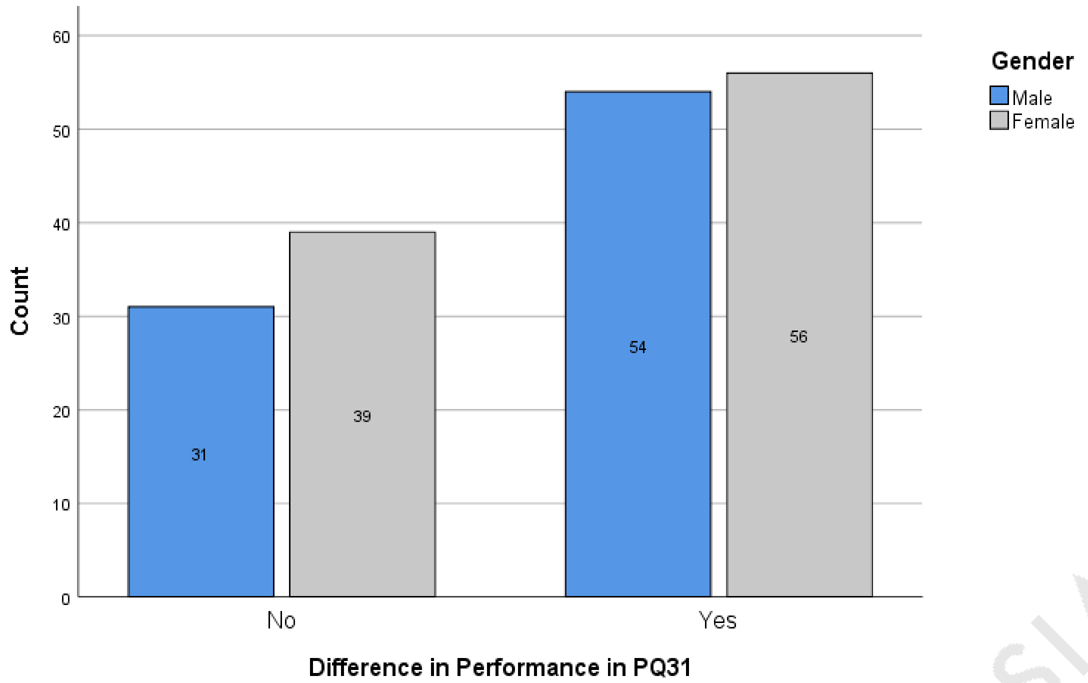
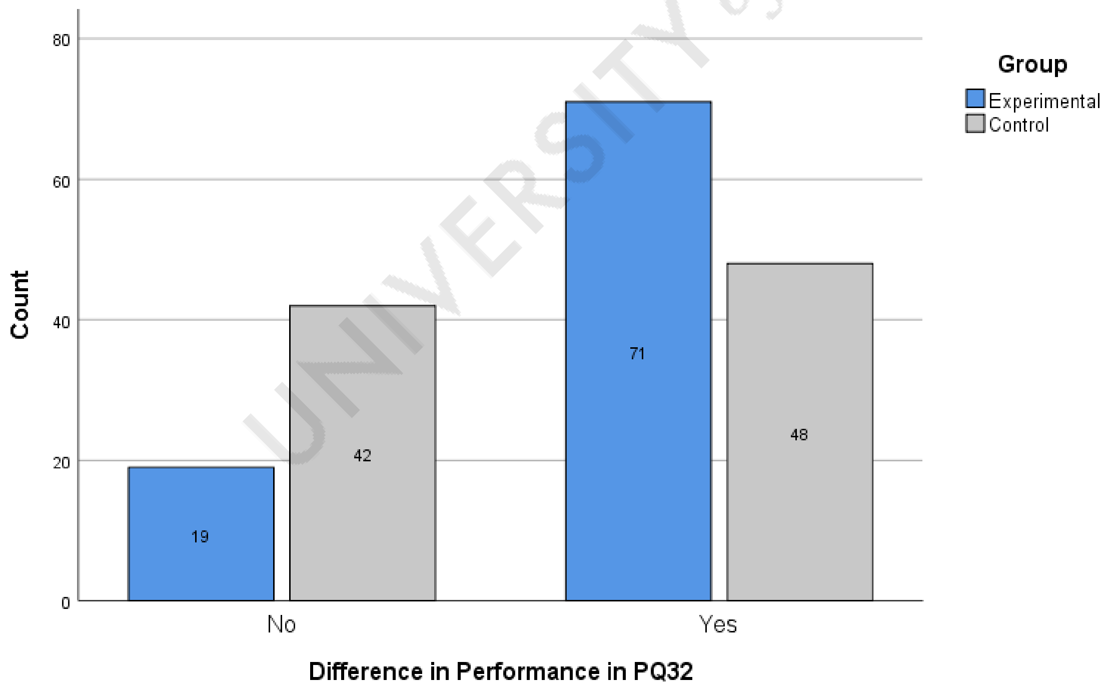


Figure 30: Investigating Potential Association between Group / Gender and Understanding of Question 31 of PHYSICS Knowledge Test

Figure 30 shows that the improvement in students' understanding of Question 31, requiring the identification of stretch, was significantly associated with group (Phi = -0.274, p=0.000<0.050) but not with gender (Phi = -0.047, p=0.529>0.050).



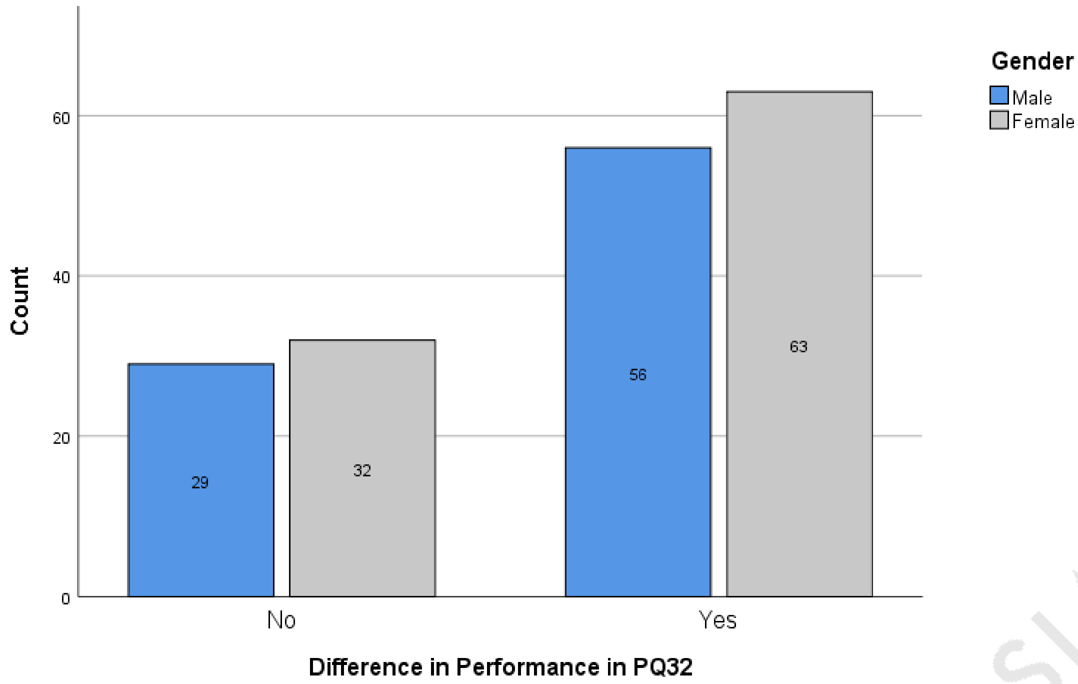
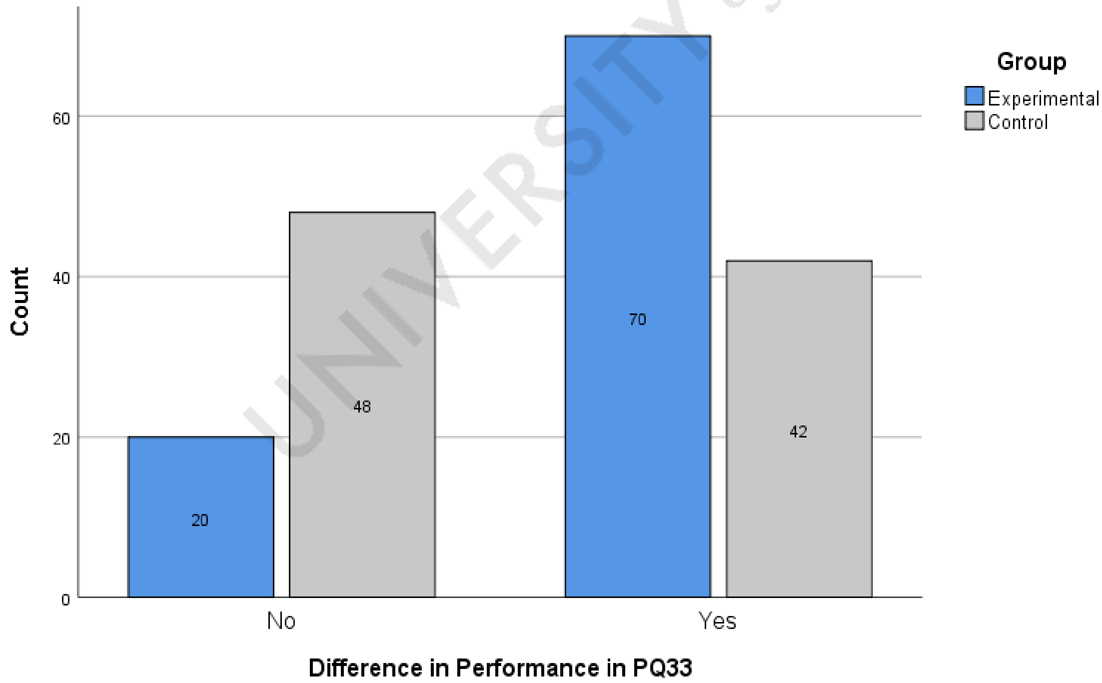


Figure 31: Investigating Potential Association between Group / Gender and Understanding of Question 32 of PHYSICS Knowledge Test

Figure 31 indicates that the improvement in students' score in Question 32, about the relationship between stretch and weights' force, was significantly associated with group (Phi = -0.270, p=0.000<0.050) but not with gender (Phi = 0.005, p=0.951>0.050).



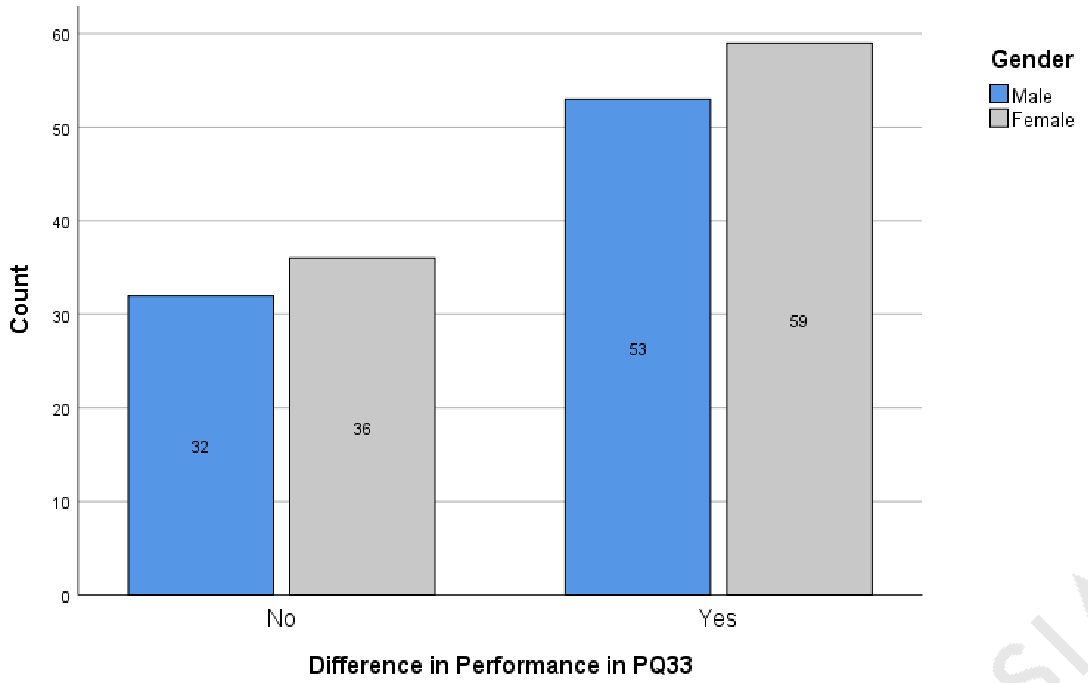
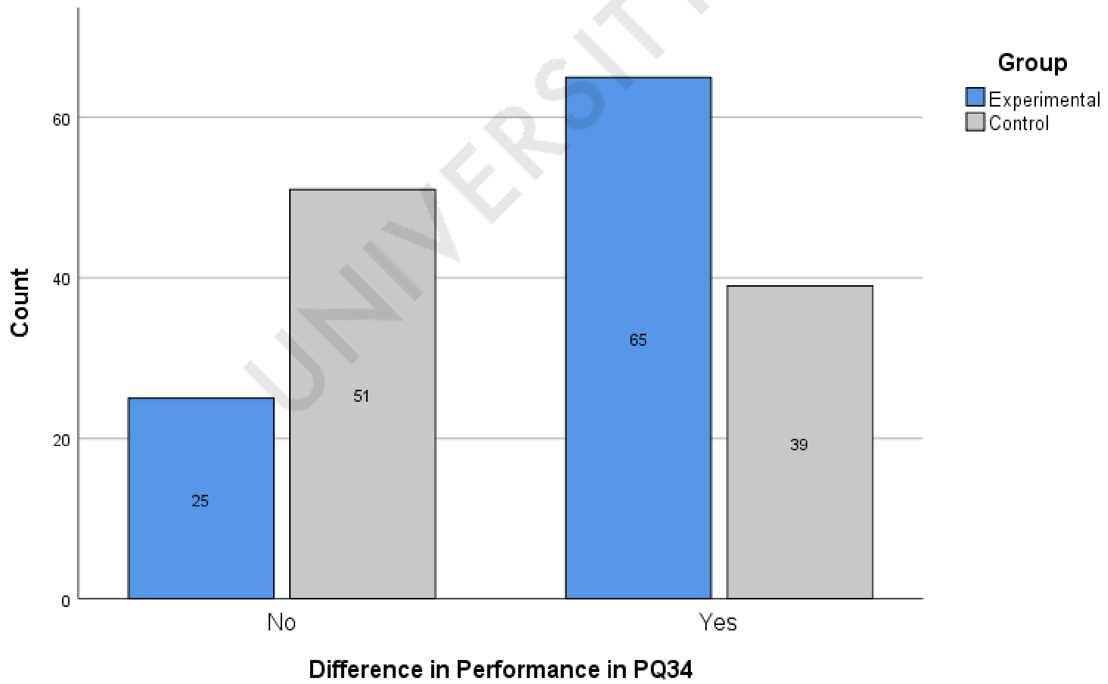


Figure 32: Investigating Potential Association between Group / Gender and Understanding of Question 33 of PHYSICS Knowledge Test

According to Figure 32, students' understanding of Question 33, requiring calculations of a spring's length after stretch, was significantly improved within the experimental group (Phi = -0.321, p=0.000<0.050), whereas gender had no significant effect (Phi = -0.003, p=0.973>0.050).



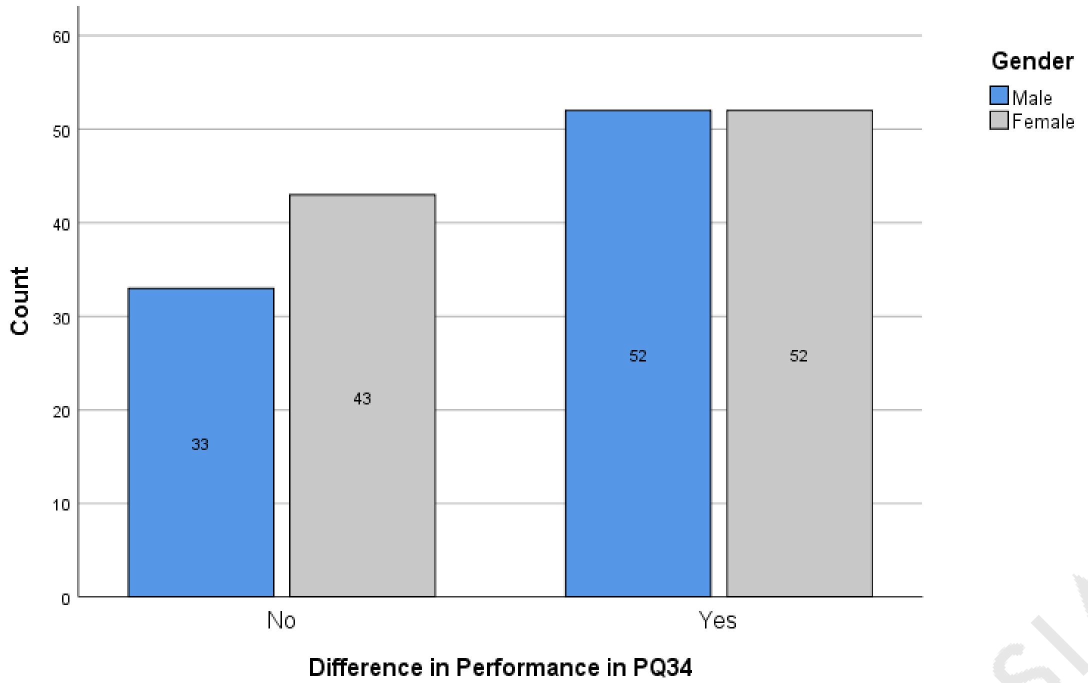


Figure 33: Investigating Potential Association between Group / Gender and Understanding of Question 34 of PHYSICS Knowledge Test

Again, Figure 33 shows that students' understanding of Question 34 on the identification of a push or pull was significantly improved within the experimental group (Phi = -0.292, p=0.000<0.050), whereas gender had no significant effect (Phi = -0.065, p=0.382>0.050).

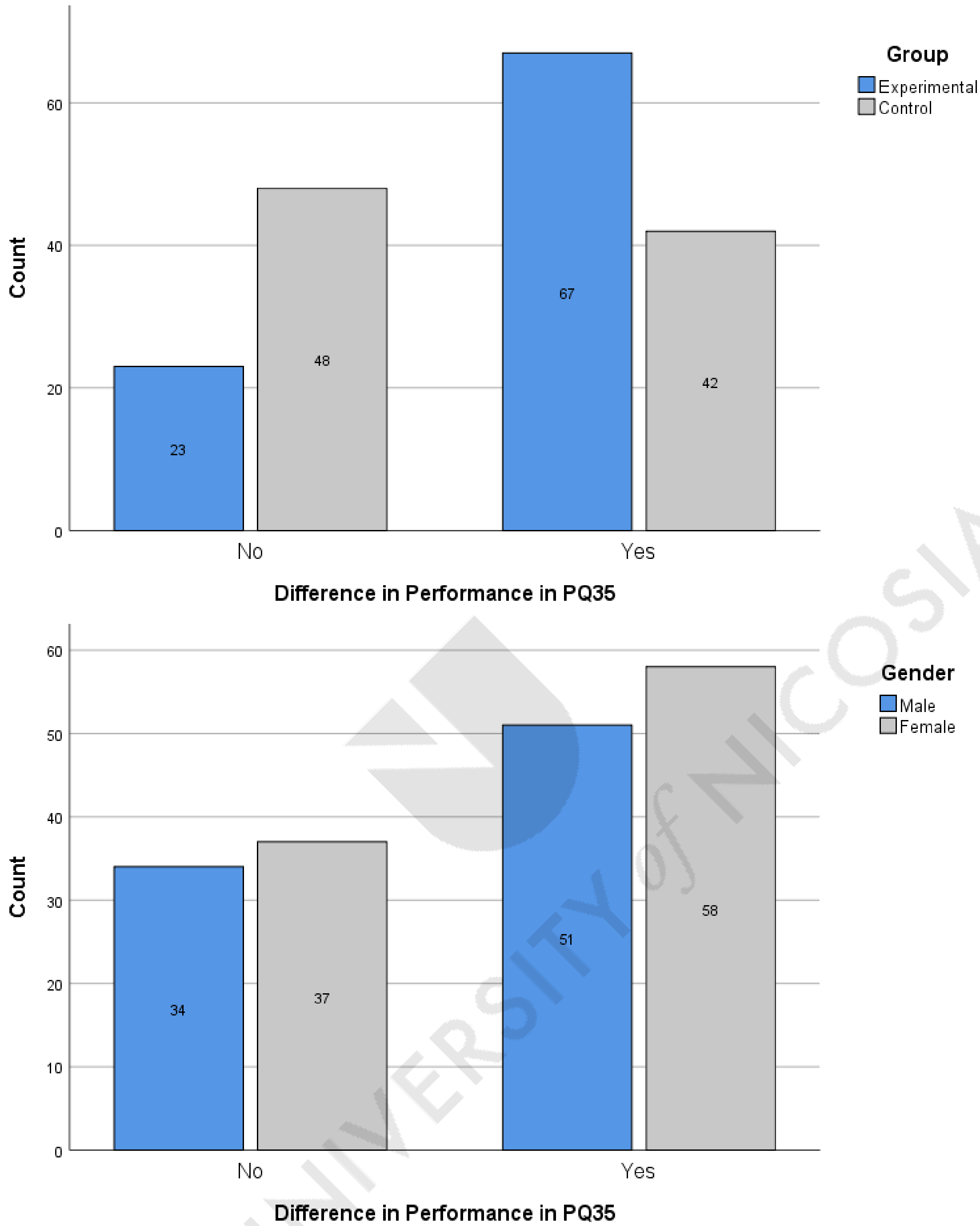


Figure 34: Investigating Potential Association between Group / Gender and Understanding of Question 35 of PHYSICS Knowledge Test

According to Figure 34 students' understanding of Question 35, about action and reaction forces, was significantly improved within the experimental group (Phi = -0.284, p=0.000<0.050), whereas gender had no significant effect (Phi = 0.011, p=0.885>0.050).

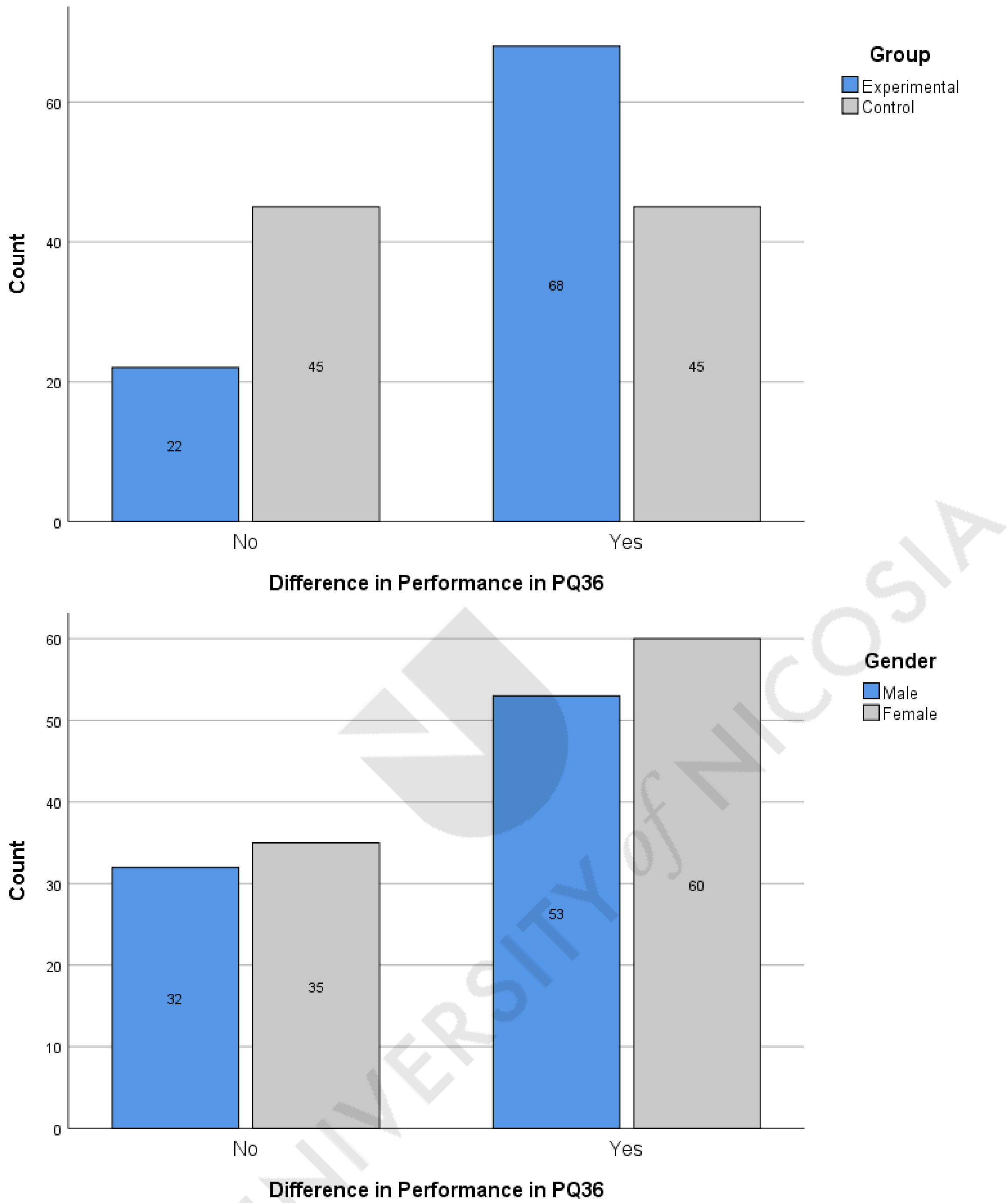


Figure 35: Investigating Potential Association between Group / Gender and Understanding of Question 36 of PHYSICS Knowledge Test

Figure 35 depicts the improvement in students' understanding of Question 36, about movement on a smooth surface under specific conditions, which can be significantly associated with group (Phi = -0.264, p=0.000<0.050), but not with gender (Phi = 0.008, p=0.911>0.050).

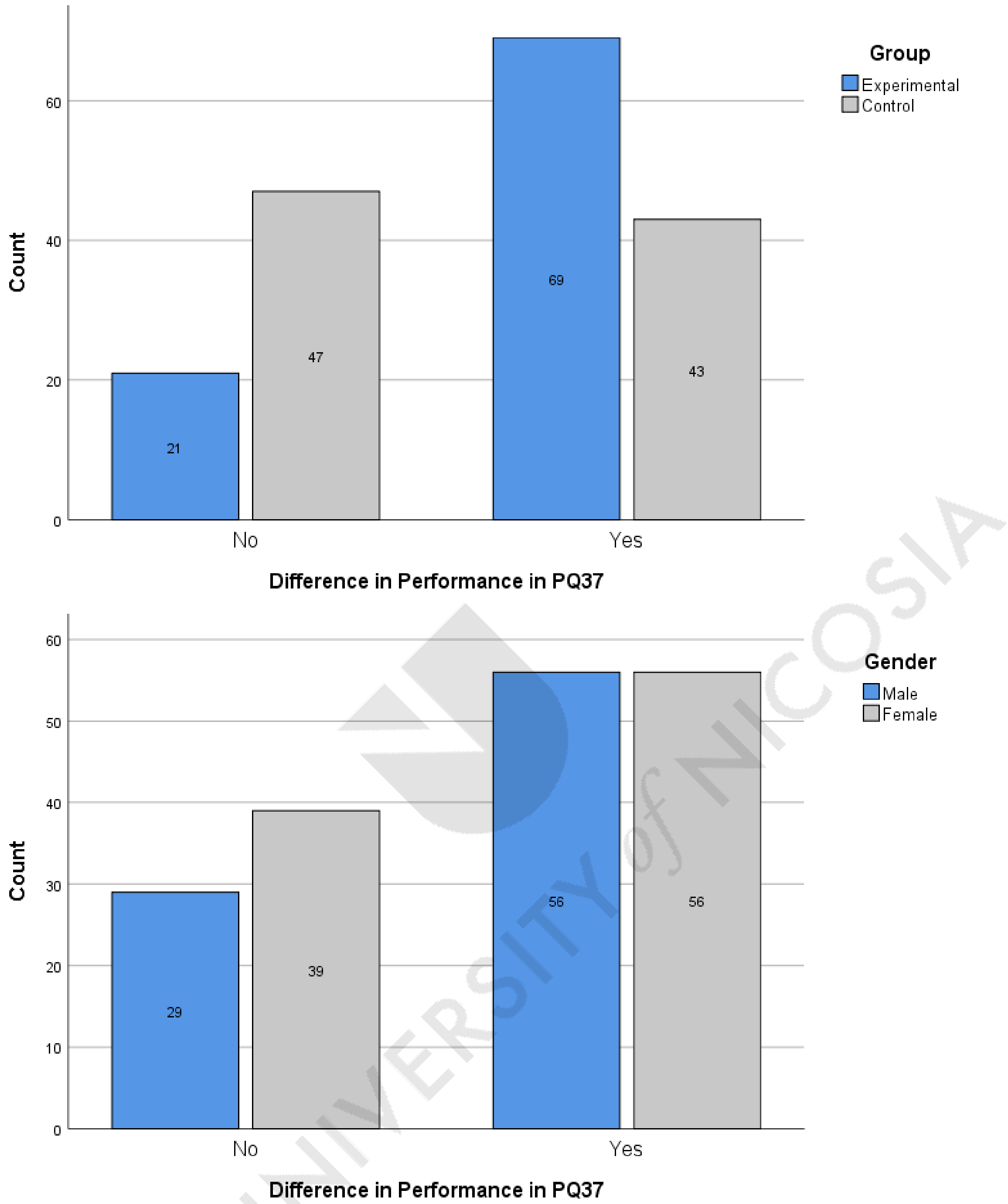


Figure 36: Investigating Potential Association between Group / Gender and Understanding of Question 37 of PHYSICS Knowledge Test

Similarly, Figure 36 depicts the improvement in students' understanding of Question 37, about the motion of two boys under specific conditions, which can be significantly associated with group (Phi = -0.298, p=0.000<0.050), but not with gender (Phi = -0.071, p=0.338>0.050).

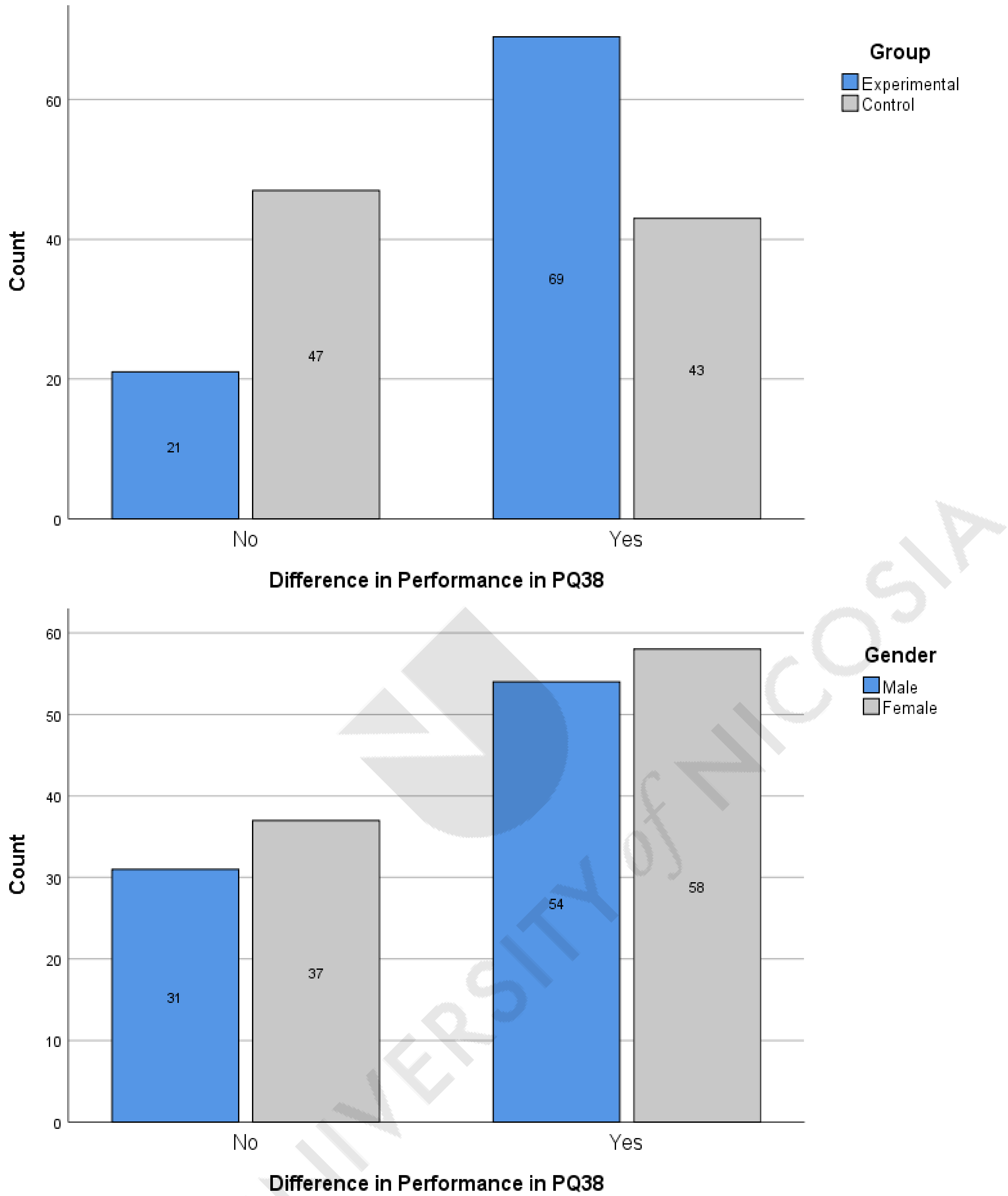


Figure 37: Investigating Potential Association between Group / Gender and Understanding of Question 38 of PHYSICS Knowledge Test

Figure 37 shows that the improvement in students' understanding of Question 38, about the definition of stretching, can be significantly related with group (Phi = -0.298, p=0.000<0.050), but not with gender (Phi = -0.026, p=0.732>0.050).

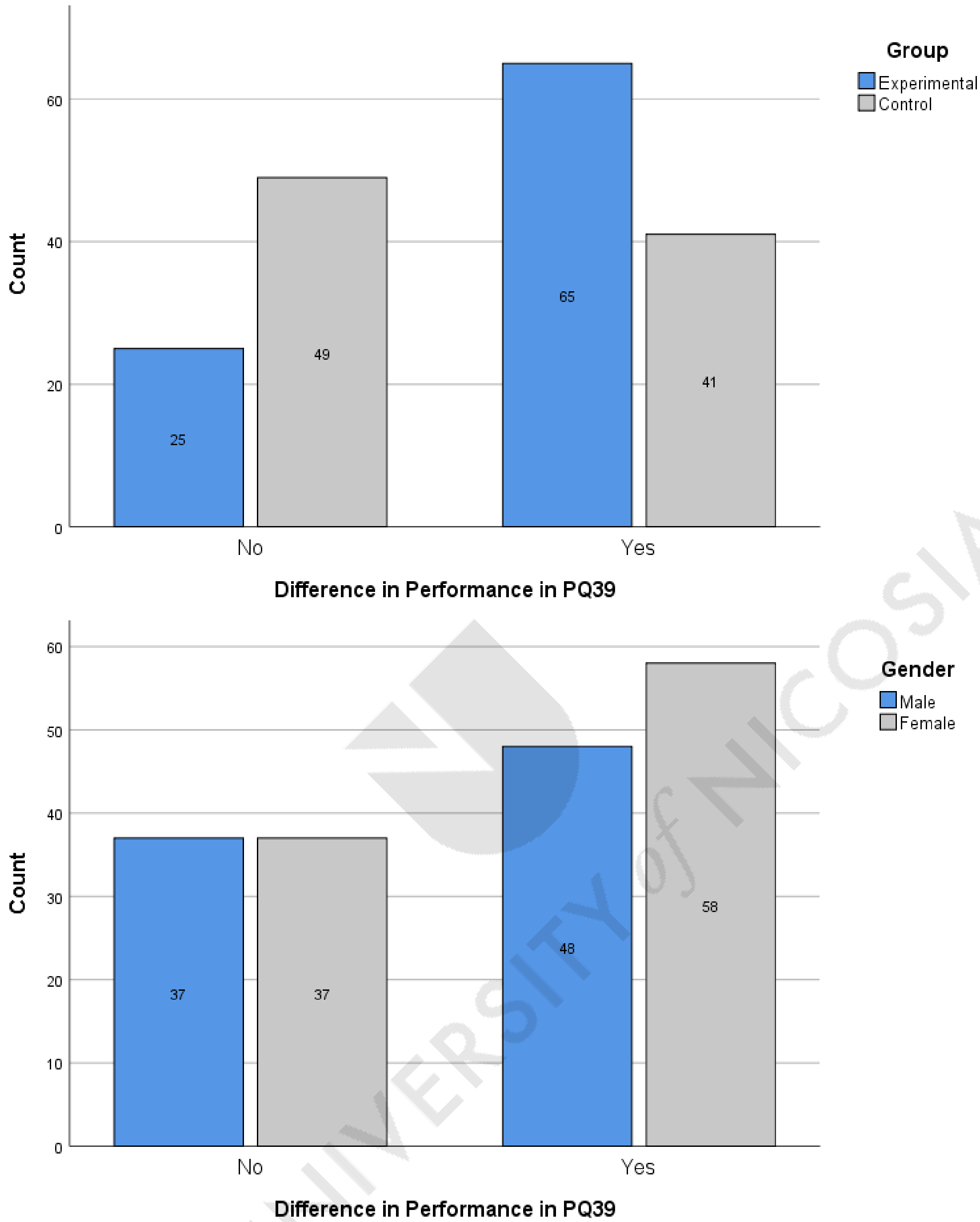


Figure 38: Investigating Potential Association between Group / Gender and Understanding of Question 39 of PHYSICS Knowledge Test

Figure 38 indicates that the improvement in students' score in Question 39 requiring a more critical understanding of stretch, is significantly associated with group (Phi = -0.271, $p=0.000<0.050$), but not with gender (Phi = 0.046, $p=0.533>0.050$).

Finally, Figures 39 - 46 involve questions from the fifth subtopic, "Weight/Gravity".

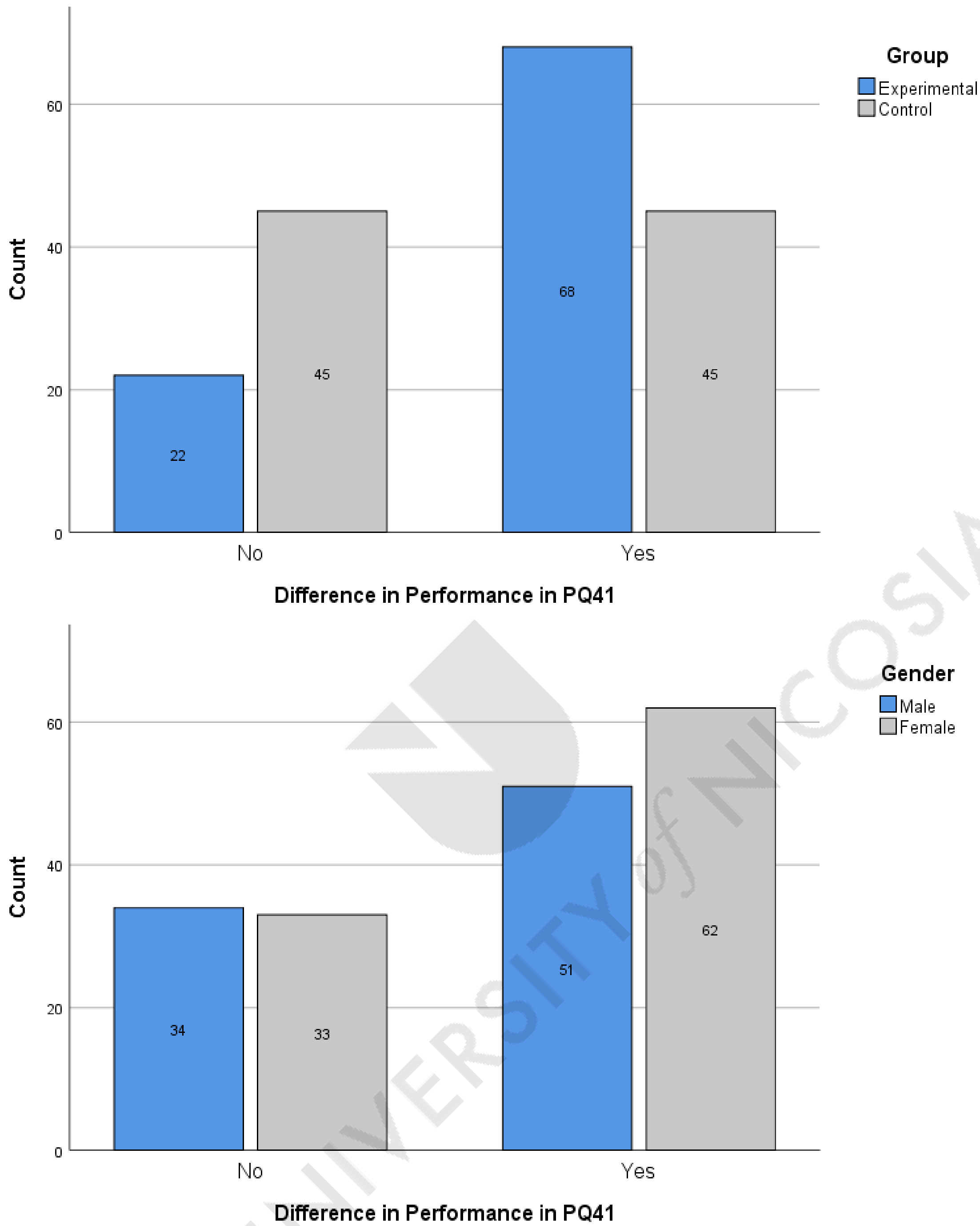


Figure 39: Investigating Potential Association between Group / Gender and Understanding of Question 41 of PHYSICS Knowledge Test

Figure 39 shows that the improvement in students' score in Question 41, regarding the definition of gravity, is once again significantly associated with group (Phi = -0.264, p=0.000<0.050), but not with gender (Phi = 0.054, p=0.466>0.050).

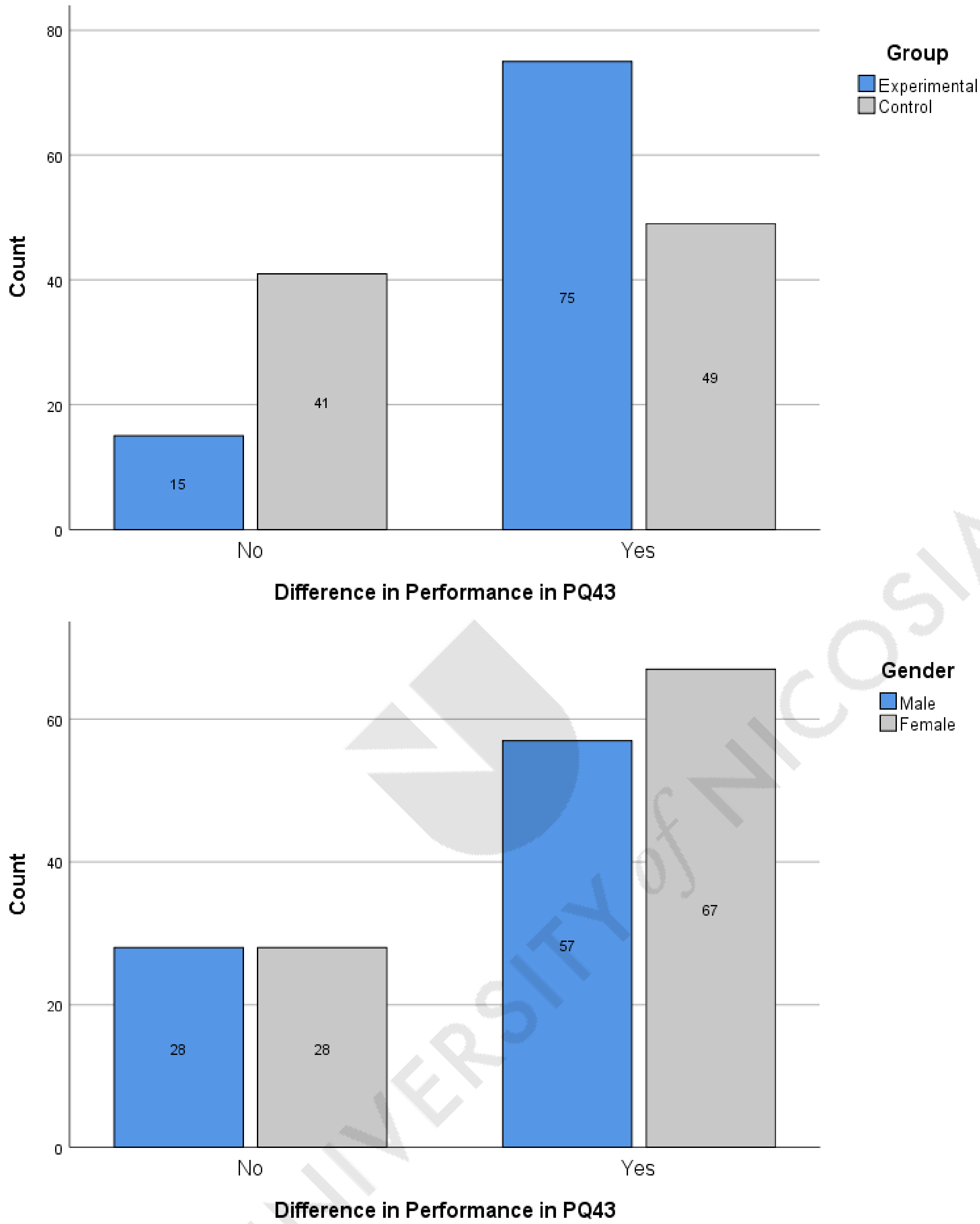


Figure 40: Investigating Potential Association between Group / Gender and Understanding of Question 43 of PHYSICS Knowledge Test

According to Figure 40, the improvement in students' score in Question 43, asking to identify gravitational force, is significantly related with group (Phi = -0.312, p=0.000<0.050), but not with gender (Phi = 0.037, p=0.616>0.050).

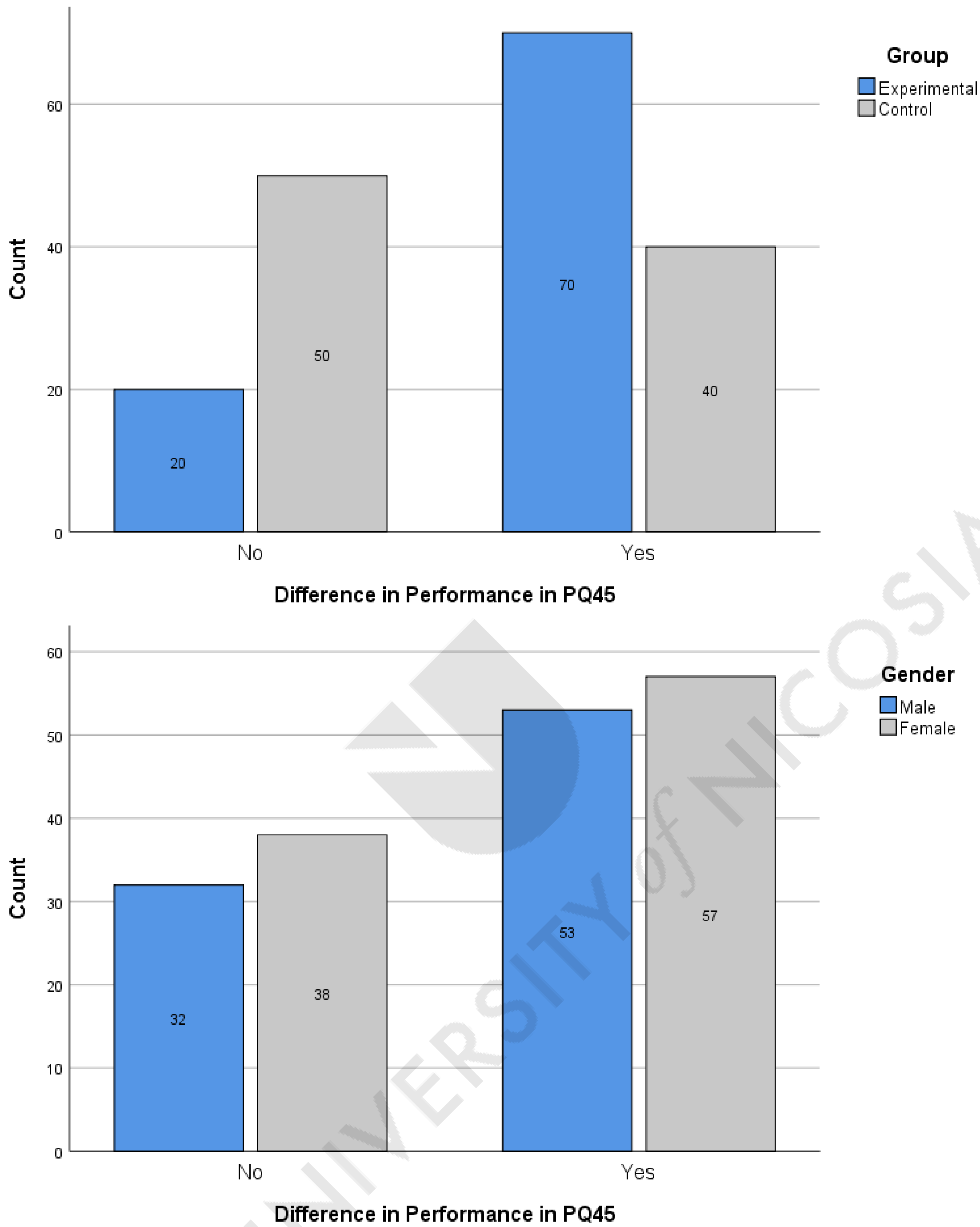


Figure 41: Investigating Potential Association between Group / Gender and Understanding of Question 45 of PHYSICS Knowledge Test

Figure 41 indicates that the improvement in students' score in Question 45, regarding the unit of weight in the metric system, is significantly associated with group (Phi = -0.342, p=0.000<0.050), but not with gender (Phi = -0.024, p=0.746>0.050).

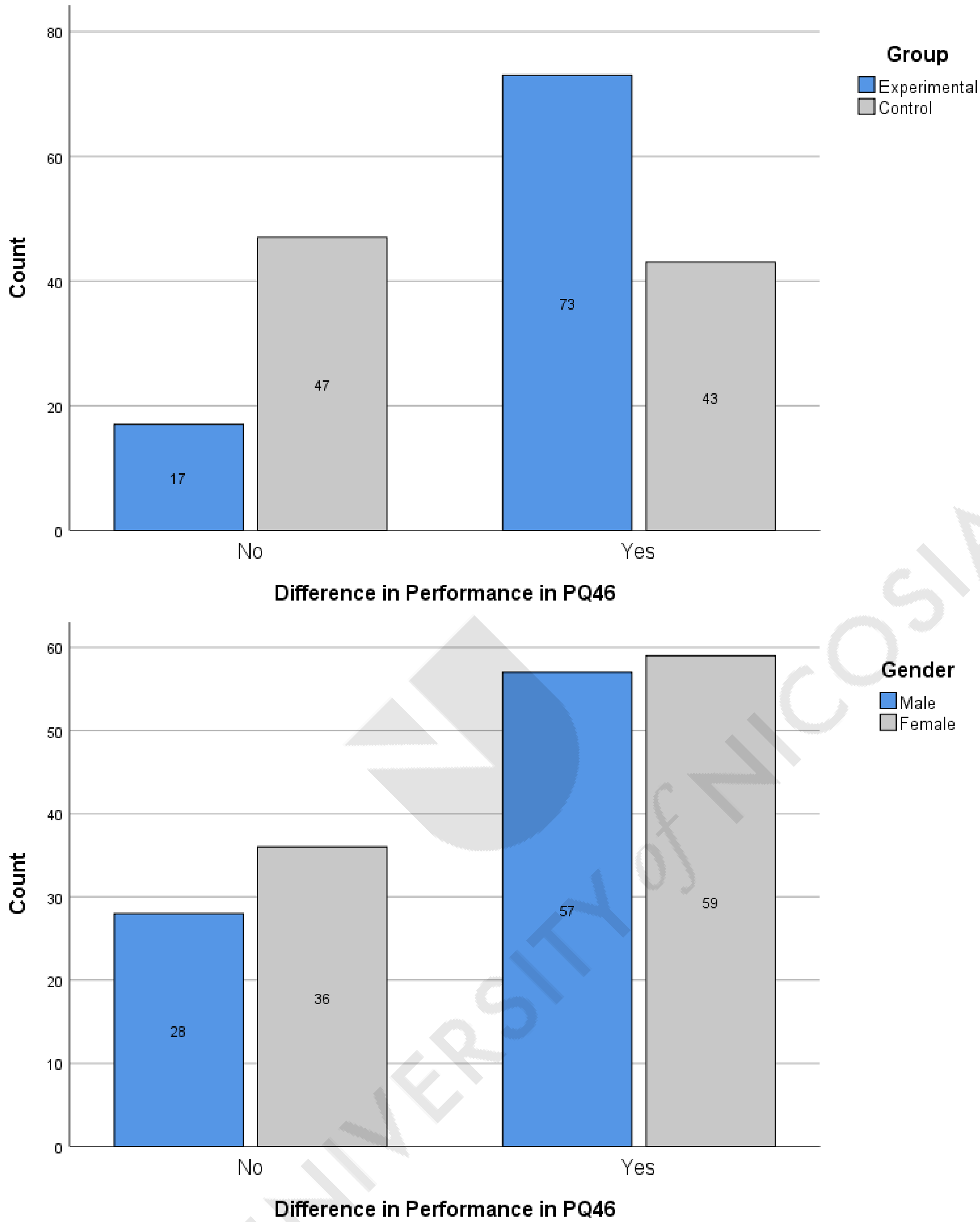


Figure 42: Investigating Potential Association between Group / Gender and Understanding of Question 46 of PHYSICS Knowledge Test

Similarly, based on Figure 42, the improvement in students' undestanding of Question 46 about the effects of weight force in running, is significantly related with group (Phi = -0.348, p=0.000<0.050), but not with gender (Phi = -0.052, p=0.488>0.050).

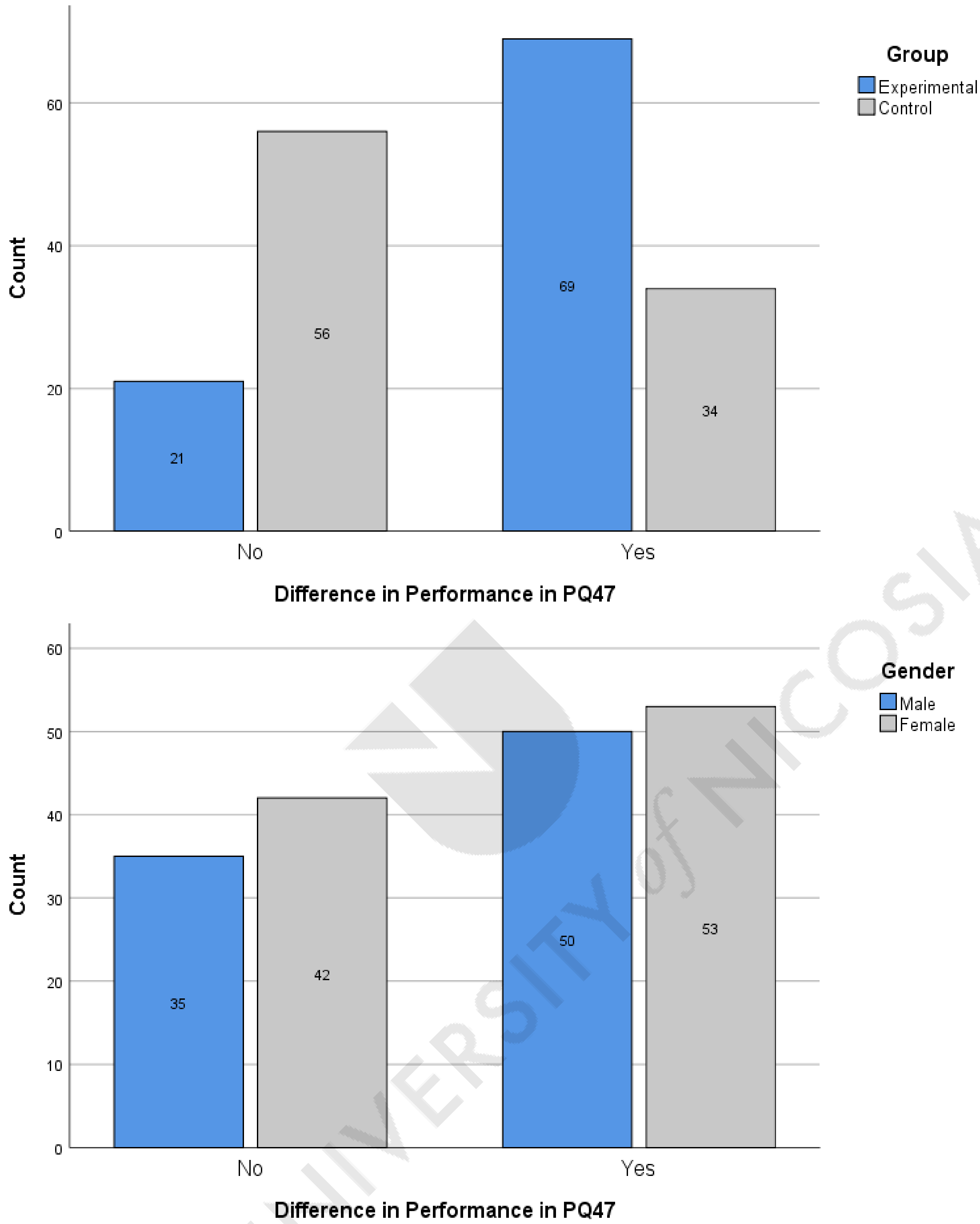


Figure 43: Investigating Potential Association between Group / Gender and Understanding of Question 47 of PHYSICS Knowledge Test

According to Figure 43, students' undestanding of Question 47 about the effects of balanced forces, was significantly improved within the experimental group (Phi = -0.393, p=0.000<0.050), but not between the two genders (Phi = -0.031, p=0.681>0.050).

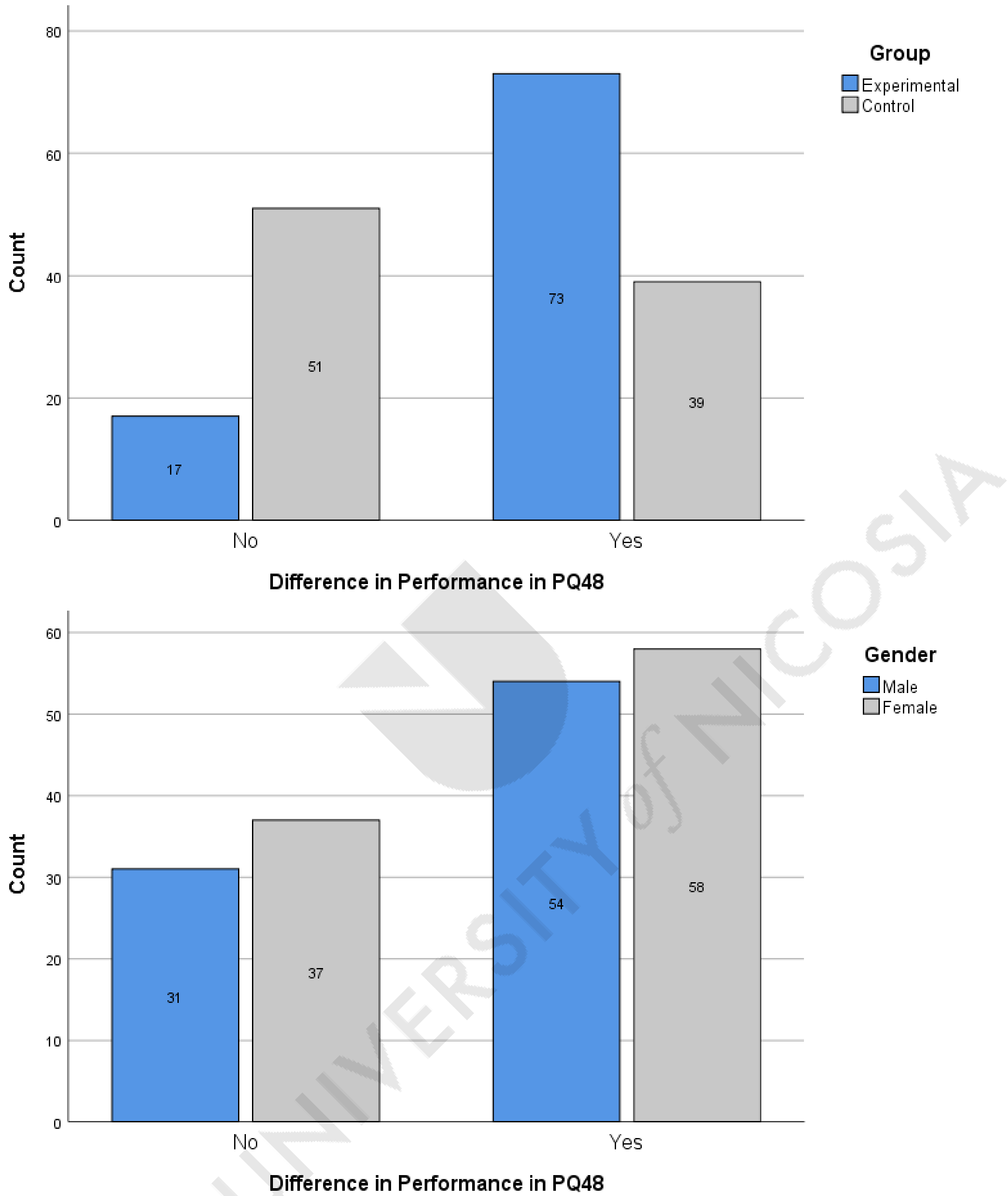


Figure 44: Investigating Potential Association between Group / Gender and Understanding of Question 48 of PHYSICS Knowledge Test

Again, according to Figure 44, the improvement in students' understanding of Question 48 about gravity-related acceleration, was significantly associated with group (Phi = -0.390, p=0.000<0.050), but not with gender (Phi = -0.026, p=0.732>0.050).

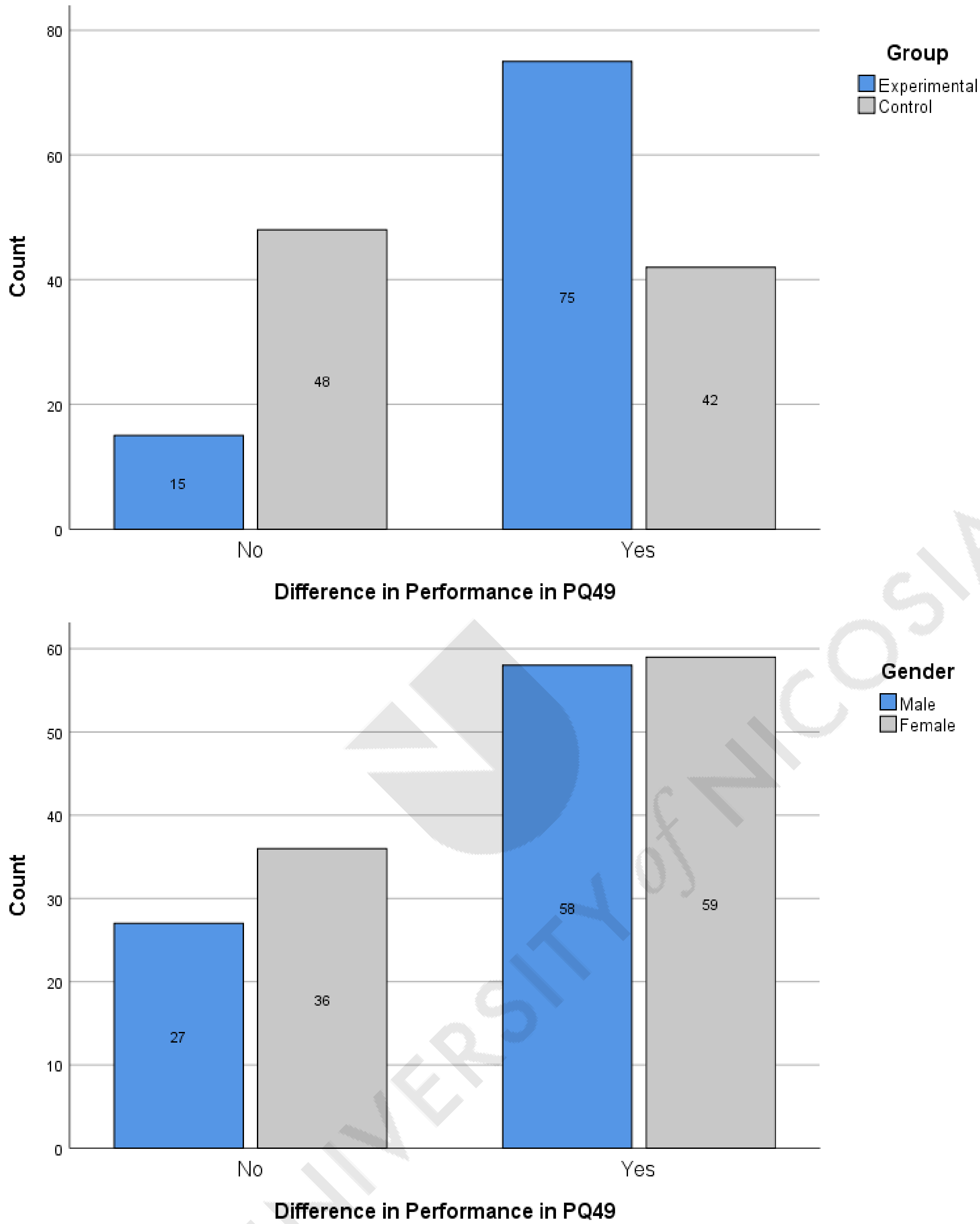


Figure 45: Investigating Potential Association between Group / Gender and Understanding of Question 49 of PHYSICS Knowledge Test

Figure 45 shows that the improvement in students' score of Question 49 requiring a critical overall understanding of forces, was significantly associated with group (Phi = -0.384, p=0.000<0.050), but not with gender (Phi = -0.064, p=0.389>0.050).

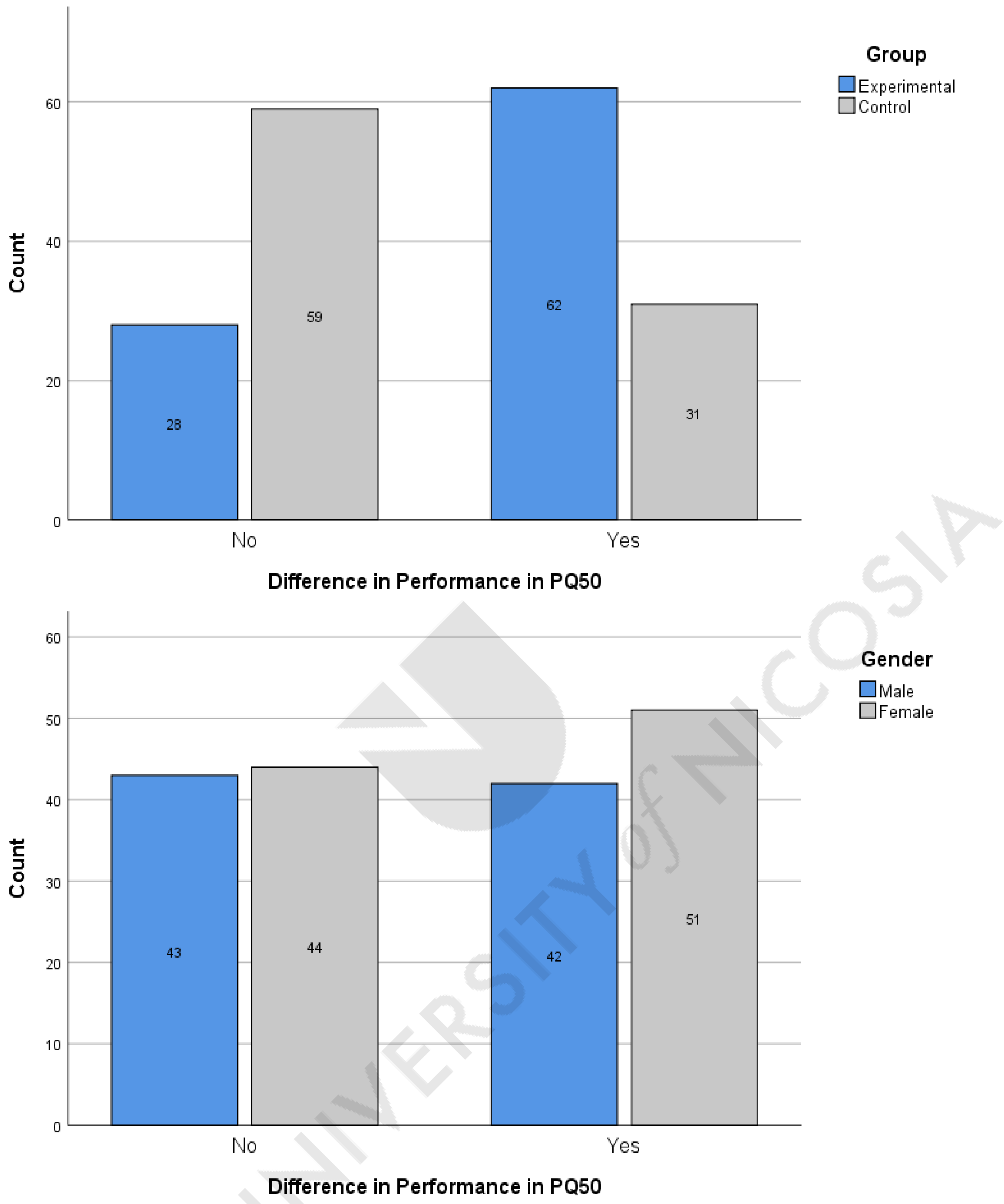


Figure 46: Investigating Potential Association between Group / Gender and Understanding of Question 50 of PHYSICS Knowledge Test

Finally, Figure 46 indicates that the improvement in students' score of Question 50, also requiring a critical overall understanding of forces, was significantly associated with group (Phi = -0.345, p=0.000<0.050), but not with gender (Phi = 0.043, p=0.567>0.050).

The final set of tests that were carried out on each individual question of PHYSICS knowledge test involved a series of independent-samples t-test per dichotomous variable related to the difference in understanding per question, which compared the means of each variable between the independent samples created according to the two-category variables of group and gender. As expected, the results of these t-tests confirmed the results of the previous two procedures.

Table 7 summarizes the results regarding the first t-test where group was used as the grouping variable, while Table 8 summarizes the results of the second t-test where gender was used as the grouping variable. The full output of related statistical analysis generated in SPSS is available in Tables 7(a), 7(b) and Tables 8(a), 8(b) respectively in Appendix C.

In detail, Table 7 shows the difference in the means of each variable, i.e. the improvement in students' performance in each question of Physics Knowledge test, between the experimental and control group. It also incorporates the results of the independent samples test, available in Table 7(b) in Appendix C, which can be interpreted based on Levent's test of equality of variances, determining if the two groups of the factor under consideration have approximately the same or different amounts of variability between scores. When the significance (Sig.) value is higher than the significance level of $a = 5\%$, then the variability is not significantly different, and equal variances are assumed, thus results are interpreted based on the first row of each question variable. Otherwise, equal variances are not assumed and results are taken from the second row. Then, the results of the two-tailed t-test for equality of means are studied based on the significance value of the column "Sig. (2-tailed)", where a value less than the significance level of $a = 5\%$ implies that there is a statistically significant difference between the two conditions/groups of the studied factor.

Following this process, once again the the results of the previous statistical tests are confirmed.

Table 7: Group Statistics and T-Test Results for the 1st Set of Independent-Samples T-Tests with Group as the Grouping Variable

T-Test Results

		Group Statistics			t-test for Equality of Means	
	Group	N	Mean	Std. Deviation	t	Sig. (2-tailed)
Difference in Performance in Question 2 of Physics Knowledge Test	Experimental	90	**.83**	.375	**2.617**	**.010**
	Control	90	**.67**	.474		
Difference in Performance in Question 3 of Physics Knowledge Test	Experimental	90	.62	.488	.455	.649
	Control	90	.59	.495		
Difference in Performance in Question 6 of Physics Knowledge Test	Experimental	90	.71	.456	.954	.341
	Control	90	.64	.481		
Difference in Performance in Question 7 of Physics Knowledge Test	Experimental	90	.62	.488	.606	.545
	Control	90	.58	.497		
Difference in Performance in Question 8 of Physics Knowledge Test	Experimental	90	**.73**	.445	**2.367**	**.019**
	Control	90	**.57**	.498		
Difference in Performance in Question 10 of Physics Knowledge Test	Experimental	90	.73	.445	.973	.332
	Control	90	.67	.474		
Difference in Performance in Question 11 of Physics Knowledge Test	Experimental	90	.66	.478	.310	.757
	Control	90	.63	.485		
Difference in Performance in Question 12 of Physics Knowledge Test	Experimental	90	.72	.450	.488	.626
	Control	90	.69	.466		
Difference in Performance in Question 13 of Physics Knowledge Test	Experimental	90	.64	.481	.763	.446
	Control	90	.59	.495		
Difference in Performance in Question 14 of Physics Knowledge Test	Experimental	90	.68	.470	-.320	.749
	Control	90	.70	.461		
Difference in Performance in Question 17 of Physics Knowledge Test	Experimental	90	.69	.466	-4.964	.000
	Control	90	.96	.207		
Difference in Performance in Question 18 of Physics Knowledge Test	Experimental	90	.76	.432	2.252	.026
	Control	90	.60	.493		
Difference in Performance in Question 19 of Physics Knowledge Test	Experimental	90	.66	.478	.310	.757
	Control	90	.63	.485		
Difference in Performance in Question 20 of Physics Knowledge Test	Experimental	90	.77	.425	2.585	.011
	Control	90	.59	.495		
Difference in Performance in Question 21 of Physics Knowledge Test	Experimental	90	.81	.394	4.458	.000
	Control	90	.51	.503		
Difference in Performance in Question 22 of Physics Knowledge Test	Experimental	90	.81	.982	2.485	.014
	Control	90	.52	.502		
Difference in Performance in Question	Experimental	90	.78	.418	2.923	.004

23 of Physics Knowledge Test	Control	90	.58	.497		
Difference in Performance in Question 24 of Physics Knowledge Test	Experimental	90	.81	.394	3.652	.000
	Control	90	.57	.498		
Difference in Performance in Question 25 of Physics Knowledge Test	Experimental	90	.80	.402	.000	1.000
	Control	90	.80	.402		
Difference in Performance in Question 26 of Physics Knowledge Test	Experimental	90	.79	.410	2.481	.014
	Control	90	.62	.488		
Difference in Performance in Question 27 of Physics Knowledge Test	Experimental	90	.81	.394	3.972	.000
	Control	90	.54	.501		
Difference in Performance in Question 28 of Physics Knowledge Test	Experimental	90	.73	.445	3.774	.000
	Control	90	.47	.502		
Difference in Performance in Question 29 of Physics Knowledge Test	Experimental	90	.71	.456	2.335	.021
	Control	90	.54	.501		
Difference in Performance in Question 30 of Physics Knowledge Test	Experimental	90	.71	.456	2.951	.004
	Control	90	.50	.503		
Difference in Performance in Question 31 of Physics Knowledge Test	Experimental	90	.74	.439	3.794	.000
	Control	90	.48	.502		
Difference in Performance in Question 32 of Physics Knowledge Test	Experimental	90	.79	.410	3.741	.000
	Control	90	.53	.502		
Difference in Performance in Question 33 of Physics Knowledge Test	Experimental	90	.78	.418	4.520	.000
	Control	90	.47	.502		
Difference in Performance in Question 34 of Physics Knowledge Test	Experimental	90	.72	.450	4.080	.000
	Control	90	.43	.498		
Difference in Performance in Question 35 of Physics Knowledge Test	Experimental	90	.74	.439	3.955	.000
	Control	90	.47	.502		
Difference in Performance in Question 36 of Physics Knowledge Test	Experimental	90	.76	.432	3.657	.000
	Control	90	.50	.503		
Difference in Performance in Question 37 of Physics Knowledge Test	Experimental	90	.77	.425	4.164	.000
	Control	90	.48	.502		
Difference in Performance in Question 38 of Physics Knowledge Test	Experimental	90	.77	.425	4.164	.000
	Control	90	.48	.502		
Difference in Performance in Question 39 of Physics Knowledge Test	Experimental	90	.72	.450	3.756	.000
	Control	90	.46	.501		
Difference in Performance in Question 41 of Physics Knowledge Test	Experimental	90	.76	.432	3.657	.000
	Control	90	.50	.503		
Difference in Performance in Question 43 of Physics Knowledge Test	Experimental	90	.83	.375	4.381	.000
	Control	90	.54	.501		
Difference in Performance in Question	Experimental	90	.78	.418	4.854	.000

45 of Physics Knowledge Test	Control	90	.44	.500		
Difference in Performance in Question 46 of Physics Knowledge Test	Experimental	90	.81	.394	4.955	.000
	Control	90	.48	.502		
Difference in Performance in Question 47 of Physics Knowledge Test	Experimental	90	.77	.425	5.702	.000
	Control	90	.38	.488		
Difference in Performance in Question 48 of Physics Knowledge Test	Experimental	90	.81	.394	5.644	.000
	Control	90	.43	.498		
Difference in Performance in Question 49 of Physics Knowledge Test	Experimental	90	.83	.375	5.555	.000
	Control	90	.47	.502		
Difference in Performance in Question 50 of Physics Knowledge Test	Experimental	90	.69	.466	4.898	.000
	Control	90	.34	.478		

Similarly, consolidated Table 8, resulting from Tables 8(a) and 8(b) in Appendix C, confirms previous tests, showing that in non of the questions of the Physics Knowledge Test did students demonstrate an improvement of understanding significantly associated with gender.

Table 8: Group Statistics and T-Test Results for the 2nd Set of Independent-Samples T-Tests with Gender as the Grouping Variable

T-Test Results

		Group Statistics			t-test for Equality of Means	
	Gender	N	Mean	Std. Deviation	t	Sig. (2-tailed)
Difference in Performance in Question 2 of Physics Knowledge Test	Male	85	.72	.453	-.945	.346
	Female	95	.78	.417		
Difference in Performance in Question 3 of Physics Knowledge Test	Male	85	.59	.495	-.447	.655
	Female	95	.62	.488		
Difference in Performance in Question 6 of Physics Knowledge Test	Male	85	.69	.464	.441	.659
	Female	95	.66	.475		
Difference in Performance in Question 7 of Physics Knowledge Test	Male	85	.60	.493	.000	1.000
	Female	95	.60	.492		
Difference in Performance in Question 8 of Physics Knowledge Test	Male	85	.62	.487	-.701	.484
	Female	95	.67	.471		
Difference in Performance in Question 10 of Physics Knowledge Test	Male	85	.69	.464	-.162	.871
	Female	95	.71	.458		
Difference in Performance in Question	Male	85	.64	.484	-.241	.810

11 of Physics Knowledge Test	Female	95	.65	.479		
Difference in Performance in Question	Male	85	.69	.464	-.317	.752
12 of Physics Knowledge Test	Female	95	.72	.453		
Difference in Performance in Question	Male	85	.67	.473	1.411	.160
13 of Physics Knowledge Test	Female	95	.57	.498		
Difference in Performance in Question	Male	85	.72	.453	.433	.785
14 of Physics Knowledge Test	Female	95	.66	.475		
Difference in Performance in Question	Male	85	.85	.362	.413	.821
17 of Physics Knowledge Test	Female	95	.80	.402		
Difference in Performance in Question	Male	85	.71	.458	.448	.760
18 of Physics Knowledge Test	Female	95	.65	.479		
Difference in Performance in Question	Male	85	.69	.464	.188	1.320
19 of Physics Knowledge Test	Female	95	.60	.492		
Difference in Performance in Question	Male	85	.72	.453	.280	1.084
20 of Physics Knowledge Test	Female	95	.64	.482		
Difference in Performance in Question	Male	85	.71	.458	.231	1.203
21 of Physics Knowledge Test	Female	95	.62	.488		
Difference in Performance in Question	Male	85	.76	1.019	.116	1.579
22 of Physics Knowledge Test	Female	95	.58	.496		
Difference in Performance in Question	Male	85	.73	.447	.161	1.408
23 of Physics Knowledge Test	Female	95	.63	.485		
Difference in Performance in Question	Male	85	.72	.453	.433	.785
24 of Physics Knowledge Test	Female	95	.66	.475		
Difference in Performance in Question	Male	85	.80	.402	1.000	.000
25 of Physics Knowledge Test	Female	95	.80	.402		
Difference in Performance in Question	Male	85	.68	.468	.521	-.643
26 of Physics Knowledge Test	Female	95	.73	.448		
Difference in Performance in Question	Male	85	.72	.453	.280	1.084
27 of Physics Knowledge Test	Female	95	.64	.482		
Difference in Performance in Question	Male	85	.61	.490	.762	.303
28 of Physics Knowledge Test	Female	95	.59	.495		
Difference in Performance in Question	Male	85	.60	.493	.469	-.725
29 of Physics Knowledge Test	Female	95	.65	.479		
Difference in Performance in Question	Male	85	.66	.477	.167	1.386
30 of Physics Knowledge Test	Female	95	.56	.499		
Difference in Performance in Question	Male	85	.64	.484	.532	.627
31 of Physics Knowledge Test	Female	95	.59	.495		
Difference in Performance in Question	Male	85	.66	.477	.951	-.061

32 of Physics Knowledge Test	Female	95	.66	.475		
Difference in Performance in Question 33 of Physics Knowledge Test	Male	85	.62	.487	.973	.034
	Female	95	.62	.488		
Difference in Performance in Question 34 of Physics Knowledge Test	Male	85	.61	.490	.385	.870
	Female	95	.55	.500		
Difference in Performance in Question 35 of Physics Knowledge Test	Male	85	.60	.493	.886	-.143
	Female	95	.61	.490		
Difference in Performance in Question 36 of Physics Knowledge Test	Male	85	.62	.487	.912	-.111
	Female	95	.63	.485		
Difference in Performance in Question 37 of Physics Knowledge Test	Male	85	.66	.477	.341	.955
	Female	95	.59	.495		
Difference in Performance in Question 38 of Physics Knowledge Test	Male	85	.64	.484	.734	.340
	Female	95	.61	.490		
Difference in Performance in Question 39 of Physics Knowledge Test	Male	85	.56	.499	.535	-.621
	Female	95	.61	.490		
Difference in Performance in Question 41 of Physics Knowledge Test	Male	85	.60	.493	.469	-.726
	Female	95	.65	.479		
Difference in Performance in Question 43 of Physics Knowledge Test	Male	85	.67	.473	.618	-.499
	Female	95	.71	.458		
Difference in Performance in Question 45 of Physics Knowledge Test	Male	85	.62	.487	.748	.322
	Female	95	.60	.492		
Difference in Performance in Question 46 of Physics Knowledge Test	Male	85	.67	.473	.491	.690
	Female	95	.62	.488		
Difference in Performance in Question 47 of Physics Knowledge Test	Male	85	.59	.495	.683	.409
	Female	95	.56	.499		
Difference in Performance in Question 48 of Physics Knowledge Test	Male	85	.64	.484	.734	.340
	Female	95	.61	.490		
Difference in Performance in Question 49 of Physics Knowledge Test	Male	85	.68	.468	.392	.858
	Female	95	.62	.488		
Difference in Performance in Question 50 of Physics Knowledge Test	Male	85	.49	.503	.569	-.570
	Female	95	.54	.501		

Consequently, based on the abovementioned statistical procedures, Table 9 summarizes the conclusions reached considering the first set of hypotheses described in page 46 ($H_1^0 \ldots H_{41}^0$), while all null hypotheses of the second set described in page 46 ($H_{42}^0 \ldots H_{83}^0$) were accepted, since there was no statistically significant association found between gender and improvement in students' understanding of any of the questions included in PHYSICS Knowledge Test.

Table 9: Summary of Hypotheses Testing Results for Each Individual Question of PHYSICS Knowledge Test (1st Set of Hypotheses about Group)

Summary of Hypotheses Testing Results for Each Individual Question of PHYSICS Knowledge Test		
# Question	**Outcome**	**Conclusion**
1	H_1^0 Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 1 of PHYSICS knowledge test.
2	H_2^0 Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 2 of PHYSICS knowledge test.
3	H_3^0 Accepted	There is no statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 3 of PHYSICS knowledge test.
6	H_4^0 Accepted	There is no statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 6 of PHYSICS knowledge test.
7	H_5^0 Accepted	There is no statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 7 of PHYSICS knowledge test.
8	H_6^0 Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 8 of PHYSICS knowledge test.
10	H_7^0 Accepted	There is no statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 10 of PHYSICS knowledge test.
11	H_8^0 Accepted	There is no statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 11 of PHYSICS knowledge test.
12	H_9^0 Accepted	There is no statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 12 of PHYSICS knowledge test.
13	H_{10}^0 Accepted	There is no statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 13 of PHYSICS knowledge test.
14	H_{11}^0 Accepted	There is no statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 14 of PHYSICS knowledge test.
17	H_{12}^0 Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 17 of PHYSICS knowledge test.
18	H_{13}^0 Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 18 of PHYSICS knowledge test.
19	H_{14}^0 Accepted	There is no statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 19 of PHYSICS knowledge test.
20	H_{15}^0 Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 20 of PHYSICS knowledge test.

21	H_{16}^{0} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 21 of PHYSICS knowledge test.
22	H_{17}^{0} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 22 of PHYSICS knowledge test.
23	H_{18}^{0} Rejected	There is a statistically significant difference between the experimental and control group, regarding the understanding of Question 23 of PHYSICS knowledge test.
24	H_{18}^{0} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 24 of PHYSICS knowledge test.
25	H_{19}^{0} Accepted	There is no statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 25 of PHYSICS knowledge test.
26	H_{20}^{0} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 26 of PHYSICS knowledge test.
27	H_{21}^{0} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 27 of PHYSICS knowledge test.
28	H_{22}^{0} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 28 of PHYSICS knowledge test.
29	H_{23}^{0} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 29 of PHYSICS knowledge test.
30	H_{24}^{0} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 30 of PHYSICS knowledge test.
31	H_{25}^{0} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 31 of PHYSICS knowledge test.
32	H_{26}^{0} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 32 of PHYSICS knowledge test.
33	H_{27}^{0} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 33 of PHYSICS knowledge test.
34	H_{28}^{0} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 34 of PHYSICS knowledge test.
35	H_{29}^{0} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 35 of PHYSICS knowledge test.
36	H_{30}^{0} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 36 of PHYSICS knowledge test.
37	H_{31}^{0} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 37 of PHYSICS knowledge test.
38	H_{32}^{0} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 38 of PHYSICS knowledge test.
39	H_{33}^{0} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 39 of PHYSICS knowledge test.
41	H_{34}^{0} Accepted	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 41 of PHYSICS knowledge test.

43	H_{35}^{0} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 43 of PHYSICS knowledge test.
45	H_{36}^{0} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 45 of PHYSICS knowledge test.
46	H_{37}^{0} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 46 of PHYSICS knowledge test.
47	H_{38}^{0} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 47 of PHYSICS knowledge test.
48	H_{39}^{0} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 48 of PHYSICS knowledge test.
49	H_{40}^{0} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 49 of PHYSICS knowledge test.
50	H_{41}^{0} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 50 of PHYSICS knowledge test.

4.2. Improvement in the Understanding of Each Question – Subtopic of P.E. Fields Test

Similarly with the methodology described in the previous section, a new dichotomous variable was also computed per each individual question of P.E. fields test, indicating whether there was a difference in the students' performance and understanding in the "pre" and "post" phases of the trial, with 0 representing the negative answer and 1 signifying a positive answer. However, it must be noted that in the case of P.E. fields tests, each question is simultaneously one of the five subtopics under examination in P.E.

Again, the first step was to apply nonparametric correlations between each of these variables and each of the two factors under consideration, i.e. group and gender, leading to the generation of Table 10, which summarizes the results (the entire output of Table 10, as calculated in SPSS, is available in Appendix C). The dichotomous variables are nominal, so Spearman's rho was deemed appropriate to test for statistically significant correlation.

Table 10 indicates the existence of statistically significant relationships between three out of the five dichotomous variables and group, at a significance level of either $a = 1\%$ or

$a = 5\%$. On the contrary, there were no statistically significant relationships between any of the dichotomous variables and gender.

More specifically, at a significance level of $a = 1\%$, there was a statistically significant difference in the students' performance and understanding in the "pre" and "post" phases of the trial, regarding Question 5 related to the subtopic "Energy Balance/Body Mass Index". At a significance level of $a = 5\%$, there was a statistically significant difference in the students' performance and understanding in the "pre" and "post" phases of the trial, regarding the first and second subtopics "Transfer of the Ball" and "Air Resistance". Finally, there was no statistically significant difference in the students' performance and understanding in the "pre" and "post" phases of the trial, regarding the third and fourth subtopics about "Aerobic Exercise" and "Flexibility".

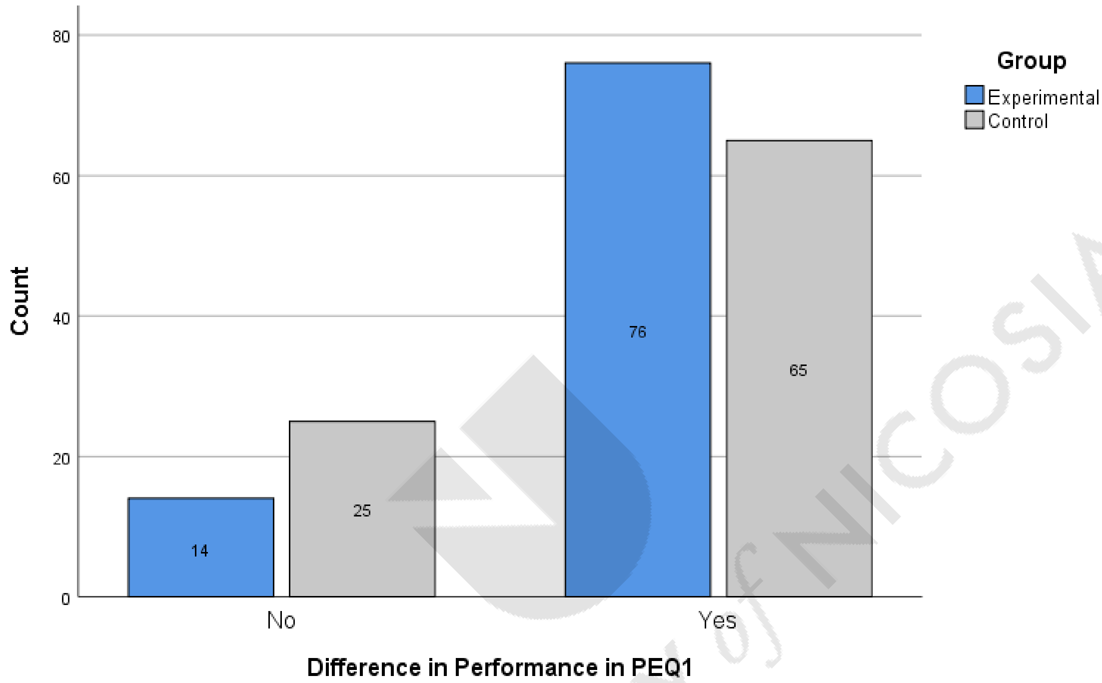
Table 10: Nonparametric Correlations Investigating the Association between Group / Gender and the Understanding of Individual Questions - Subtopics of P.E. Fields Test

Nonparametric Correlations (Calculation of Spearman's rho Correlation Coefficient)		
	Group	**Gender**
Difference in Performance in Question-Subtopic 1 of P.E. Fields Test	-.148*	.070
Difference in Performance in Question-Subtopic 2 of P.E. Fields Test	-.190*	.107
Difference in Performance in Question-Subtopic 3 of P.E. Fields Test	-.116	.005
Difference in Performance in Question-Subtopic 4 of P.E. Fields Test	-.101	.077
Difference in Performance in Question-Subtopic 5 of P.E. Fields Test	-.193**	.080
** Correlation is significant at the 0.01 level (2-tailed).		
* Correlation is significant at the 0.05 level (2-tailed).		

The aforementioned results of nonparametric correlations were confirmed by the results of crosstab and independent-sample t-test procedures.

The results of crosstabs are summarized in Table 10(b), available in Appendix C

In the following pages, Figures 47 – 51 are again indicative of the results as they visualize the distribution of alternative values of the dichotomous question-related variables per group and per gender.



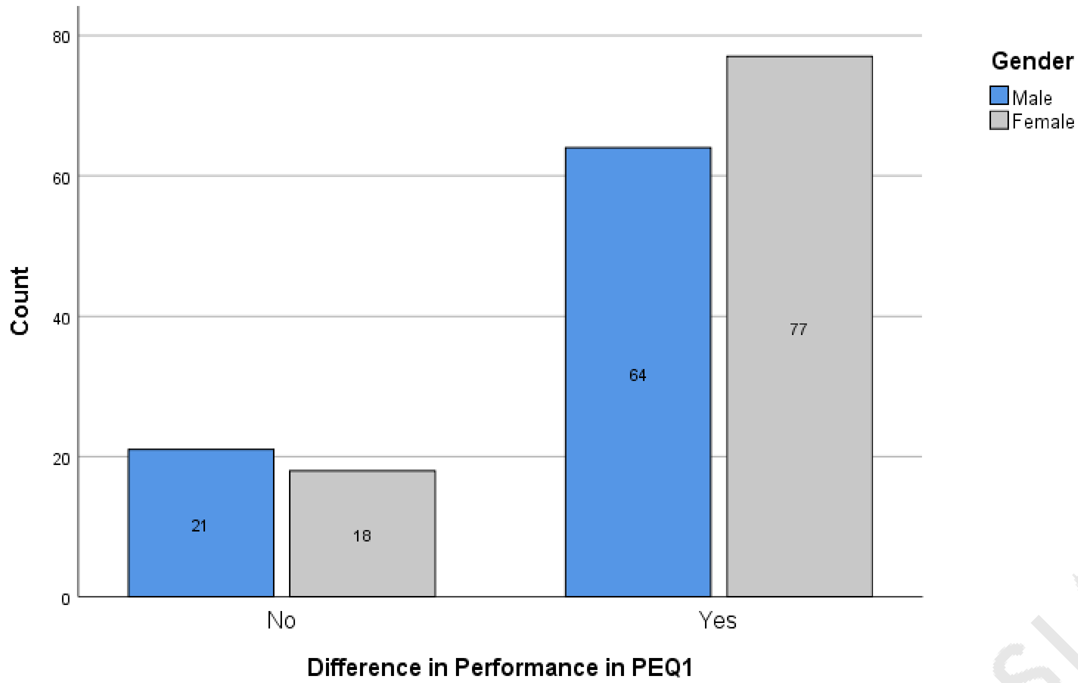
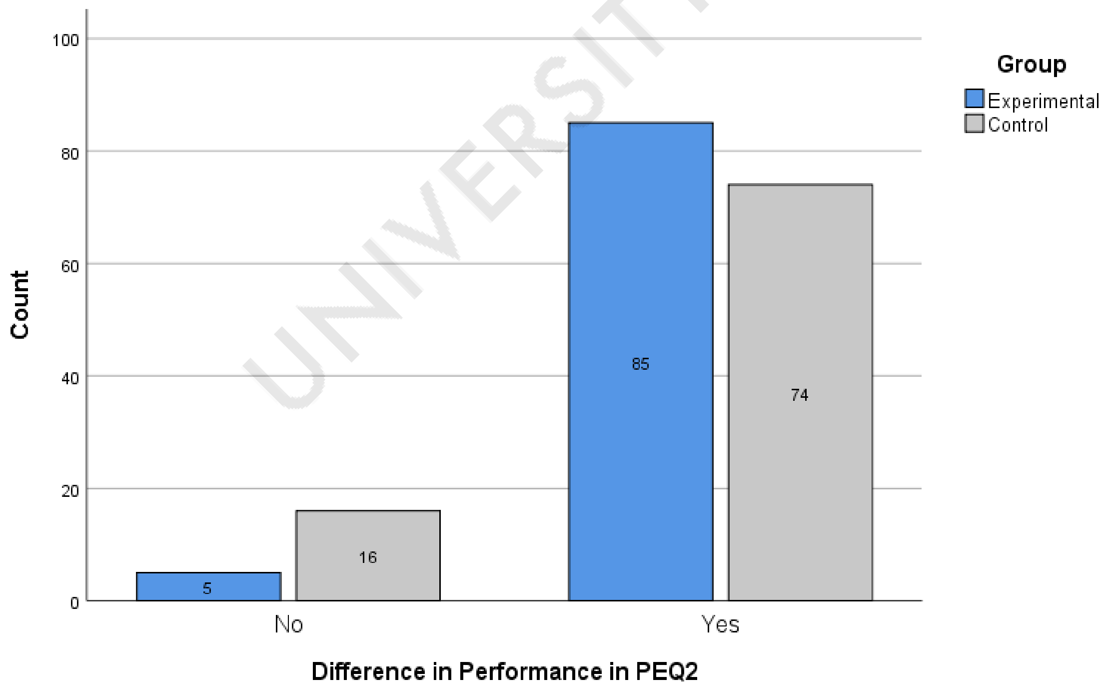


Figure 47: Investigating Potential Association between Group / Gender and Understanding of Question 1 of P.E. Fields Test

Figure 47 shows that in the first question / activity of P.E. Fields test regarding the subtopic "Transfer of the Ball", students' improvement of performance is weakly associated with group (Phi = -0.148, $p=0.047<0.050$), while it does not appear related to gender (Phi = 0.070, $p=0.349>0.050$).



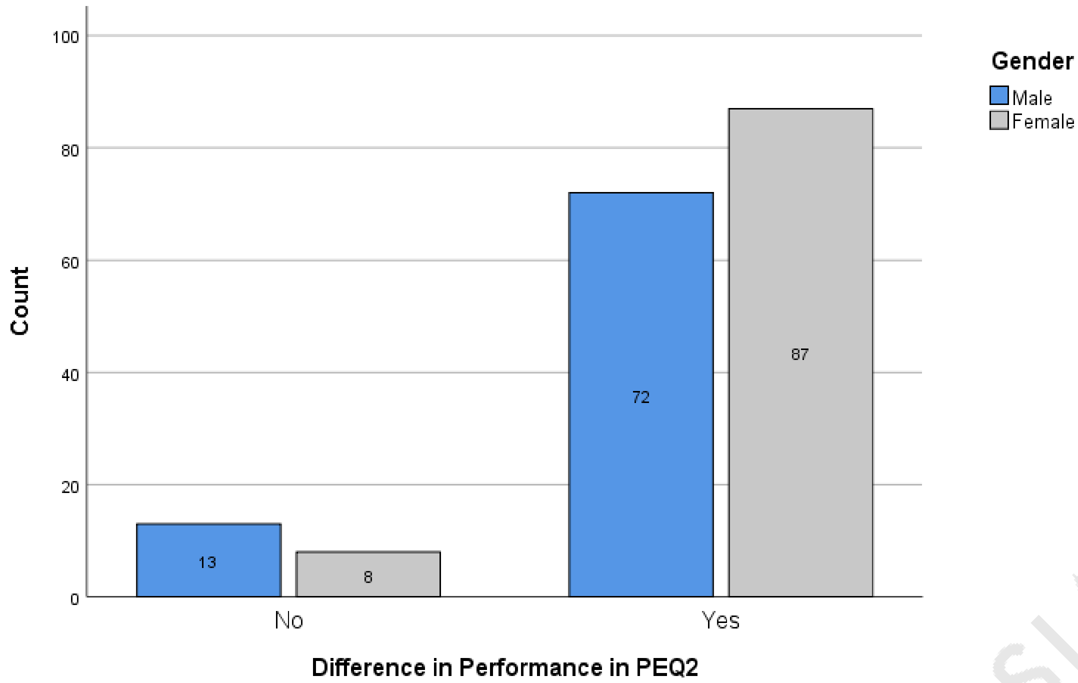


Figure 48: Investigating Potential Association between Group / Gender and Understanding of Question 2 of P.E. Fields Test

Again, Figure 48 shows that students' improvement of performance in the second question / activity of P.E. Fields test about "Air Resistance" is weakly associated with group (Phi = -0.190, p=0.011<0.050), but not with gender (Phi = 0.107, p=0.152>0.050).

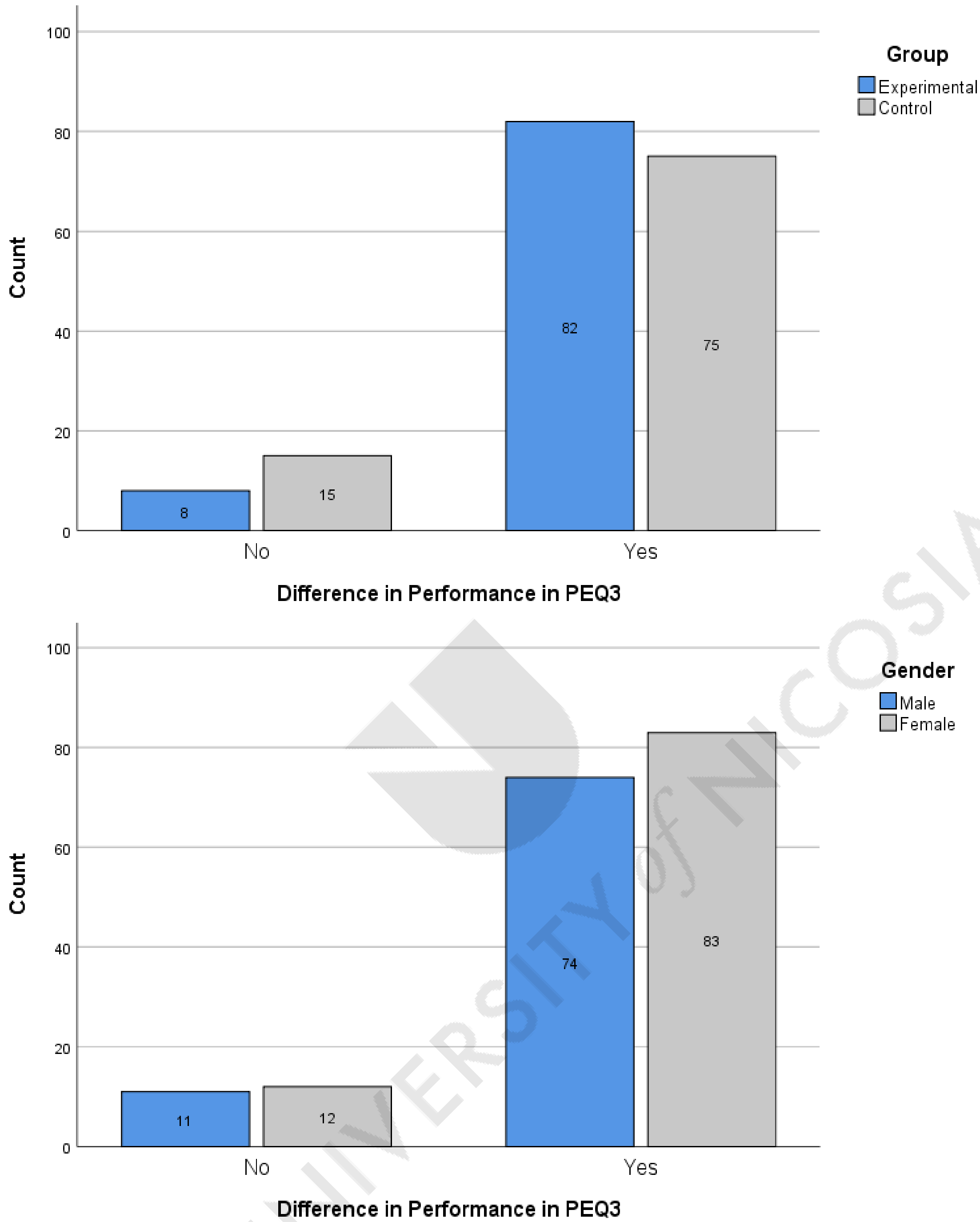


Figure 49: Investigating Potential Association between Group / Gender and Understanding of Question 3 of P.E. Fields Test

According to Figure 49, students' improvement of performance in the third question / activity of P.E. Fields test about "Aerobic Exercise" was not associated with either group (Phi = -0.116, p=0.118>0.050) or gender (Phi = 0.005, p=0.950>0.050).

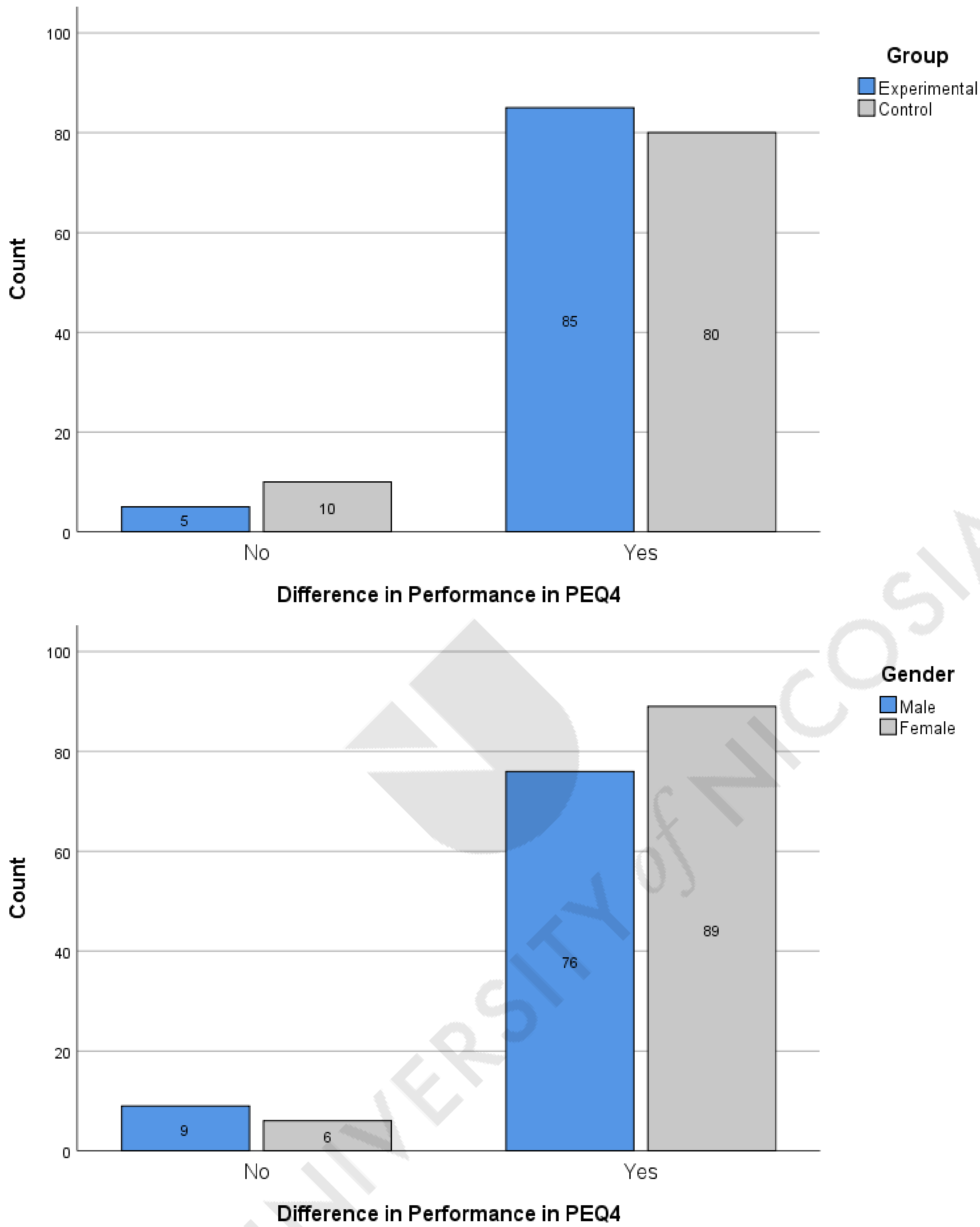


Figure 50: Investigating Potential Association between Group / Gender and Understanding of Question 4 of P.E. Fields Test

On the contrary, Figure 50 shows that neither group (Phi = -0.101, p=0.178>0.050) nor gender (Phi = 0.077, p=0.300>0.050) seem to influence the difference in students' performance in the forth question/activity of P.E. Fields Test about "Flexibility".

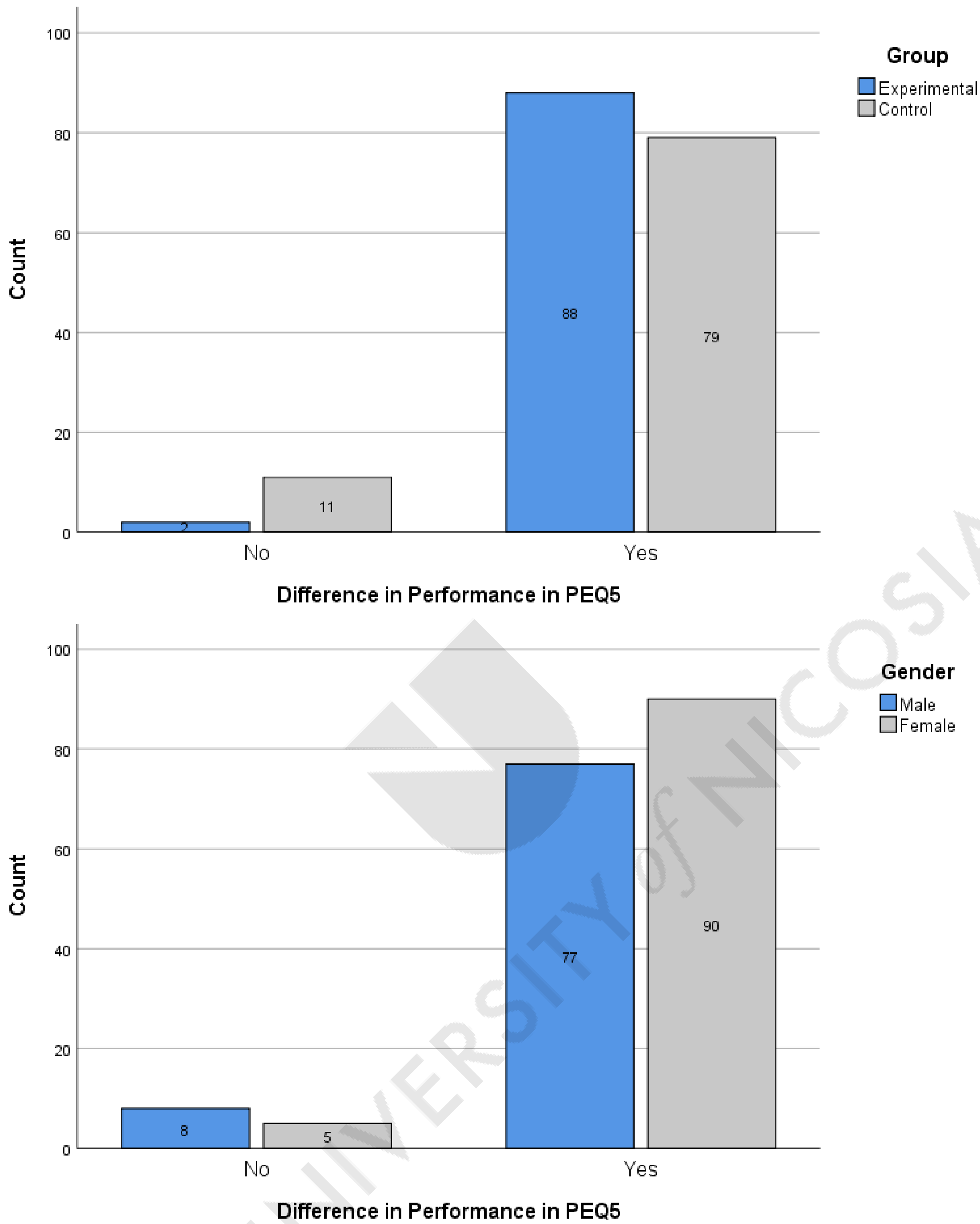


Figure 51: Investigating Potential Association between Group / Gender and Understanding of Question 5 of P.E. Fields Test

Finally, there seems to be a weak relationship between group and the improvement of students'performance in the fifth question/activity of P.E. Fields Test about "Energy Balance/Body Mass Index" (Phi = -0.193, p=0.010<0.050), whereas gender does not have any significant effect (Phi = 0.080, p=0.283>0.050).

The final set of tests that were performed on each individual question – subtopic of P.E. fields test involved a series of independent-samples t-test per dichotomous variable related to the difference in understanding per question, which compared the means of each variable between the independent samples created according to the two-category variables of group and gender. As expected, the results of these t-tests confirmed the results of the previous two procedures.

Table 11 summarizes the results regarding the first t-test where group was used as the grouping variable, while Table 12 summarizes the results of the second t-test where gender was used as the grouping variable. The full output of related statistical analysis generated in SPSS is available in Tables 11(a), 11(b) and Tables 12(a), 12(b) respectively in Appendix C.

Table 11: Group Statistics and T-Test Results for the 1st Set of Independent-Samples T-Tests with Group as the Grouping Variable

T-Test Results

		Group Statistics			t-test for Equality of Means	
	Group	N	Mean	Std. Deviation	t	Sig. (2-tailed)
Difference in Performance in Question-Subtopic 1 of P.E. Fields Test	Experimental	90	**.84**	.364	**2.001**	**.047**
	Control	90	**.72**	.450		
Difference in Performance in Question-Subtopic 2 of P.E. Fields Test	Experimental	90	**.94**	.230	**2.587**	**.011**
	Control	90	**.82**	.384		
Difference in Performance in Question-Subtopic 3 of P.E. Fields Test	Experimental	90	.91	.286	1.565	.120
	Control	90	.83	.375		
Difference in Performance in Question-Subtopic 4 of P.E. Fields Test	Experimental	90	.94	.230	1.348	.180
	Control	90	.89	.316		
Difference in Performance in Question-Subtopic 5 of P.E. Fields Test	Experimental	90	**.98**	.148	**2.627**	**.010**
	Control	90	**.88**	.329		

Similarly, consolidated Table 12, resulting from Tables 12(a) and 12(b) in Appendix C, confirms previous tests, showing that in none of the questions/activities of P.E. Fields Test did students demonstrate an improvement of understanding significantly associated with gender.

Table 12: Group Statistics and T-Test Results for the 2nd Set of Independent-Samples T-Tests with Gender as the Grouping Variable

T-Test Results

		Group Statistics			t-test for Equality of Means	
	Group	N	Mean	Std. Deviation	t	Sig. (2-tailed)
Difference in Performance in Question-Subtopic 1 of P.E. Fields Test	Male	85	.75	.434	-.928	.355
	Female	95	.81	.394		
Difference in Performance in Question-Subtopic 2 of P.E. Fields Test	Male	85	.85	.362	-1.414	.159
	Female	95	.92	.279		
Difference in Performance in Question-Subtopic 3 of P.E. Fields Test	Male	85	.87	.338	-.062	.951
	Female	95	.87	.334		
Difference in Performance in Question-Subtopic 4 of P.E. Fields Test	Male	85	.89	.310	-1.019	.310
	Female	95	.94	.245		
Difference in Performance in Question-Subtopic 5 of P.E. Fields Test	Male	85	.91	.294	-1.055	.293
	Female	95	.95	.224		

The process of interpreting t-test results was explained in the Section 4.1. In this case, results confirm previous tests on the significance of group and/or gender in the improvement of students' performance in each of the five activities/subtopics. In other words, group is a significant factor for activities/subtopics 1, 2 and 5, i.e. Transfer of the Ball, Air Resistance and Energy Balance/Body Mass Index, while it does not play an important role for the remaining activities, 3 (Aerobic Exercise) and 4 (Flexibility). Gender is once again insignificant to the improvement of students' score.

Consequently, based on the abovementioned statistical procedures, Table 13 summarizes the conclusions reached considering the first set of hypotheses described in page 46 (H^0_{84} … H^0_{88}), while all null hypotheses of the second set described in page 47 (H^0_{89} … H^0_{93}) were accepted, since there was no statistically significant association found between gender and improvement in students' performance of any of the questions/activities included in P.E. Fields Test.

Table 13: Summary of Hypotheses Testing Results for Each Individual Question - Subtopic of P.E. Fields Test

Summary of Hypotheses Testing Results for Each Individual Question - Subtopic of P.E. Fields Test		
# Activity	**Outcome**	**Conclusion**
1	H^0_{84} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 1 of P.E. Fields test and the respective subtopic “Transfer of the Ball”.
2	H^0_{85} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 2 of P.E. Fields test and the respective subtopic “Air Resistance”.
3	H^0_{86} Accepted	There is no statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 3 of P.E. Fields test and the respective subtopic “Aerobic Exercise”.
4	H^0_{87} Accepted	There is no statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 4 of P.E. Fields test and the respective subtopic “Flexibility”.
5	H^0_{88} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Question 5 of P.E. Fields test and the respective subtopic “Energy Balance/Body Mass Index”.

4.3. Understanding of Each Subtopic of PHYSICS Knowledge Test in the Pre-Trial and Post-Trial Phases

The next step in the statistical analysis of the acquired data was to assess the potential impact of the two independent factors, group and gender, on the students’ understanding of each of the five subtopics in PHYSICS, i.e. Friction/Stopping Distance, Air Resistance, Up Thrust, Stretch and Weight/Gravity in the pre-trial and post-trial phases.

To this end, five new variables were computed for each trial phase (pre and post) to aggregate the results of all individual questions belonging to each subtopic. The new variables were calculated as the average value of the individual questions per trial phase and per case (student). Therefore, the new quantitative variables were:

- Performance in FRICTION/STOPPING DISTANCE (pre)

- Performance in FRICTION/STOPPING DISTANCE (post)
- Performance in AIR RESISTANCE (pre)
- Performance in AIR RESISTANCE (post)
- Performance in UP THRUST (pre)
- Performance in UP THRUST (post)
- Performance in STRETCH (pre)
- Performance in STRETCH (post)
- Performance in WEIGHT/GRAVITY (pre)
- Performance in WEIGHT/GRAVITY (post)

After defining the new variables, the first step of this part of the analysis involved parametric correlations and a series of Independent-Samples T-Tests, to assess whether the independent factors “group” and “gender” were associated significantly with each of the new variables.

Table 14 summarizes the results of the parametric correlations (the entire output of this table, as calculated in SPSS, is available in Appendix C), where it appears that all variables except for Performance in WEIGHT/GRAVITY (pre) have a statistically significant relationship with the factor “group” at a significance level of $a = 1\%$, whereas none of the variables are significantly related with gender.

Table 14: Parametric Correlations Investigating the Association between Group / Gender and the Understanding of Subtopics of PHYSICS in Pre- and Post-Trial Phases

Nonparametric Correlations (Calculation of Pearson Correlation Coefficient)		
	Group	**Gender**
Performance in FRICTION/ STOPPING DISTANCE (pre)	-.510**	-.082
Performance in FRICTION/ STOPPING DISTANCE (post)	-.495**	-.022
Performance in AIR RESISTANCE (pre)	-.439**	-.080
Performance in AIR RESISTANCE (post)	-.432**	-.116
Performance in UPTHRUST (pre)	-.189*	-.056
Performance in UPTHRUST (post)	-.460**	-.074
Performance in STRETCH (pre)	-.203**	-.059
Performance in STRETCH (post)	-.510**	-.055
Performance in WEIGHT/GRAVITY (pre)	-.004	-.097

Performance in WEIGHT/GRAVITY (post)	-.494**	-.060
** Correlation is significant at the 0.01 level (2-tailed).		
* Correlation is significant at the 0.05 level (2-tailed).		

The independent-samples t-test compared the means of each variable between the independent samples created according to the two-category variables of group and gender. As expected, the results of these t-tests confirmed the results of the previous procedure.

Table 15 summarizes the results regarding the first t-test where group was used as the grouping variable, while Table 16 summarizes the results of the second t-test where gender was used as the grouping variable. The full output of related statistical analysis generated in SPSS is available in Tables 15(a), 15(b) and Tables 16(a), 16(b) respectively in Appendix C.

Table 15: Group Statistics and T-Test Results for the 1st Set of Independent-Samples T-Tests with Group as the Grouping Variable

T-Test Results

		Group Statistics			t-test for Equality of Means	
	Group	N	Mean	Std. Deviation	t	Sig. (2-tailed)
Performance in FRICTION/ STOPPING DISTANCE (pre)	Experimental	90	**.2593**	.18548	**7.900**	**.000**
	Control	90	**.0741**	.12268		
Performance in FRICTION/ STOPPING DISTANCE (post)	Experimental	90	**.9685**	.08617	**7.602**	**.000**
	Control	90	**.6889**	.33817		
Performance in AIR RESISTANCE (pre)	Experimental	90	**.2667**	.23269	**6.511**	**.000**
	Control	90	**.0833**	.13117		
Performance in AIR RESISTANCE (post)	Experimental	90	**.9542**	.14569	**6.396**	**.000**
	Control	90	**.7125**	.32749		
Performance in UPTHRUST (pre)	Experimental	90	**.1989**	.22108	**2.562**	**.011**
	Control	90	**.1267**	.15050		
Performance in UPTHRUST (post)	Experimental	90	**.9556**	.16767	**6.921**	**.000**
	Control	90	**.6656**	.36045		
Performance in STRETCH (pre)	Experimental	90	**.2012**	.22216	**2.760**	**.006**
	Control	90	**.1222**	.15629		
Performance in STRETCH (post)	Experimental	90	**.9556**	.14212	**7.907**	**.000**
	Control	90	**.5988**	.40379		
Performance in WEIGHT/GRAVITY (pre)	Experimental	90	.1681	.18086	.058	.954
	Control	90	.1667	.14022		
Performance in WEIGHT/GRAVITY	Experimental	90	**.9528**	.14823	**7.587**	**.000**

(post)	Control	90	**.6125**	.39884		

Table 16: Group Statistics and T-Test Results for the 2nd Set of Independent-Samples T-Tests with Gender as the Grouping Variable

T-Test Results

		Group Statistics			t-test for Equality of Means	
	Gender	N	Mean	Std. Deviation	t	Sig. (2-tailed)
Performance in FRICTION/ STOPPING DISTANCE (pre)	Male	85	.1824	.19007	1.093	.276
	Female	95	.1526	.17474		
Performance in FRICTION/ STOPPING DISTANCE (post)	Male	85	.8353	.29378	.295	.769
	Female	95	.8228	.27484		
Performance in AIR RESISTANCE (pre)	Male	85	.1926	.22621	1.069	.287
	Female	95	.1592	.19334		
Performance in AIR RESISTANCE (post)	Male	85	.8676	.25174	1.575	.117
	Female	95	.8026	.30158		
Performance in UPTHRUST (pre)	Male	85	.1741	.21885	.749	.455
	Female	95	.1526	.16493		
Performance in UPTHRUST (post)	Male	85	.8353	.29061	.994	.321
	Female	95	.7884	.33671		
Performance in STRETCH (pre)	Male	85	.1739	.21099	.786	.433
	Female	95	.1509	.18114		
Performance in STRETCH (post)	Male	85	.7974	.35060	.731	.466
	Female	95	.7591	.35198		
Performance in WEIGHT/GRAVITY (pre)	Male	85	.1838	.16090	1.297	.196
	Female	95	.1526	.16122		
Performance in WEIGHT/GRAVITY (post)	Male	85	.8044	.33209	.800	.425
	Female	95	.7632	.35705		

Consequently, based on the abovementioned statistical procedures, Table 17 summarizes the conclusions reached considering the following sets of hypotheses, as described on page 47:

1. Null Hypotheses: H_{94}^{0} … H_{98}^{0}
2. Null Hypotheses: H_{99}^{0} … H_{103}^{0}

Table 17: Summary of Hypotheses Testing Results for Each Subtopic of PHYSICS Knowledge Test in the Pre-Trial and Post-Trial Phases

Summary of Hypotheses Testing Results for Each Individual Subtopic of PHYSICS Knowledge Test		
# Subtopic	**Outcome**	**Conclusion**
1 (pre)	H^0_{94} Rejected	There is a statistically significant difference between the experimental and control group, regarding the understanding of Subtopic 1 (Friction/Stopping Distance) of PHYSICS knowledge test in the pre-trial phase.
2 (pre)	H^0_{95} Rejected	There is a statistically significant difference between the experimental and control group, regarding the understanding of Subtopic 2 (Air Resistance) of PHYSICS knowledge test in the pre-trial phase.
3 (pre)	H^0_{96} Rejected	There is a statistically significant difference between the experimental and control group, regarding the understanding of Subtopic 3 (Up Thrust) of PHYSICS knowledge test in the pre-trial phase.
4 (pre)	H^0_{97} Rejected	There is a statistically significant difference between the experimental and control group, regarding the understanding of Subtopic 4 (Stretch) of PHYSICS knowledge test in the pre-trial phase.
5 (pre)	H^0_{98} Accepted	There is no statistically significant difference between the experimental and control group, regarding the understanding of Subtopic 5 (Weight/Gravity) of PHYSICS knowledge test in the pre-trial phase.
1 (post)	H^0_{99} Rejected	There is a statistically significant difference between the experimental and control group, regarding the understanding of Subtopic 1 (Friction/Stopping Distance) of PHYSICS knowledge test in the post-trial phase.
2 (post)	H^0_{100} Rejected	There is a statistically significant difference between the experimental and control group, regarding the understanding of Subtopic 2 (Air Resistance) of PHYSICS knowledge test in the post-trial phase.
3 (post)	H^0_{101} Rejected	There is a statistically significant difference between the experimental and control group, regarding the understanding of Subtopic 3 (Up Thrust) of PHYSICS knowledge test in the post-trial phase.
4 (post)	H^0_{102} Rejected	There is a statistically significant difference between the experimental and control group, regarding the understanding of Subtopic 4 (Stretch) of PHYSICS knowledge test in the post-trial phase.
5 (post)	H^0_{103} Rejected	There is a statistically significant difference between the experimental and control group, regarding the understanding of Subtopic 5 (Weight/Gravity) of PHYSICS knowledge test in the post-trial phase.

On the other hand, the next two sets of hypotheses, presented on page 47, were all accepted, since there was no significant link found between gender and students' understanding of each Subtopic of PHYSICS Knowledge Test in either phase:

1. Null Hypotheses: $H_{104}^{0} \ldots H_{109}^{0}$
2. Null Hypotheses: $H_{110}^{0} \ldots H_{113}^{0}$

4.4. Understanding of Each Subtopic of P.E. Fields Test in the Pre-Trial and Post-Trial Phases

The same evaluation was performed for the potential impact of the two independent factors, group and gender, on the students' understanding of each of the five subtopics in P.E. , i.e. Transfer of the Ball, Air Resistance, Aerobic Exercise, Flexibility and Energy Balance/Body Mass Index.

To this end, the nominal variables representing the responses to each question in P.E. fields test were employed in nonparametric correlations and a series of Independent-Samples T-Tests, to assess whether the independent factors "group" and "gender" were associated significantly with each of the variables.

Table 18 summarizes the results of nonparametric correlations (the entire output of this table, as calculated in SPSS, is available in Appendix C), where it appears that only variables "Performance in TRANSFER OF THE BALL (post)" and "Performance in AIR RESISTANCE (post)" have a statistically significant relationship with the factor "group" at a significance level of $a = 1\%$, whereas none of the variables are significantly related with gender.

Table 18: Nonparametric Correlations Investigating the Association between Group / Gender and the Understanding of Subtopics of P.E. in Pre- and Post-Trial Phases

Nonparametric Correlations (Calculation of Spearman's rho Correlation Coefficient)		
	Group	**Gender**
Performance in TRANSFER OF THE BALL (pre)	-.041	-.058
Performance in TRANSFER OF THE BALL (post)	-.209**	.038
Performance in AIR RESISTANCE (pre)	-.043	-.138
Performance in AIR RESISTANCE (post)	-.222**	.056
Performance in AEROBIC EXERCISE (pre)	-.054	-.066
Performance in AEROBIC EXERCISE (post)	-.133	-.077
Performance in FLEXIBILITY (pre)	.000	-.010
Performance in FLEXIBILITY (post)	-.127	.089
Performance in ENERGY BALANCE/BMI (pre)	.130	-.051
Performance in ENERGY BALANCE/BMI (post)	-.146	.062

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

The independent-samples t-test compared the means of each variable between the independent samples created according to the two-category variables of group and gender. The results of t-tests confirmed the results of correlations.

Table 19 summarizes the results regarding the first t-test where group was used as the grouping variable, while Table 20 summarizes the results of the second t-test where gender was used as the grouping variable. The full output of related statistical analysis generated in SPSS is available in Tables 19(a), 19(b) and Tables 20(a), 20(b) respectively in Appendix C.

Table 19: Group Statistics and T-Test Results for the 1st Set of Independent-Samples T-Tests with Group as the Grouping Variable

T-Test Results

		Group Statistics			t-test for Equality of Means	
	Group	N	Mean	Std. Deviation	t	Sig. (2-tailed)
Performance in TRANSFER OF THE BALL (pre)	Experimental	90	.09	.286	.554	.580
	Control	90	.07	.251		
Performance in TRANSFER OF THE BALL (post)	Experimental	90	**.93**	.251	**2.849**	**.005**
	Control	90	**.79**	.410		
Performance in AIR RESISTANCE (pre)	Experimental	90	.02	.148	.580	.563
	Control	90	.01	.105		
Performance in AIR RESISTANCE (post)	Experimental	90	**.97**	.181	**3.041**	**.003**
	Control	90	**.83**	.375		
Performance in AEROBIC EXERCISE (pre)	Experimental	90	.06	.230	.720	.472
	Control	90	.03	.181		
Performance in AEROBIC EXERCISE (post)	Experimental	90	.94	.230	1.790	.075
	Control	90	.87	.342		
Performance in FLEXIBILITY (pre)	Experimental	90	.03	.181	.000	1.000
	Control	90	.03	.181		
Performance in FLEXIBILITY (post)	Experimental	90	.98	.148	1.714	.089
	Control	90	.92	.269		
Performance in ENERGY BALANCE/ BMI (pre)	Experimental	90	.00	.000	-1.752	.083
	Control	90	.03	.181		
Performance in ENERGY BALANCE/ BMI (post)	Experimental	90	.98	.148	1.962	.052
	Control	90	.91	.286		

Table 20: Group Statistics and T-Test Results for the 2nd Set of Independent-Samples T-Tests with Gender as the Grouping Variable

T-Test Results

		Group Statistics			t-test for Equality of Means	
	Gender	N	Mean	Std. Deviation	t	Sig. (2-tailed)
Performance in TRANSFER OF THE BALL (pre)	Male	85	.09	.294	.771	.442
	Female	95	.06	.245		
Performance in TRANSFER OF THE BALL (post)	Male	85	.85	.362	-.513	.608
	Female	95	.87	.334		
Performance in AIR RESISTANCE (pre)	Male	85	.04	.186	1.753	.083
	Female	95	.00	.000		
Performance in AIR RESISTANCE (post)	Male	85	.88	.324	-.744	.458
	Female	95	.92	.279		
Performance in AEROBIC EXERCISE (pre)	Male	85	.06	.237	.882	.379
	Female	95	.03	.176		
Performance in AEROBIC EXERCISE (post)	Male	85	.93	.258	1.045	.297
	Female	95	.88	.322		
Performance in FLEXIBILITY (pre)	Male	85	.04	.186	.138	.891
	Female	95	.03	.176		
Performance in FLEXIBILITY (post)	Male	85	.93	.258	-1.173	.243
	Female	95	.97	.176		
Performance in ENERGY BALANCE/ BMI (pre)	Male	85	.02	.152	.677	.499
	Female	95	.01	.103		
Performance in ENERGY BALANCE/ BMI (post)	Male	85	.93	.258	-.830	.408
	Female	95	.96	.202		

Consequently, based on the abovementioned statistical procedures, Table 21 summarizes the conclusions reached considering the following sets of hypotheses, as described on pages 47-48:

1. Null Hypotheses: $H_{114}^{0} \ldots H_{118}^{0}$
2. Null Hypotheses: $H_{119}^{0} \ldots H_{123}^{0}$

Table 21: Summary of Hypotheses Testing Results for Each Subtopic of P.E. Fields Test in the Pre-Trial and Post-Trial Phases

Summary of Hypotheses Testing Results for Each Subtopic of P.E. Fields Test		
# Subtopic	**Outcome**	**Conclusion**
1 (pre)	H^0_{114} Accepted	There is no statistically significant difference between the experimental and control group, regarding the understanding of Subtopic 1 (Transfer of the Ball) of P.E. fields test in the pre-trial phase.
2 (pre)	H^0_{115} Accepted	There is no statistically significant difference between the experimental and control group, regarding the understanding of Subtopic 2 (Air Resistance) of P.E. fields test in the pre-trial phase.
3 (pre)	H^0_{116} Accepted	There is no statistically significant difference between the experimental and control group, regarding the understanding of Subtopic 3 (Aerobic Exercise) of P.E. fields test in the pre-trial phase.
4 (pre)	H^0_{117} Accepted	There is no statistically significant difference between the experimental and control group, regarding the understanding of Subtopic 4 (Flexibility) of P.E. fields test in the pre-trial phase.
5 (pre)	H^0_{118} Accepted	There is no statistically significant difference between the experimental and control group, regarding the understanding of Subtopic 5 (Energy Balance/Body Mass Index) of P.E. fields test in the pre-trial phase.
1 (post)	H^0_{119} Rejected	There is a statistically significant difference between the experimental and control group, regarding the understanding of Subtopic 1 (Transfer of the Ball) of P.E. fields test in the post-trial phase.
2 (post)	H^0_{120} Rejected	There is a statistically significant difference between the experimental and control group, regarding the understanding of Subtopic 2 (Air Resistance) of P.E. fields test in the post-trial phase.
3 (post)	H^0_{121} Accepted	There is no statistically significant difference between the experimental and control group, regarding the understanding of Subtopic 3 (Aerobic Exercise) of P.E. fields test in the post-trial phase.
4 (post)	H^0_{122} Accepted	There is no statistically significant difference between the experimental and control group, regarding the understanding of Subtopic 4 (Flexibility) of P.E. fields test in the post-trial phase.
5 (post)	H^0_{123} Accepted	There is no statistically significant difference between the experimental and control group, regarding the understanding of Subtopic 5 (Energy Balance/Body Mass Index) of P.E. fields test in the post-trial phase.

On the other hand, null hypotheses $H_{124}^{0} \ldots H_{128}^{0}$ and $H_{129}^{0} \ldots H_{133}^{0}$, presented on page 48, were all accepted, since there was no significant link found between gender and students' understanding of each Subtopic of P.E. Fields Test in either phase.

4.5. Improvement in the Understanding of Each Subtopic of PHYSICS Knowledge Test

Using the quantitative variables presented in Section 4.3, the next step of the statistical analysis involved the application of the General Linear Model (GLM) and particularly a series of GLM Repeated Measures procedures to investigate whether any changes in students' understanding of each subtopic of PHYSICS Knowledge Test between the pre- and post-trial phases could somehow be related to the independent factors gender and group.

To apply the three-way ANOVA Repeated Measures analysis, a within-subjects factor, "test-time", was defined with two levels which represented the values of the (average) performance in each subtopic pre- and post-trial. Moreover, there were two between-subjects factors, the existing variables "group" and "gender".

This procedure was performed five times, once per subtopic. Results presented in Tables 22 and 23 below indicated that there was a statistically significant interaction between test_time and group for all subtopics except for "Air Resistence", whereas there was neither a statistically significant interaction between test_time and gender nor a statistically significant three-way interaction for any of the subtopics.

Table 22: Summary of Three-way Repeated Measures Descriptive Statistics & Multivariate Tests Results for the Interaction Between Performance in Each Subtopic of PHYSICS and Group in the Pre-Trial and Post-Trial Phases

Three-way Repeated Measures Descriptive Statistics & Multivariate Tests					
	Group	N	Mean	Std. Deviation	Measurement / Group Interaction
Performance in FRICTION/ STOPPING DISTANCE (pre)	Experimental	90	.2593	.18548	F= 4.863
	Control	90	.0741	.12268	p=0.029 < α=0.05
Performance in FRICTION/ STOPPING DISTANCE (post)	Experimental	90	.9685	.08617	
	Control	90	.6889	.33817	
Performance in AIR RESISTANCE (pre)	Experimental	90	.2667	.13117	F= 1.535
	Control	90	.0833	.20958	p=0.217 > α=0.05
Performance in AIR RESISTANCE (post)	Experimental	90	.9542	.14569	
	Control	90	.7125	.32749	
Performance in UP THRUST (pre)	Experimental	90	.1989	.22108	F= 15.792
	Control	90	.1267	.15050	p=0.000 < α=0.01
Performance in UP THRUST (post)	Experimental	90	.9556	.16767	
	Control	90	.6656	.36045	
Performance in STRETCH (pre)	Experimental	90	.2012	.22216	F= 24.397
	Control	90	.1222	.15629	p=0.000 < α=0.01
Performance in STRETCH (post)	Experimental	90	.9556	.1412	
	Control	90	.5988	.40379	
Performance in WEIGHT/ GRAVITY (pre)	Experimental	90	.1681	.18086	F= 43.144
	Control	90	.1667	.14022	p=0.000 < α=0.01
Performance in WEIGHT/ GRAVITY (post)	Experimental	90	.9528	.14823	
	Control	90	.6125	.39884	

Table 23: Summary of Three-way Repeated Measures Descriptive Statistics & Multivariate Tests Results for the Interaction Between Performance in Each Subtopic of PHYSICS and Gender in the Pre-Trial and Post-Trial Phases

Three-way Repeated Measures Descriptive Statistics & Multivariate Tests					
	Gender	N	Mean	Std. Deviation	Measurement / Group Interaction
Performance in FRICTION/ STOPPING DISTANCE (pre)	Male	85	.1824	.19007	F= 0.58 p=0.810 > α=0.05
	Female	95	.1526	.17474	
Performance in FRICTION/ STOPPING DISTANCE (post)	Male	85	.8353	.29378	
	Female	95	.8228	.27484	
Performance in AIR RESISTANCE (pre)	Male	85	.1926	.22621	F= 0.568 p=0.452 > α=0.05
	Female	95	.1592	.19334	
Performance in AIR RESISTANCE (post)	Male	85	.8676	.25174	
	Female	95	.8026	.30158	
Performance in UP THRUST (pre)	Male	85	.1741	.21885	F= 0.590 p=0.443 > α=0.05
	Female	95	.1526	.16493	
Performance in UP THRUST (post)	Male	85	.8353	.29061	
	Female	95	.7884	.33671	
Performance in STRETCH (pre)	Male	85	.1739	.21099	F= 0.428 p=0.514 > α=0.05
	Female	95	.1509	.18114	
Performance in STRETCH (post)	Male	85	.7974	.35060	
	Female	95	.7591	.35198	
Performance in WEIGHT/ GRAVITY (pre)	Male	85	.1838	.16090	F= 0.498 p=0.481 > α=0.05
	Female	95	.1526	.16122	
Performance in WEIGHT/ GRAVITY (post)	Male	85	.8044	.33209	
	Female	95	.7632	.35705	

Below, the Profile Plots of Estimated Marginal Means of each dependent variable at the pre- and post-trial phases for both between-subjects factors (Group and Gender) are presented.

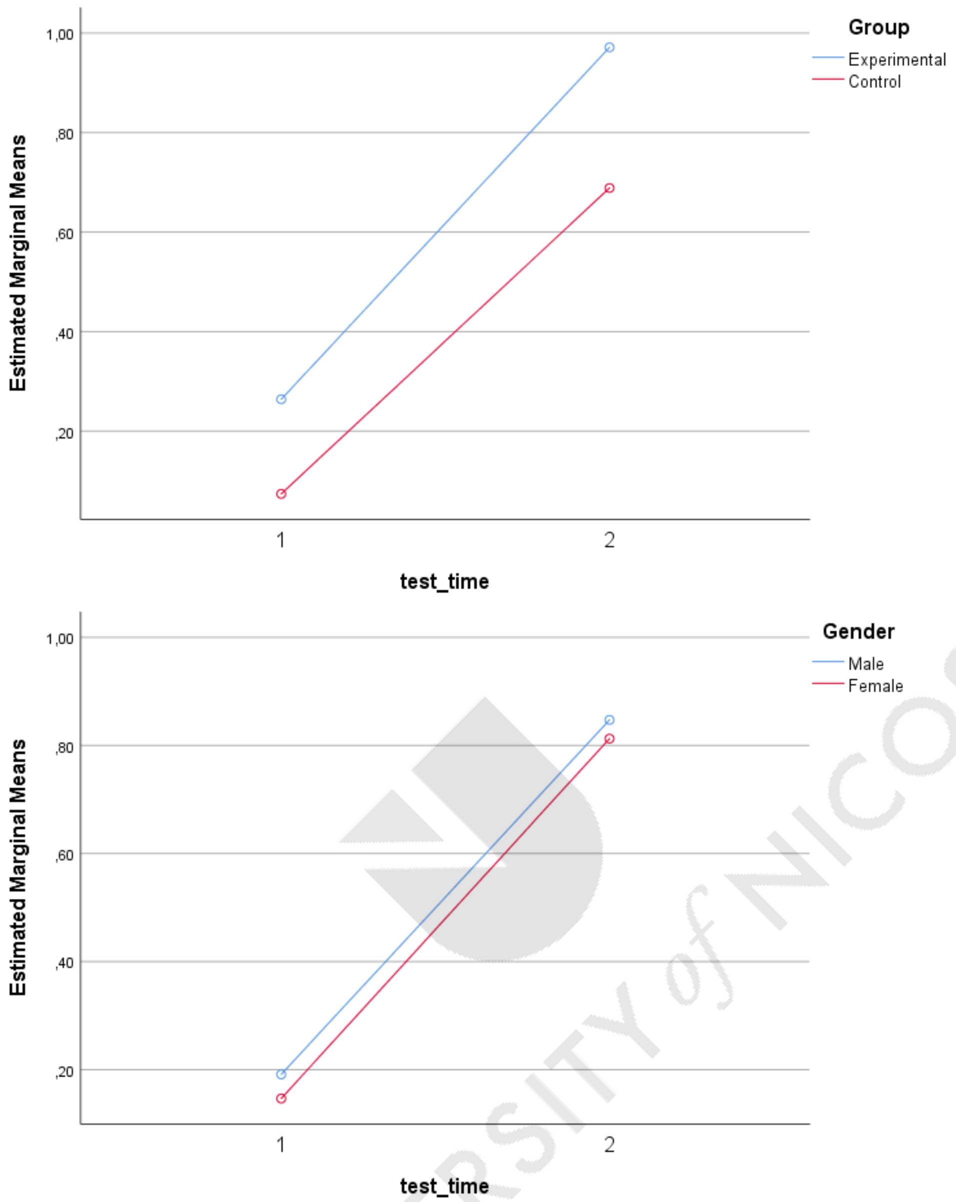


Figure 52: Profile Plots for Performance in FRICTION/ STOPPING DISTANCE

In general, a profile plot of one factor shows whether the estimated marginal means are increasing or decreasing across levels. For two or more factors, parallel lines indicate that there is no interaction between factors, whereas nonparallel lines indicate an interaction. Therefore, Figure 52 indicates an interaction between group and students' performance in FRICTION/ STOPPING DISTANCE, with the dependent variable being higher for the experimental group and increasing over time. On the contrary, although students' performance still increases from the pre-trial to the post-trial phase, the lines of the two genders are parallel, implying that gender does not have a significant effect on performance.

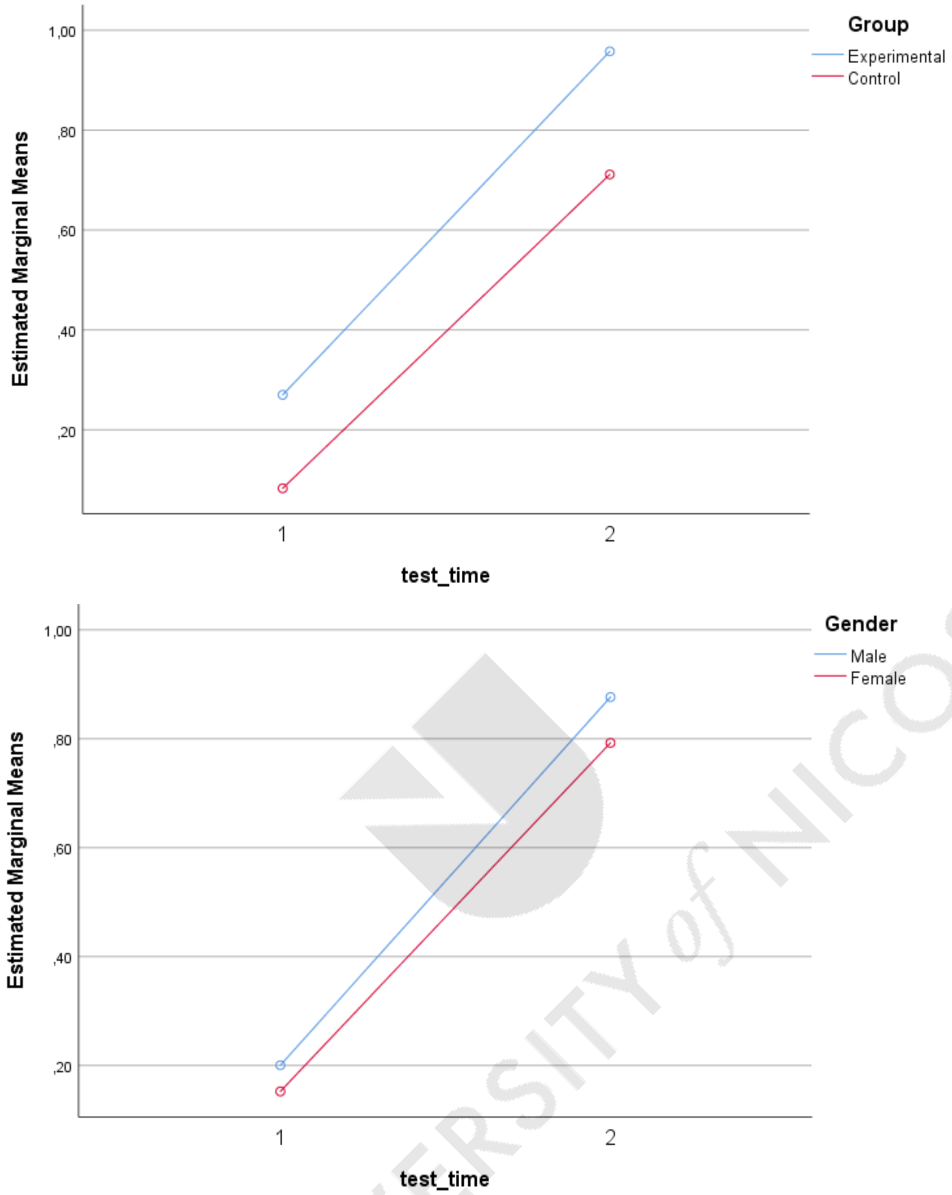
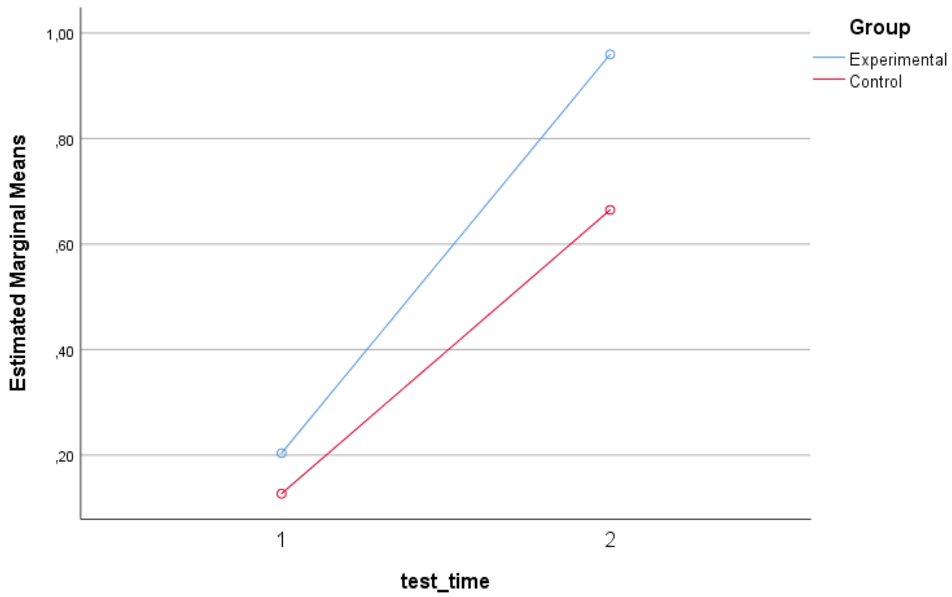


Figure 53: Profile Plots for Performance in AIR RESISTANCE

Figure 53 indicates that students' performance in AIR RESISTANCE improves between the pre- and post-trial phases in both cases of group and gender. However, in both cases, the plot lines are almost parallel, implying that there is no statistically significant association between the dependent variable and any of the two factors.



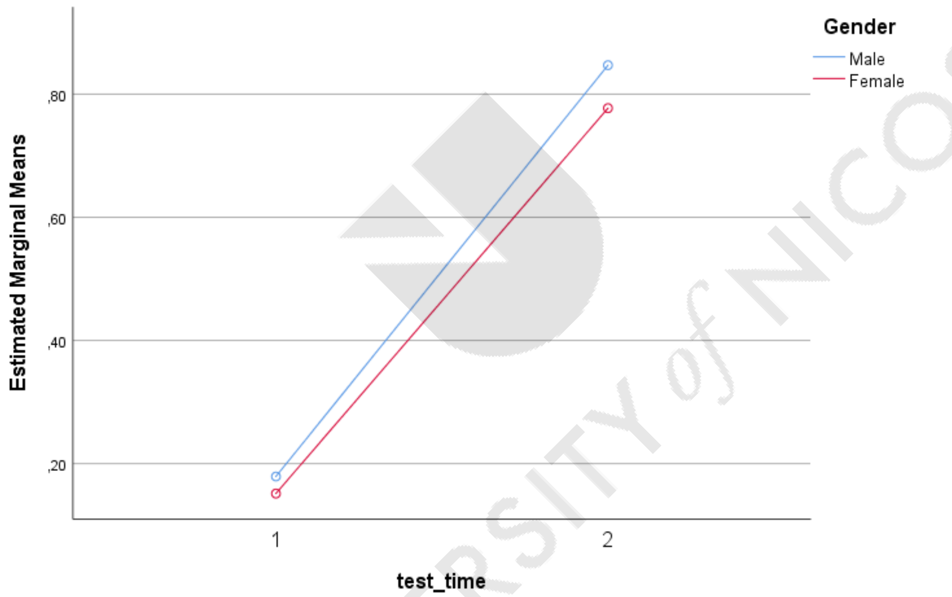
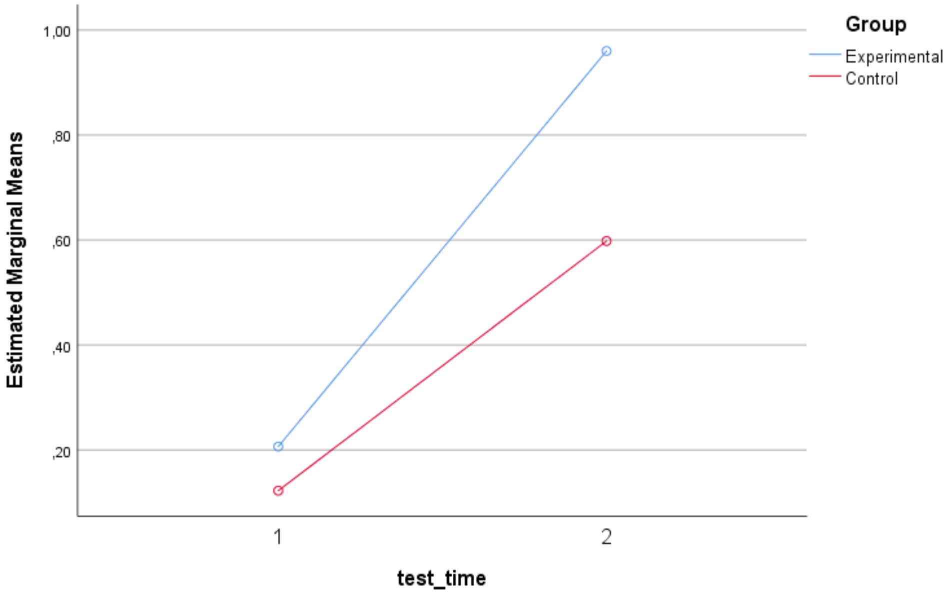


Figure 54: Profile Plots for Performance in UP THRUST

Figure 54 indicates an interaction between group and students' performance in UP THRUST, which increases between the two phases, since the plot lines of experimental and control groups are unparallel. On the contrary, although students' performance still increases from the pre-trial to the post-trial phase, the lines of the two genders are almost parallel, which means that gender does not have a significant effect on students' performance in UP THRUST.



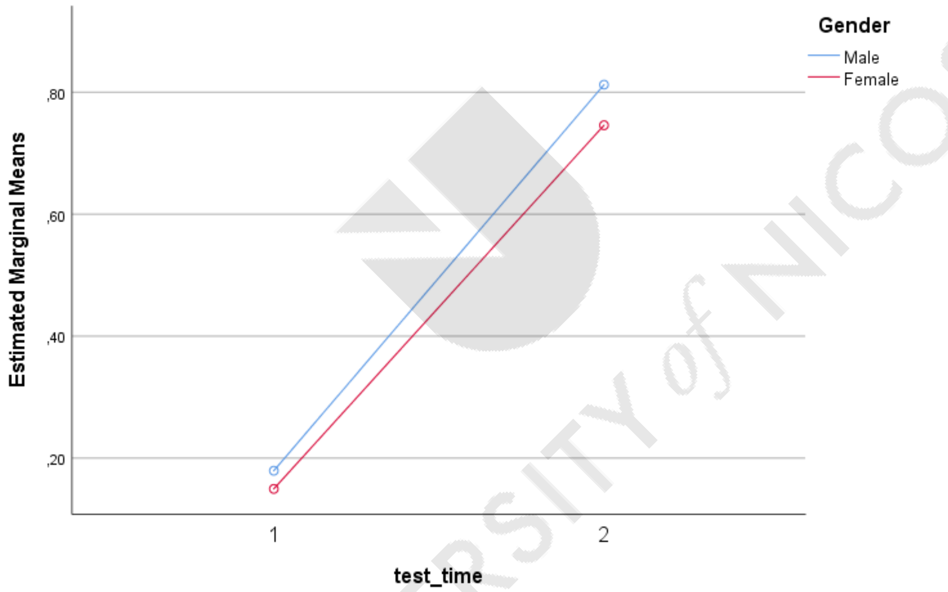


Figure 55: Profile Plots for Performance in STRETCH

Similarly, Figure 55 indicates a significant association between group and students' performance in STRETCH, which increases between the two phases, since the plot lines of experimental and control groups are definitely unparallel. In the case of gender, students' performance also increases from the pre-trial to the post-trial phase, but the lines of the two genders are almost parallel, thus gender does not have a significant effect on students' performance in STRETCH.

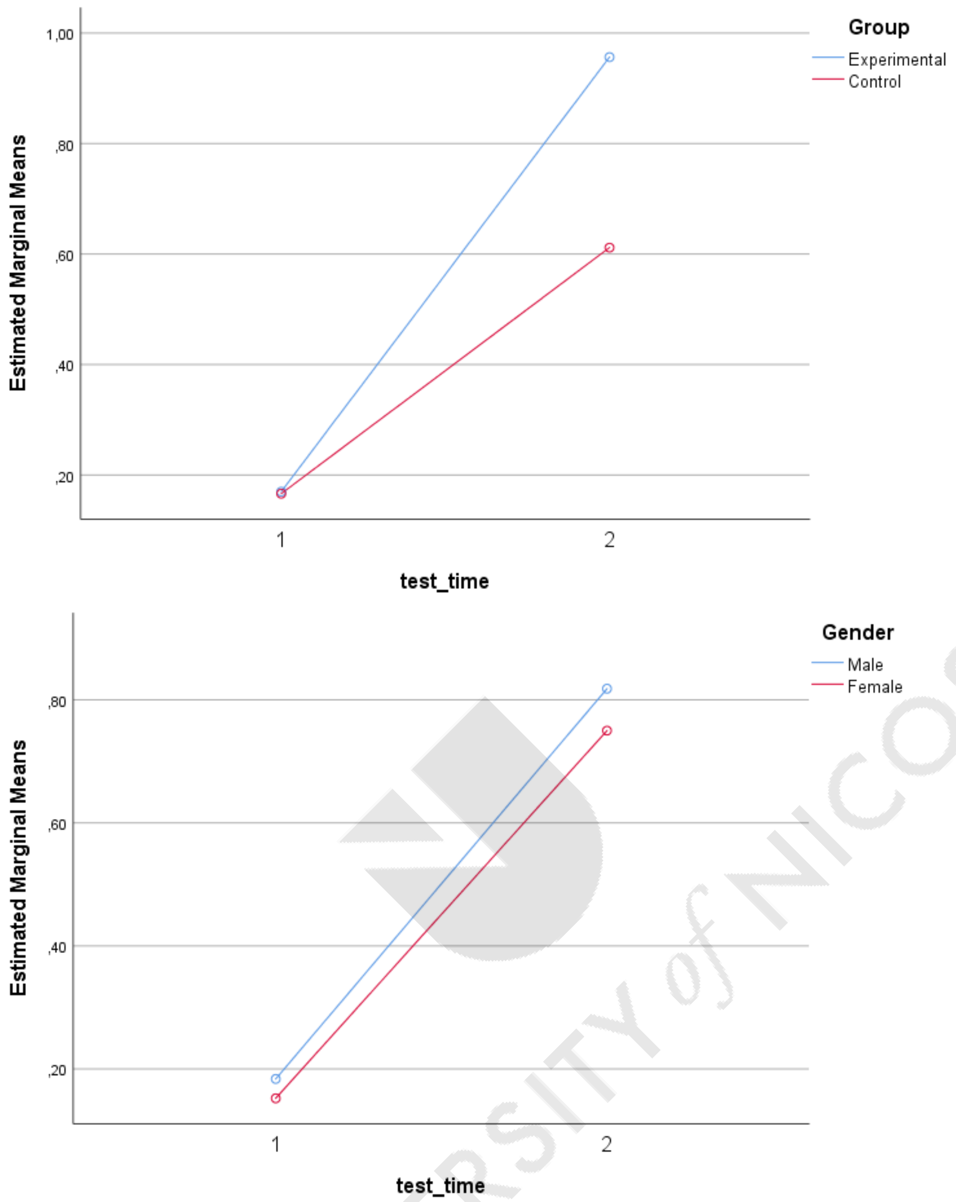


Figure 56: Profile Plots for Performance in WEIGHT/GRAVITY

Finally, Figure 56 indicates a significant association between group and students' performance in WEIGHT/GRAVITY, which increases between the two phases, since the plot lines of experimental and control groups are not only unparallel but intersecting. In the case of gender, students' performance also increases from the pre-trial to the post-trial phase, however the lines of the two genders are once again almost parallel, so gender does not have a significant effect on students' performance in WEIGHT/GRAVITY.

Consequently, based on the statistical procedures described previously, Table 24 summarizes the conclusions reached considering hypotheses $H_{134}^{0} \ldots H_{138}^{0}$, as described on page 48.

Table 24: Summary of Hypotheses Testing Results for Each Subtopic of PHYSICS Knowledge Test

Summary of Hypotheses Testing Results for Each Subtopic of PHYSICS Knowledge Test		
# Subtopic	**Outcome**	**Conclusion**
1	H_{134}^{0} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Subtopic 1 (Friction/Stopping Distance) of PHYSICS knowledge test.
.2	H_{135}^{0} Accepted	There is no statistically significant difference between the experimental and control group, regarding the improvement of understanding of Subtopic 2 (Air Resistance) of PHYSICS knowledge test.
3	H_{136}^{0} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Subtopic 3 (Up Thrust) of PHYSICS knowledge test.
4	H_{137}^{0} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Subtopic 4 (Stretch) of PHYSICS knowledge test.
5	H_{138}^{0} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement of understanding of Subtopic 5 (Weight/Gravity) of PHYSICS knowledge test.

On the other hand, null hypotheses $H_{139}^{0} \ldots H_{143}^{0}$, presented on page 48, were all accepted, since there was no significant link found between gender and the improvement of students' understanding of any of the Subtopics in PHYSICS knowledge test.

4.6. Improvement in the Understanding of “Forces” in PHYSICS

Following the same methodology as in the previous section, the last two steps of the statistical analysis of this research involve the assessment of the potential interaction between the improvement in students’ understanding of “Forces” in the two disciplines and the two independent factors (Group and Gender).

For the purposes of this evaluation, a new variable was computed for each trial phase (pre and post) to aggregate the results of all individual questions belonging to the test related to each discipline. The new quantitative variables were calculated as the average value of the individual questions per trial phase and per case (student). Therefore, the new quantitative variables were:

- Performance in PHYSICS (pre)
- Performance in PHYSICS (post)
- Performance in P.E. (pre)
- Performance in P.E. (post)

This section focuses on PHYSICS and the next on P.E. Therefore, the two first variables were used in a three-way repeated measures analysis, similar to that of the previous section.

Results presented in Tables 25 and 25 below indicated that there was a statistically significant interaction between test_time and group, while there was neither a statistically significant interaction between test_time and gender nor a statistically significant three-way interaction for PHYSICS.

Table 25: Summary of Three-way Repeated Measures Descriptive Statistics & Multivariate Tests Results for the Interaction Between Performance in PHYSICS and Group in the Pre-Trial and Post-Trial Phases

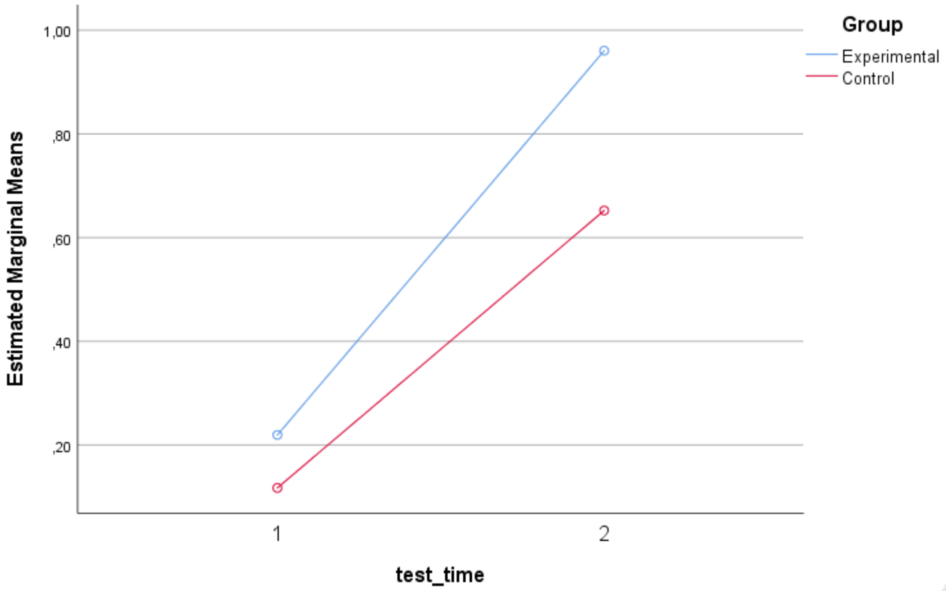
Three-way Repeated Measures Descriptive Statistics & Multivariate Tests					
	Group	N	Mean	Std. Deviation	Measurement / Group Interaction
Performance in PHYSICS (pre)	Experimental	90	.2154	.16018	F= 19.714
	Control	90	.1173	.09562	p=0.000 < α=0.01

Performance in PHYSICS (post)	Experimental	90	.9566	.11987	
	Control	90	.6531	.34582	

Table 26: Summary of Three-way Repeated Measures Descriptive Statistics & Multivariate Tests Results for the Interaction Between Performance in PHYSICS and Gender in the Pre-Trial and Post-Trial Phases

Three-way Repeated Measures Descriptive Statistics & Multivariate Tests					
	Gender	N	Mean	Std. Deviation	Measurement / Group Interaction
Performance in PHYSICS (pre)	Male	85	.1808	.15915	F= 0.449
	Female	95	.1535	.12069	p=0.504 > α=0.05
Performance in PHYSICS (post)	Male	85	.8273	.29121	
	Female	95	.7849	.30708	

Profile Plots of Estimated Marginal Means of the dependent variable at the pre- and post-trial phases for both Group and Gender are depicted below.



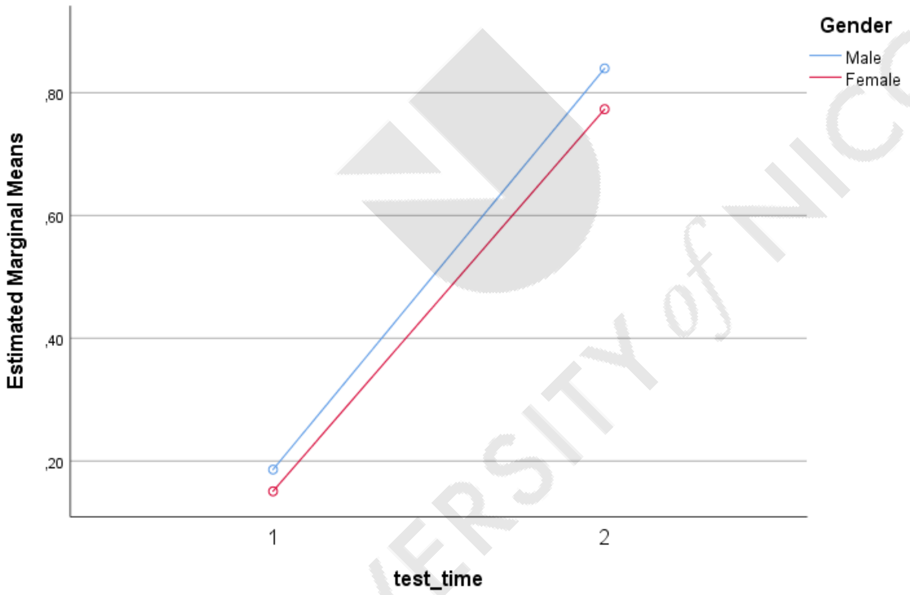


Figure 57: Profile Plots for Performance in PHYSICS

Figure 57 shows that there is indeed an interaction between group and students' performance in the discipline of PHYSICS, with the dependent variable being higher for the experimental group and increasing over time. On the contrary, in the case of gender, although students' performance still increases from the pre-trial to the post-trial phase, the lines of the two genders are almost parallel, therefore gender does not appear to have a significant effect on students' performance in PHYSICS.

Consequently, based on the statistical procedures described previously, Table 27 summarizes the conclusions reached considering the following hypotheses, described in detail on pages 48-49:

1. Null Hypothesis: H_{144}^{0}
2. Null Hypothesis: H_{145}^{0}

Table 27: Summary of Hypotheses Testing Results for PHYSICS Knowledge Test

Summary of Hypotheses Testing Results for PHYSICS Knowledge Test	
Outcome	**Conclusion**
H_{144}^{0} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement in the understanding of "FORCES" in PHYSICS.
H_{145}^{0} Accepted	There is no statistically significant difference between male and female participants, regarding the improvement in the understanding of "FORCES" in PHYSICS.

4.7. Improvement in the Understanding of "Forces" in P.E.

Finally, this section focuses on P.E., with the last two new variables of the previous section being used in a three-way repeated measures analysis, similar to that of the previous section.

Results presented in Tables 28 and 29 below indicated that there was a statistically significant interaction between test_time and group, while there was neither a statistically significant interaction between test_time and gender nor a statistically significant three-way interaction for PHYSICS.

Table 28: Summary of Three-way Repeated Measures Descriptive Statistics & Multivariate Tests Results for the Interaction Between Performance in P.E. and Group in the Pre-Trial and Post-Trial Phases

Three-way Repeated Measures Descriptive Statistics & Multivariate Tests					
	Group	N	Mean	Std. Deviation	Measurement / Group Interaction
Performance in P.E. (pre)	Experimental	90	.0400	.08585	F= 12.054
	Control	90	.0356	.08781	p=0.001 < α=0.01
Performance in P.E. (post)	Experimental	90	.9600	.08585	
	Control	90	.8644	.20216	

Table 29: Summary of Three-way Repeated Measures Descriptive Statistics & Multivariate Tests Results for the Interaction Between Performance in P.E. and Gender in the Pre-Trial and Post-Trial Phases

Three-way Repeated Measures Descriptive Statistics & Multivariate Tests					
	Gender	N	Mean	Std. Deviation	Measurement / Group Interaction
Performance in P.E. (pre)	Male	85	.0494	.09713	F= 1.504
	Female	95	.0274	.07501	p=0.222 > α=0.05
Performance in P.E. (post)	Male	85	.9035	.16216	
	Female	95	.9200	.16347	

Figure 58 below contains the Profile Plots of Estimated Marginal Means of the dependent variable at the pre- and post-trial phases for both between-subjects factors (Group and Gender).

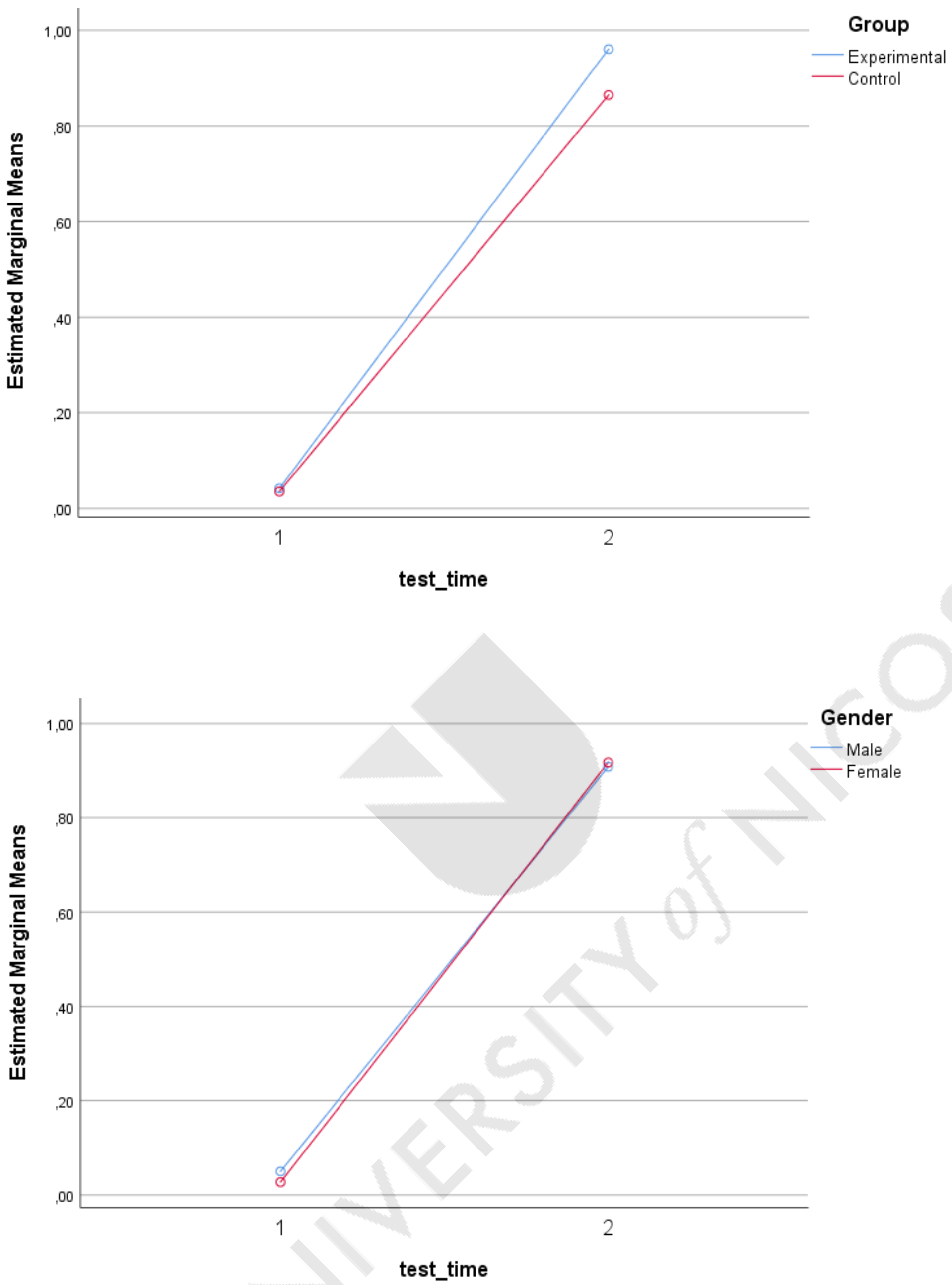


Figure 58: Profile Plots for Performance in P.E.

Figure 58 indicates a significant association between group and students' improving performance in the discipline of P.E., since the plot lines of experimental and control groups are not only unparallel but intersecting. In the case of gender, students' performance also increases from the pre-trial to the post-trial phase, however this time the lines are almost identical, therefore gender does not have a significant effect on students' performance in P.E.

Consequently, based on the statistical procedures described previously, Table 30 summarizes the conclusions reached considering the following hypotheses, which were presented on page 49:

1. Null Hypothesis: H^0_{146}
2. Null Hypothesis: H^0_{147}

Table 30: Summary of Hypotheses Testing Results for P.E. Fields Test

Summary of Hypotheses Testing Results for P.E. Fields Test	
Outcome	**Conclusion**
H^0_{146} Rejected	There is a statistically significant difference between the experimental and control group, regarding the improvement in the understanding of "FORCES" in P.E.
H^0_{147} Accepted	There is no statistically significant difference between male and female participants, regarding the improvement in the understanding of "FORCES" in P.E.

V. Discussion

Based on the results of the present study, there was a significant improvement in the experimental group students' performance and understanding in the "pre" and "post" phases of the trial, regarding the following questions:

- Questions 2, 8 (under subtopic "Friction/Stopping Distance")
- Questions 17, 18, 20 (under subtopic "Air Resistance")
- Question 21, 22, 23, 24, 26, 27, 28, 29, 30 (under subtopic "Up Thrust")
- Questions 30, 31, 32, 33, 34, 35, 36, 37, 38, 39 (under subtopic "Stretch")
- Questions 41, 43, 45, 46, 47, 48, 49, 50 (under subtopic "Weight/Gravity")

On the contrary, there was no statistically significant difference in the experimental group students' performance and understanding in the "pre" and "post" phases of the trial, regarding the following questions:

- Questions 3, 6, 7, 10 (under subtopic "Friction/Stopping Distance")
- Questions 11, 12, 13, 14, 19 (under subtopic "Air Resistance")
- Question 25 (under subtopic "Up Thrust")

In detail, in the first Physics subtopic, i.e. "Friction/Stopping Distance", there were significantly more students in the experimental group who improved their answers post trial than those of the control group when asked about an example of intentional friction increase (Question 2) and about forces making a walking person move forward (Question 8), which shows that the actual experience of the forces obviously helped students to understand the idea. There was no statistically significant difference between students of the experimental and the control group and the improvement of their understanding about frictional force (Question 3), friction levels among different surfaces (Question 6), factors affecting the distance a passenger is thrown from a moving car (Question 7) and the acknowledgement of friction from its definition (Question 10). This wasn't a surprise since all students experienced friction between different surfaces in everyday life.

In the second Physics subtopic, i.e. "Air Resistance", there was no indication of statistically significant relationship between the group students were assigned to during the trial (experimental or control) and the improvement of their understanding of the explanation of air resistance (Question 11), the effects of air resistance on a person falling with a parachute (Question 12), the estimated difficulty of running with 1, 2 or 3 parachutes (Question 13), the forces other than air resistance acting on a fired bullet (Question 14) and the effect of car acceleration on air resistance (Question 19). On the other hand, when asked about the shape of objects reducing air and water resistance (Question 17), students from the control group surprisingly demonstrated a far greater improvement post-trial than students from the experimental group. Finally, students from the experimental group had a significantly higher performance improvement than those from the control group in questions regarding the effects of multiple forces acting on a tennis ball (Question 18) and the relationship between different-shape and different-weight objects' acceleration in the absence of air resistance (Question 20).

In the third Physics subtopic, i.e. "Up Thrust", students from the experimental group improved their performance post-trial far better than students from the control group in all questions but one. In other words, experimental group students showed a statistically better understanding than the control group students in the post-trial tests regarding the direction of up thrust and weight (Question 21), the effects of up thrust on a stone inside different fluids (Question 22), the identification of up thrust's definition (Question 23), the easiest way to float using different objects (Question 24), the effect of objects' density on their ability to float (Question 26), the factors affecting up thrust (Question 27), the relationship between up thrust and an object's geographic location (Question 28), the relationship between up thrust and an object's weight (Question 29) and the relationship between up thrust and the fluid where the object is submerged (Question 30). On the contrary, when asked about the effect of equal up thrust and weight (Question 25), students vastly improved their score post trial; however, this improvement was not related to the test group they were belonged to. Obviously since the experimental group actually experienced the force of up thrust, having their lesson done in the swimming pool, did the tremendous difference.

In the fourth Physics subtopic, i.e. "Stretch", students from the experimental group improved their performance significantly more than those from the control group in all related questions about the identification of stretch (Question 31), the relationship between stretch and weights' force (Question 32), calculations of a spring's length after stretch (Question

33), the identification of a push or pull (Question 34), action and reaction forces (Question 35), movement on a smooth surface under specific conditions (Question 36), body stretch in different positions (Question 37), the definition of stretch (Question 38) and a more critical understanding of stretch and related notions (Question 39). Here it is clear that the improvement was based on the "hands on" activities.

Similarly, in the fifth Physics subtopic, i.e. "Weight/Gravity", the experimental group students from the improved their understanding significantly more than the control group students in all related questions regarding the definition of gravity (Question 41), the identification of gravitational force (Question 43), the unit of weight in the metric system (Question 45), the effects of weight force in running (Question 46), the effects of balanced forces (Question 47), gravity-related acceleration (Question 48) and a critical overall understanding of forces (Questions 49 and 50). The potential to make significant and distinctive contribution from the interdisciplinarity to the development in each of these domains is so clear.

A distinctive examination of students' overall performance in each Physics subtopic per test group (experimental – control) and per trial phase (pre – post) showed that in the pre-trial test, the experimental group students significantly outperformed the control group students in subtopics 1 – 4, regarding "Friction/Stopping Distance", "Air Resistance", "Up Thrust" and "Stretch", while there was no significant difference between the two groups in subtopic 5 regarding "Weight/Gravity". On the other hand, in the post-trial test, students from the experimental group had a significantly better overall performance in all five subtopics. PE in combination with Physics and the teaching in different environment make significant contributions to the education and development of children. It is amazing how beneficial the fusion of these two topics can be.

The same conclusion was reached when investigating the impact of group on the overall performance of students in the Physics' topic of Forces. In other words, experimental group students had a significantly more improved overall performance than control group students in the Physics' topic of Forces. Sometimes Physics teachers feel that their laboratory is their kingdom and everything should be done in there using the traditional ways of teaching. Forces were better understood when experienced.

After following the same methodology to examine the role that gender played in students' understanding of several Physics notions pre- and post-trial, it was found that in the first Physics subtopic, i.e. "Friction/Stopping Distance", there was no statistically significant difference between boys and girls regarding the improvement of their understanding about any of the individual questions. In the second Physics subtopic, i.e. "Air Resistance", there was no indication of statistically significant relationship between the gender of students and the improvement of their understanding in any of the related questions. In the third Physics subtopic, students may have improved their score post trial; however, this improvement was not significantly related to their gender. Again, in the fourth Physics subtopic, i.e. "Stretch", there was no indication of statistically significant relationship between the gender of students and the improvement of their understanding in any of the related questions. In the fifth Physics subtopic, i.e. "Weight/Gravity", there was no statistically significant difference between boys and girls regarding the improvement of their understanding about any of the individual questions. The sample consisted of 12 year old children. This could be the answer of having no statistically significant difference. Findings showed difference in a different age group, older than this (Mujtaba, T., & Reiss, M. J. 2012).

A distinctive examination of students' overall performance in each Physics subtopic per gender (male – female) and per trial phase (pre – post) showed that there was no significant difference between the two genders' performance in any of the subtopics, both in the pre-trial and the post-trial tests. This shows something different from what is supported in school pupils interest (Van Wersch, A., Trew, K., & Turner, I. 1992) where there is a great interest of females. There is no recent bibliography to support or not our findings.

The same conclusion was reached when investigating the impact of gender on the overall performance of students in the Physics' topic of Forces. In other words, male students did not appear to have a significantly more improved overall performance than female students in the Physics' topic of Forces.

The present study also investigated the performance of students in five specific subtopics in P.E. When examining the performance of students from both groups in P.E. subtopics, results showed that experimental group students' improvement of performance in the first P.E. subtopic, i.e. "Transfer of the Ball", was better than that of control group students. It is so different actually experienced the movement and specifically the transfer of an object than just reading about it.

Results also indicated that experimental group students' improvement of performance in the second P.E. subtopic, i.e. "Air Resistance", was better than that of control group students. On the contrary, although there was a vast improvement in students' performance post-trial in the third P.E. subtopic, i.e. "Aerobic Exercise", there was no significant difference between the two groups. The same conclusion was also reached in the case of the fourth P.E. subtopic, i.e. "Flexibility", where the great improvement in students' performance post-trial was not significantly influenced by the group they were assigned to. Finally, experimental group students' improvement of performance in the fifth P.E. subtopic, i.e. "Energy Balance/Body Mass Index", was better than that of control group students. Great improvement was shown here since students actually practiced the exercises.

The distinctive examination of students' overall performance in each P.E. subtopic per test group (experimental – control) and per trial phase (pre – post) showed that in the pre-trial test, there was no significant difference between the performance of two groups in any of the subtopics. On the other hand, in the post-trial test, students from the experimental group had a significantly better overall performance in the first and second P.E. subtopics, i.e. "Transfer of the Ball" and "Air Resistance.

The last test that was run regarding students' overall performance in P.E. demonstrated that students from the experimental group significantly outperformed those from the control group.

On the other hand, when examining the performance of students from both genders in P.E. subtopics, results showed that male students' improvement of performance in the first P.E. subtopic, i.e. "Transfer of the Ball", was not significantly better than that of female students. Moreover, male students' improvement of performance in the second P.E. subtopic, i.e. "Air Resistance", was not significantly better than that of female students. Despite the great improvement in students' performance post-trial in the third P.E. subtopic, i.e. "Aerobic Exercise", there was no significant difference between the two genders. The same conclusion was also reached in the case of the fourth P.E. subtopic, i.e. "Flexibility", where the great improvement in students' performance post-trial was not significantly influenced by their gender. Finally, students' improvement of performance in the fifth P.E. subtopic, i.e. "Energy Balance/Body Mass Index", was not influenced by gender.

The distinctive examination of students' overall performance in each P.E. subtopic per gender (male – female) and per trial phase (pre – post) showed that in the pre-trial test, there was no significant difference between the performance of two genders in any of the subtopics. Similarly, in the post-trial test, there was no significant difference between the performance of two genders in any of the subtopics. The last test regarding students' overall performance in P.E. demonstrated that the improvement of students' performance did not appear to be significantly affected by their gender. So far researches when dealing with this age group show a greater interest of girls than in boys in the lesson of P.E and their performance to it (Stratton, G., 1996). In the present research probably due to the interdisciplinarity this is not the case.

The initial analysis of the data gives us a positive view of the impact of the program on accepting interdisciplinary practices in the educational process. The cooperative processes followed in the design of the program, the structuring of the teaching content, the production of educational material and the design of pedagogical activities as well as the implementation, evaluation and feedback show, with a first analysis, that they have boosted the connection of physics as a cognitive object in the physical education. At the same time, this program seems to have facilitated the interdisciplinary organization of the section of PH that we could call Physical Activity in secondary Education and which could be at the heart of the physical education activities.

Summarizing the results of this research, we could support the view of the positive effect of interdisciplinary teaching intervention on the development of physical education teaching and the climate of understanding in secondary school pupils. In particular, with regard to the scientific – cognitive development of students, it appears that through the interdisciplinary approach, students have the opportunity to approach experientially abstract scientific concepts and relate them with the development of their skills in physical education. In this way, more prominent processes and rules have been achieved, which in the "traditional learning environment" managed them at an abstract level often without real understanding and consolidation.

The pupils in the experimental group were asked to understand and link contexts such as Friction/ Stopping distance and Transfer of the ball in football, in appropriately selected kinetic content to develop kinetic skills that will help them in understanding object manipulation and throwing the ball into target, as well as feeling and orientation in space. Moreover, we observed that through the teaching of Air resistance, which aimed to understand how forces are related and applied, students are taught targeted and systematic concepts of physics such as angles, or symmetry-asymmetry.

In particular, with regard to cognitive development of students, it appears that through the interdisciplinary approach, students have the opportunity to approach experientially abstract mathematical concepts. In this way, more clear processes and rules have been established that in the "traditional learning environment" they were managed at an abstract level often without real understanding and consolidation. Investigations (Hatch & Smith, 2004) that have assessed the cognitive development of students through the implementation of cross-curricular programs lead to similar conclusions. At the same time, children through the game develop a more positive attitude towards mathematics. Sciences such as Physics, Biology, Chemistry, etc. can be integrated into cross-curricular subjects with Physical Education, achieving substantial knowledge. In addition, it could be argued that interdisciplinary teaching, in physical education, can cause students' interest in more energetic participation in the lesson and at the same time to increase the satisfaction derived from it. Therefore, teachers should provide adequate stimuli to learner's interest by offering opportunities for connecting previously obtained knowledge with more recently presented bits of information, thus ensuring more meaningful learning. This finding in our study agrees with the same finding by other studies, too (Cothran et al., 2005; Jaakkola & Watt, 2011).

It seems that the different plot and justification of the lesson, the innovative actions implemented through an interdisciplinary teaching, improve pupils' moods or feelings, which, according to Deci & Ryan (2000), can influence children's internal stimulation. Moreover, the satisfaction and increase of the internal motivation in the interdisciplinary courses of physical education is also related to the change in the perceived value of the lesson for children. Although this has not been part of our analysis, it is an implication for further study that should be discussed. As Papaioannou & Theodorakis (1996) emphasizes that the value lies in whether the lesson helps their personal progress and the resources they provide for their lives (knowledge, health, social relations, moral development), it seems that the interdisciplinary teaching approach can make a substantial contribution in this direction. Methods of teaching such as interdisciplinary teaching can be an integral part of the educational process and therefore teachers should be encouraged in this direction and strengthened with training programs to provide them with the necessary knowledge. Moreover, in the context of the necessity to develop curricula with different specifications than those of the traditional and searching new ways and methods of teaching, interdisciplinary teaching of physics and physical education is proposed on the one hand as a contemporary and interesting choice and on the other hand as an integrated proposal. We should not forget that Osborne and Collins (2001), found that teachers do not usually provide many examples from everyday life and that was why students found the lessons irrelevant and boring.

The consolidation of physical education with other cognitive content such as physics or social sciences can be perceived in two ways. The first concerns the incorporation of the physical education. In other cognitive contents, while the latter refers to the inclusion of content from other scientific areas in the content of physical education in order to teach students subjects from physics, language or social sciences. While very few have been written about the incorporation of the in other scientific fields, our results seem to be in agreement with the considerable literature that exists on the possibility of learning subjects from other scientific areas in the physical education lesson. (eg Placek & O'Sallivan, 1997; Cone et al., 1998; Werner, 1999; Pica & Short, 1999; Mylosis, 2004; Gotzaridis et al., 2007; Milosis & Papaioannou, 2007).

The alternative teaching methods used in our research demonstrated a more rapid development of children's scientific and athletic skills than those of traditional methods and therefore appear to be an important tool for their use in teaching physical education. This seems to be in accordance with previous research that has shown that at these ages the participation of pupils in physical education depends to a great extent on the motivations given to them, and especially in these ages, the way they understand. This means that the introduction of different concepts of physics can be an important incentive to engage in physical education, especially among pupils of secondary schools who may still struggle to understand such complicated concepts; this raises concerns about how these alternative forms of teaching can be applied in a way that motivates students as well. As has been shown in the case of this study in school education, alternative methods can not only be applied to physical education but are expected to deliver better results.

In addition, it could be argued that interdisciplinary teaching, in physical education, can cause students' interest in more energetic participation in the lesson and at the same time to increase the satisfaction derived from it. Despite the fact that this study did not measure satisfaction or motivation, it seems that the different plot and justification of the lesson, the innovative actions implemented through the interdisciplinary teaching, improve pupils' understanding of concepts which, according to Deci & Ryan (2000), can influence children's internal stimulation.

In the case of secondary education, it is easier to integrate them into educational processes because they can be combined with the organized game that is the main axis of physical education. In our study, the children that participated were 12-13yo, which means that they are still in pre-puberty stage; therefore game and play are important elements of their life. From the above it can be seen that the use of alternative teaching methods can be used in physical education but clearly more research is needed in this field. However, physical education beyond the development of motor skills also contributes to the development of other skills, thus giving it qualities that make its educational role very important. This means that alternative forms of teaching, since they are an important incentive for active participation of students in physical education, can also produce results in these areas, thereby widening the understanding of physical phenomena, contributing to the creation of a more holistic personality.

Similarly, research has shown that at these ages the participation of pupils in physical education depends to a great extent on the motivations given to them, and especially in these ages, their perception of the world and their entertainment play an important role. As it has been shown in the case of two studies on school education, alternative methods can not only be applied to physical education but are expected to deliver better results.

It is necessary to investigate the effect of the cross-curricular approach on various subjects of the curriculum (Biology, Geography, etc.) in order to evaluate the effectiveness of cross-curricular programs. It is also proposed to explore the effect of the cross-thematic approach on other areas of the personality of the child such as emotional, moral and social development. Long-term didactic interventions could also be planned to assess the impact of cross-curricular programs on children's behaviors (eg healthy eating, responsible behavior, lifelong learning, etc.). Finally, the development of appropriate, valid and reliable and comprehensive tools for the evaluation of interdisciplinary programs.

VI. Conclusions & Recommendations

6.1. Conclusions

Concluding, we will summarize the most important points from the theoretical part of the work and then those from the research. The subject, which was originally chosen by the researcher and then presented and developed, concerned the new teaching method which contravene traditional methods. The main goal of this work was to study the interdisciplinary and didactic project, which was integrated in the lesson of physical education, with the use of rules of physics. Analyzing the results of the answers given by the students to the pre-audit and post-audit, it was found that the intervening process had a positive effect on the students. It is estimated that the objectives of the program have been met as there has been a significant improvement in the understanding of the terms and phenomena, and confirmation that the use of interdisciplinarity as a teaching method is effective for the development of athletic skills and knowledge.

The research intervention had multiple benefits, based on the data collected, providing students with holistic and global knowledge. Athletic skills were conquered by the contribution of different cognitive subjects, enhancing the understanding of natural phenomena among students. The variety of topics and sources, the use of various teaching methods and the continuous provision of learning incentives to students created the appropriate learning environment for creative and multisensory learning. The active participation and experiential involvement of all students in teaching led to an increased understanding of the terms of physics and their practical application to physical education.

The main objective of traditional education is to provide pupils with a wealth of theoretical knowledge that they will be able to pull at the right time as adults, and to provide solutions to the problems they may be having. To achieve this goal, the rationalization of the content of teaching in analytical programs, the strict delimitation of courses, the division of matter, and of course a pedagogy based on practical transfer of knowledge, the teacher's authority and the "sacredness" of knowledge of school textbooks. This scholasticism is identical to stagnation, routine, inertia.

The segregation of teaching content in many sub-disciplines observed at school breaks down human thought and makes it abstract, fragmented by the context that gave birth to it, irrelevant to the pupils' experiences. As a result, students who do not have the opportunity to conceive the common points of science, their implications, and their implications to the other disciplines, remain indifferent to such knowledge but also incapable of using it for new forms of thought and action.

Despite the intense international mobility of the educational community in relation to interdisciplinary education issues in Cyprus, and in terms of secondary education, interdisciplinary education is implemented sporadically, without continuity and often out of context. It is unfortunately a commonplace to organize physics programs to meet educational needs that have nothing to do with physics as defined internationally. The main reason that prevents the development of interdisciplinary education at the secondary education level is the lack of training on interdisciplinary education of teachers.

It has been stated in a number of studies that traditional PE classes in secondary education do not always yield a high level of physical activity for students (Cawley, et al 2006; Chen, et al, 2007). Realizing the value of physical education through surveys, there is a need to systematically apply and evaluate the single curriculum. The implementation of such programs in other countries, namely in England, which adopts the interdisciplinary methodological approach, has demonstrated the effectiveness of such plans. Students participating in quality programs are more likely to succeed in school and in life. Providing high-quality interdisciplinary education can be the key to a child's future success ((Cawley, et al 2006). The fundamental skills required to gain academic coverage include social development, cognitive development, and physical development. In most analytical education programs, the first two are underlined while the physical development of students is degraded. Few programs have provided quality physical activity programs for students. Today, perhaps more than ever, there is an urgent need for all participants in the secondary education process to understand that physical development is an integral part of the normal development of the child's well-being and social development and must be integrated harmoniously and equally in the contemporary secondary education program.

Primary and Secondary Education schools as institutions, but also the teachers themselves, are showing a lot of stiffness and embarrassment as to the essential integration of interdisciplinary teaching into their cognitive subjects. The traditional school actually cancels the interdisciplinary design and implements, through a homogenized function, a generally monothematic teaching that leaves little space for cooperative teaching practices and horizontal interconnection of knowledge. This empirically described situation and the need to have a fuller picture of the relationships that take place in the implementation of physics in a physical education program in compulsory secondary education has been the motivation for the realization of this work.

The reflection of the work and the lack of previous comparative study led to the selection of comparative pedagogical methodologies for approaching environmental education in secondary education.

The integrated application of interdiction is the elimination of discrete courses and the exploration of a subject or problem of interest to students. As shown in this study, this can be achieved through exploratory and discovery methods, where the learner is actively involved in learning. Such a method is the method of the interdisciplinary teaching of physics and physical education through a work plan. Work plan means organizing and developing projects of any kind and at every level, theoretical-scientific or practical-technical. Its duration may be short or long, ranging from several hours to several years. At the level of education, the minimum time at which a project can be developed is 2-3 hours, and the maximum may last for a whole academic year. In all cases, the basic structure and the individual elements of the method are essentially the same, as explored in this study. The stages of the process which are followed in our methodology as well, are placement, planning, execution and evaluation.

Wishing to build a supportive learning environment in the educational process, we sought change, diversity, creativity and innovation in how to teach physical education. Our desire and goal was to make teaching teaching-focused, energetic, experiential, authentic, cooperative and challenging, making teaching a good practice.

6.2. Recommendations & Implications

These interdisciplinary approaches organize the process of building diverse knowledge through the systematic exploration of personnel issues, social scientific interest, issues that raise concerns and dilemmas in individuals and controversies in society and, finally, problematic situations requiring a solution. The original problems, to be understood and much more to be solved, presuppose the substantial engagement of two more sciences. In the light of the above and given the conclusions we have drawn and who have informed us of the uncertain and inconsequential situation in which there are still things about the reformation of the existing philosophy of the educational structure we consider it necessary to make some suggestions, in the short, medium and long term, which would be good for action. We will begin with the short-term level.

On the basis of the contents of the interdisciplinary Single Framework of Educational Programs for secondary school, it is possible to formulate suggestions as to the theoretical background that supports it and the teachers who want to apply it most in course of physical education, and with the scientific theories of Piaget and the scientists who followed his views, who emphasize the importance of child-centered activities for knowledge development, the Cypriot Analytical Programs have substantially remained away from the application of interdisciplinary teaching activities.

The training of teachers of secondary education in physical Education would initially be a positive step towards achieving the objectives of physical education. The introduction of specializations in secondary education may provide solutions to this particular curriculum or other quality curriculum for secondary education so that it has the right results, and Physical Education will achieve its goal.

The implementation of a quality secondary education program by highly trained staff can ensure the most likely success of its objectives. A qualitative curriculum will have better results not so much in the academic field as in the social field and in lifelong learning, compared to other curricula such as direct Teaching or Distar (a behavioral program emphasizing mental development), and a traditional program of an secondary school. Apart from the training of teachers, the school's infrastructure also plays a key role in the effective implementation of a training program and whether it meets the needs of the applied program.

The creation of specific venues, the provision of sporting and scientific - experimental material specifically adapted to this age, will upgrade the conditions for the implementation of a training program.

The knowledge of the course of Physical Education, from the early years of implementation of organized programs in secondary education to the present day, will help to better understand, perceive and critique the position currently held by Physical Education in secondary schools. The review of the Cypriot curricula for secondary education reveals the presence of the cognitive subject of physical education by the organization of the analytical programs. However, the extent, form and way of implementing Physical Education activities in the Cypriot secondary schools has not been studied, to see whether the curriculum proposals and recommendations are being followed.

Factors such as the high number of the students, inadequate facilities and minimal training of teachers and educators in physical education may make it difficult to implement interdisciplinary Physical Education programs. The study of the existing literature also demonstrates the existence of minimal research regarding the effect of an interdisciplinary program regarding physics and physical education on the whole development of secondary school children, both in motor development and in their social, mental and emotional enhancement.

Surveys focusing on the relationship between Physical Education and success in other subjects, when it is applied consistently throughout the academic year, with the smooth admission of interdisciplinary education to secondary schools, and with the lifelong adoption of healthy lifestyles, will demonstrate the necessity of proper implementation of physical education programs in secondary education. Today, the need to conduct research to demonstrate and scientifically substantiate the beneficial effect of a full and properly organized interdisciplinary program which will include physical education and physics (or other scientific lessons) on the smooth psychosomatic and cognitive development of the infant is more urgent. These surveys will be the cornerstone for the development of a modern and integrated curriculum.

For the more effective implementation of interdisciplinary teaching, and to avoid potential problems, it is important that the teaching is followed by the choice of appropriate content, concepts and themes for interconnection, appropriate teacher preparation and selection of appropriate activities, equipment and hardware. In addition, it is very important to pay particular attention to the maintenance of high active participation time of students, with particular emphasis on experiential activities of exploration and discovery through motoric content, while minimizing the theoretical contents. Finally, collaboration with teachers of other disciplines is crucial for the fuller and more scientific teaching of unified cognitive content and the avoidance of excessive workload for students.

Teaching programs should clarify the terminology so that teachers are not confused with class lessons, to create bibliographic directories and evaluation sheets for the courses, to introduce qualitative assessment, self-evaluation and hetero-evaluation of both strands of the teaching process. There is the need, as aforementioned, to replace old books that are somewhat anachronistically and obsolete and write new, tailored to the social data of the time that will prompt educators and students to diversify schoolwork and aim for interdisciplinary teaching. There is ongoing evaluation, feedback and improvement of all teaching programs.

The integration of physics into physical education shall enhance balancing between cognitive, emotional and psychomotor goals in programs and introducing activities that promote self-knowledge, self-motivation, research learning, learning to learn, and critical thinking, having a set of teaching specifications open and flexible, adaptable to educational needs. Proposals that respond to this, which has been mentioned and concerns the fact that the pupil's interests are inconsistent with current school textbooks and hence the imperative of adapting to the needs of the student and society. In the medium term, there should be education and continuous training of all teachers on issues of theory, know-how and sociology of programs and teaching instruments and also in the design of teaching programs by the teacher himself in collaboration with the students through the action research process.

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Appendix A: Pre / Post Knowledge Test

NAME:____

MULTIPLE CHOICE QUESTIONS-CIRCLE THE CORRECT ANSWER

- FRICTION/STOPPING DISTANCE

1. The force that one surface exerts on another when the two rub against each other is called
   A. friction.
   B. acceleration.
   C. inertia.

2. Which of the following is an example of increasing friction intentionally?
   A. waxing skis
   B. adding grease to gears on a bike
   C. throwing sand on an icy driveway

3. To keep a heavy box sliding across a carpeted floor at constant speed, a person must continually exert a force on the box. This force is used primarily to overcome which of the following forces?
   A. Air resistance
   B. The weight of the box
   C. The frictional force exerted by the floor on the box

4. When do I stop more abruptly?
   A. To stop using both legs
   B. To stop with the one foot facing straight forward.
   C. To stop with the one foot facing to the side.

5. Galileo proposed a thought experiment where a sphere would be rolled down a U-shaped incline. In an "ideal scenario," the sphere would move along the incline until it returned to its original height. Why will this not occur in real life?

A. The force of gravity prevents the sphere from moving upward.

B. The friction between the sphere and the incline reduces the sphere's energy.

C. The momentum of the sphere increases as it moves, causing it to rise above its original height.

6. Which driving surface would provide the greatest friction?

A. ice

B. wet concrete

C. dry pavement

7. In an accident, the distance a passenger is thrown from a moving car is related to

A. the mass of the car

B. the size of the object that the car collides with

C. the speed of the car before it collided with another object

8. A person walking on a level surface moves forward because the forces of

A. his feet pushing backward on the ground

B. the ground pushing forward on his feet

C. the ground pushing backward on his feet

9. A ball rolling across the floor slows to a stop because

A. there are unbalanced forces acting on it.

B. the force that started it moving wears out.

C. all the forces are balanced.

10. The Force opposing the movement of one surface over another is called

A. Frozen

B. Fiction

C. Friction

- <u>AIR RESISTANCE</u>

11. Objects falling through air experience a type of friction called
    A. terminal velocity.
    B. air resistance.
    C. inertia.

12. A person from parachute falls slowly to ground due to
    A. thrust
    B. air resistance
    C. air friction

13. When it is harder for me to run?
    A. Using 1 parachute
    B. Using 2 parachutes together
    C. Using 3 parachutes together

14. Ignoring air resistance, a bullet fired horizontally has how many forces acting on it after leaving the rifle?
    A. One, from the gunpowder explosion.
    B. Two, one from the gunpowder explosion and one from gravity.
    C. Three, one from the gunpowder explosion, one from gravity, and one from the motion of the bullet.

15. Two objects are released from the same height at the same time, and one has twice the weight of the other. Ignoring air resistance,
    A. the heavier object hits the ground first.
    B. the lighter object hits the ground first.
    C. they both hit at the same time.

16. Tom is riding his bicycle he wants to go faster without pedalling faster. In addition to achieve it he must:

A. Wear a jacket

B. Bend near the steering wheel

C. Ask Jenna to ride with him

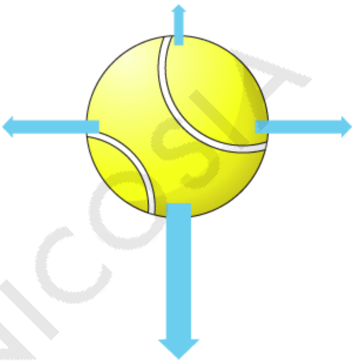
17. To reduce air and water resistance objects are shaped in

A. streamlined

B. oblongata

C. rectangular

18. The arrows in this diagram represent the sizes of forces acting on a stationary tennis ball. What will happen to the tennis ball?



A. it will stay still

B. it will start to move upwards

C. it will start to move downward

19. What happens to the air resistance on a car as the car goes faster?

A. it decreases

B. it stays the same

C. it increases

20. A football, a hockey puck, and a tennis ball all fall down in the absence of air resistance. Which of the following is true about their acceleration?

A. The acceleration of the football is greater than the other two

B. The acceleration of the hockey puck is greater than the other two

C. They all fall down with the same constant acceleration

- <u>UPTHRUST</u>

21. Up thrust and weight act in

A. same direction
B. opposite direction
C. upward

22. A stone stays less heavy in water than in

A. mud
B. soil
C. air

23. Upward force acting on an object when it is submerged into a fluid either liquid or solid it is called

A. thrust
B. up thrust
C. drag

24. When do I float easier?

A. When using board
B. When using exercise weights in the water
C. Using pool pipes

25. When up thrust is equal to weight of object then it

A. floats
B. sinks
C. moves

26. Any substance will float on water or gas if its density is less than that of

A. liquid
B. gas
C. both a and b

27. Up thrust depends on:

A. The depth of the pool/sea
B. Shape of the object submerged
C. The density of the fluid

28. A ship is travelling from the equator to the north pole. During the trip:

A. The up thrust of the ship decreases
B. The up thrust of the ship gets increases
C. The up thrust of the ship doesn't change

29. The up thrust a tanker experiences is more when:

A. The tanks are empty
B. The tanks are full
C. In Both cases up thrust is the same

30. When the same body is submerged in different fluids the force of up thrust :

A. Is the same
B. Is different
C. Is friction

- STRETCH

31. If a spring is stretch when it is

A. pulled
B. pushed
C. both a and b

32. A spring can be stretched by hanging weights on it. Which of the following is true?

A. The larger the force, the greater the stretch
B. The smaller the force, the greater the stretch
C. The spring does not exert a force on the weight

33. A student carried out an experiment by putting weights on the end of a spring. After each weight was added, the length of the spring was carefully measured. The results are summarised below.

Weight added to spring (N)	2	4	6	8	10
Length of spring (cm)	23	27	31	35	39

From the data, what would be the spring length with a weight of 15N on?

A. 51 cm

B. 47 cm

C. 49 cm

34. In science, a push or a pull is called a(n)

A. force.

B. acceleration.

C. inertia.

35. If you are launching a matchstick rocket, the action force is the rocket pushing the gases down. What is the reaction force?

A. The table pushing the rocket down.

B. The gases pushing the rocket up.

C. The gases pushing the rocket down.

36. Two boys wearing in-line skates are standing on a smooth surface with the palms of their hands touching and their arms bent, as shown above. If Boy X pushes by straightening his arms out while Boy Y holds his arms in the original position, what is the motion of the two boys?

A. Boy X does not move and Boy Y moves backward.

B. Boy Y does not move and Boy X moves backward.

C. Boy X and Boy Y both move backward.

37. When can I reach longer?

A. When seated to the sit and reach with the 2 legs bent.

B. When seated to the sit and reach with the 1 leg stretched and the other bent.

C. When seated to the sit and reach with the 2 legs stretched.

38. Stretching happens when the material or object is

A. Pulled

B. Pushed

C. Both

39. Which of the following would you recommend to prevent inflammation of the joints during or after physical activity?

A. Rub massage oil into your joints before and after exercise

B. Use carbo-loading to increase energy levels

C. Stretch your muscles thoroughly before exercise

40. Which one of the following is the best example of flexibility training?

A. Bounding and hopping exercises

B. A mixture of sprinting and walking

C. A number of stretching activities

- <u>WEIGHT/GRAVITY</u>

41. The force that pulls falling objects toward Earth is called

A. gravity.

B. free fall.

C. acceleration.

42. Gravitational force is influenced by object's

A. weight

B. shape

C. size

43. When you jump up you feel a force pulling you back on Earth it is

A. magnetic force

B. frictional force

C. gravitational force

44. Force is measured in SI unit

A. Newton

B. Ampere

C. Watt

45. What is the unit of weight in the metric system?

A. kilogram

B. newton

C. meters per second squared

46. When can I run easier?

A. Holding a medicine ball

B. Wearing ankles weights

C. Wearing weight vest

47. If the forces on an object are balanced, the object will

A. remain at rest if initially at rest.

B. continue moving in a straight line if initially moving in a straight line.

C. both A and B

48. Ignoring air resistance, an object falling toward the surface of the earth has an acceleration that is

A. constant.

B. increasing.

C. decreasing.

49. You are riding fast on a skateboard when your wheel suddenly gets stuck in a crack on the sidewalk. Why does your body go flying forward?

A. there is a net force pushing you off your skateboard

B. your inertia keeps you moving forward

C. someone pushed you

50. You just collected a huge bag of leaves in your yard, and you need to move it out to the curb. How could you get the bag to move faster?

A. use more force (push harder)

B. take some leaves out to make it weigh less (make it lighter)

C. both of the above would work (both pushing harder and making it lighter)

Appendix B: Pre / Post Fields Test

NAME: ____

1. When do you think you can stop easier?	Choice	Justification	Time Taken
A. Running (full speed) for 50m on the football pitch during a sunny day wearing flat shoes. B. Running (full speed) for 50m on the football pitch during a rainy day wearing flat shoes. C. Running (full speed) for 50m on the football pitch during a sunny day wearing running shoes D. Running (full speed) for 50m on the football pitch during a rainy day wearing running shoes E. Running (full speed) for 50m on the football pitch during a sunny day wearing only socks.			

2. When do you think you can run faster?	Choice	Justification	Time Taken
A. Running 50 m on a windy day having the wind against you B. Running 50 m on a day without wind C. Running 50 m having a parachute attached to your waist. D. Bending (at max 45 degrees) your upper body towards the direction of motion and running for 50 m E. Arm swinging while running for 50 m			

3. When do you think you can swim faster?	Choice	Justification	Time Taken
A. Hold pool buoys to cover a 25m distance			

B. Hold sponges to cover a 25m distance C. Use hand paddles to cover a 25m distance D. Use of kick boards to cover a 25m distance E. Have a ring buoy around your waist			

4. Each pair has 3 different resistance bands (of different colour)

   Use every time a different colour of band, place it around your waist as shown on the picture and try to run!

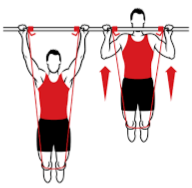
   What do you notice every time you change the band and try to run?

____

____

____

5. When do you believe is easier to perform pull ups?	Choice	Justification	Time Taken
A. Do 2 pull-ups using both arms. B. Do 2 pull-ups using both arms wearing a weight jacket. C. Do 2 pull-ups using both arms having a classmate holding with both hands your legs downwards. D. Do 2 pull-ups using both arms having a classmate pushing with both hands your legs upwards. E. Do 2 pull-ups using both arms having a resistance band on your knees (see picture).			



Appendix C: Results of Statistical Analysis

Table 6: Nonparametric Correlations Investigating the Association between Group / Gender and the Understanding of Individual Questions of PHYSICS Knowledge Test

Nonparametric Correlations

			Group	Gender
Spearman's rho	Difference in Performance in Question 2 of Physics Knowledge Test	Correlation Coefficient	-.192**	.071
		Sig. (2-tailed)	.010	.346
		N	180	180
	Difference in Performance in Question 3 of Physics Knowledge Test	Correlation Coefficient	-.034	.034
		Sig. (2-tailed)	.649	.655
		N	180	180
	Difference in Performance in Question 6 of Physics Knowledge Test	Correlation Coefficient	-.071	-.033
		Sig. (2-tailed)	.341	.659
		N	180	180
	Difference in Performance in Question 7 of Physics Knowledge Test	Correlation Coefficient	-.045	.000
		Sig. (2-tailed)	.545	1.000
		N	180	180
	Difference in Performance in Question 8 of Physics Knowledge Test	Correlation Coefficient	-.175*	.052
		Sig. (2-tailed)	.019	.484
		N	180	180
	Difference in Performance in Question 10 of Physics Knowledge Test	Correlation Coefficient	-.073	.012
		Sig. (2-tailed)	.332	.871
		N	180	180
	Difference in Performance in Question 11 of Physics Knowledge Test	Correlation Coefficient	-.023	.018
		Sig. (2-tailed)	.757	.810
		N	180	180

	Difference in Performance in Question 12 of Physics Knowledge Test	Correlation Coefficient	-.037	.024
		Sig. (2-tailed)	.626	.752
		N	180	180
	Difference in Performance in Question 13 of Physics Knowledge Test	Correlation Coefficient	-.057	-.105
		Sig. (2-tailed)	.446	.161
		N	180	180
	Difference in Performance in Question 14 of Physics Knowledge Test	Correlation Coefficient	.024	-.059
		Sig. (2-tailed)	.749	.433
		N	180	180
	Difference in Performance in Question 17 of Physics Knowledge Test	Correlation Coefficient	.349**	-.061
		Sig. (2-tailed)	.000	.413
		N	180	180
	Difference in Performance in Question 18 of Physics Knowledge Test	Correlation Coefficient	-.166*	-.057
		Sig. (2-tailed)	.026	.448
		N	180	180
	Difference in Performance in Question 19 of Physics Knowledge Test	Correlation Coefficient	-.023	-.098
		Sig. (2-tailed)	.757	.190
		N	180	180
	Difference in Performance in Question 20 of Physics Knowledge Test	Correlation Coefficient	-.190*	-.081
		Sig. (2-tailed)	.011	.282
		N	180	180
	Difference in Performance in Question 21 of Physics Knowledge Test	Correlation Coefficient	-.317**	-.089
		Sig. (2-tailed)	.000	.232
		N	180	180
	Difference in Performance in Question 22 of Physics Knowledge Test	Correlation Coefficient	-.211**	-.101
		Sig. (2-tailed)	.004	.178
		N	180	180
	Difference in Performance in Question 23 of Physics Knowledge Test	Correlation Coefficient	-.214**	-.105
		Sig. (2-tailed)	.004	.163

Spearman's rho		N	180	180
Spearman's rho	Difference in Performance in Question 24 of Physics Knowledge Test	Correlation Coefficient	-.264**	-.059
		Sig. (2-tailed)	.000	.433
		N	180	180
	Difference in Performance in Question 25 of Physics Knowledge Test	Correlation Coefficient	.000	.000
		Sig. (2-tailed)	1.000	1.000
		N	180	180
	Difference in Performance in Question 26 of Physics Knowledge Test	Correlation Coefficient	-.183*	.048
		Sig. (2-tailed)	.014	.521
		N	180	180
	Difference in Performance in Question 27 of Physics Knowledge Test	Correlation Coefficient	-.285**	-.081
		Sig. (2-tailed)	.000	.282
		N	180	180
	Difference in Performance in Question 28 of Physics Knowledge Test	Correlation Coefficient	-.272**	-.023
		Sig. (2-tailed)	.000	.762
		N	180	180
	Difference in Performance in Question 29 of Physics Knowledge Test	Correlation Coefficient	-.172*	.054
		Sig. (2-tailed)	.021	.469
		N	180	180
	Difference in Performance in Question 30 of Physics Knowledge Test	Correlation Coefficient	-.216**	-.103
		Sig. (2-tailed)	.004	.168
		N	180	180
	Difference in Performance in Question 31 of Physics Knowledge Test	Correlation Coefficient	-.274**	-.047
		Sig. (2-tailed)	.000	.532
		N	180	180
	Difference in Performance in Question 32 of Physics Knowledge Test	Correlation Coefficient	-.270**	.005
		Sig. (2-tailed)	.000	.951
		N	180	180
	Difference in Performance in Question 33 of Physics Knowledge Test	Correlation Coefficient	-.321**	-.003

		Sig. (2-tailed)	.000	.973
		N	180	180
	Difference in Performance in Question 34 of Physics Knowledge Test	Correlation Coefficient	-.292**	-.065
		Sig. (2-tailed)	.000	.385
		N	180	180
	Difference in Performance in Question 35 of Physics Knowledge Test	Correlation Coefficient	-.284**	.011
		Sig. (2-tailed)	.000	.886
		N	180	180
	Difference in Performance in Question 36 of Physics Knowledge Test	Correlation Coefficient	-.264**	.008
		Sig. (2-tailed)	.000	.912
		N	180	180
	Difference in Performance in Question 37 of Physics Knowledge Test	Correlation Coefficient	-.298**	-.071
		Sig. (2-tailed)	.000	.341
		N	180	180
	Difference in Performance in Question 38 of Physics Knowledge Test	Correlation Coefficient	-.298**	-.026
		Sig. (2-tailed)	.000	.734
		N	180	180
	Difference in Performance in Question 39 of Physics Knowledge Test	Correlation Coefficient	-.271**	.046
		Sig. (2-tailed)	.000	.535
		N	180	180
	Difference in Performance in Question 41 of Physics Knowledge Test	Correlation Coefficient	-.264**	.054
		Sig. (2-tailed)	.000	.469
		N	180	180
	Difference in Performance in Question 43 of Physics Knowledge Test	Correlation Coefficient	-.312**	.037
		Sig. (2-tailed)	.000	.618
		N	180	180
	Difference in Performance in Question 45 of Physics Knowledge Test	Correlation Coefficient	-.342**	-.024
		Sig. (2-tailed)	.000	.748
		N	180	180

	Difference in Performance in Question 46 of Physics Knowledge Test	Correlation Coefficient	-.348**	-.052
		Sig. (2-tailed)	.000	.491
		N	180	180
	Difference in Performance in Question 47 of Physics Knowledge Test	Correlation Coefficient	-.393**	-.031
		Sig. (2-tailed)	.000	.683
		N	180	180
	Difference in Performance in Question 48 of Physics Knowledge Test	Correlation Coefficient	-.390**	-.026
		Sig. (2-tailed)	.000	.734
		N	180	180
	Difference in Performance in Question 49 of Physics Knowledge Test	Correlation Coefficient	-.384**	-.064
		Sig. (2-tailed)	.000	.392
		N	180	180
	Difference in Performance in Question 50 of Physics Knowledge Test	Correlation Coefficient	-.345**	.043
		Sig. (2-tailed)	.000	.569
		N	180	180

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Table 6(b): Results from Crosstabs Related to the Association between Group / Gender and the Understanding of Individual Questions of PHYSICS Knowledge Test

Crosstabs Symmetric Measures				
			Group	Gender
Phi Cramer’s V	Difference in Performance in Question 2 of Physics Knowledge Test	Value	-.192**	.071
		Approx. Sig.	.010	.343
	Difference in Performance in Question 3 of Physics Knowledge Test	Value	-.034	.034
		Approx. Sig.	.647	.657
	Difference in Performance in Question 6 of Physics Knowledge Test	Value	-.071	-.033
		Approx. Sig.	.339	.659
	Difference in Performance in Question 7 of Physics Knowledge Test	Value	-.045	.000
		Approx. Sig.	.543	1.000
	Difference in Performance in Question 8 of Physics Knowledge Test	Value	-.175*	.052
		Approx. Sig.	.019	.481
	Difference in Performance in Question 10 of Physics Knowledge Test	Value	-.073	.012
		Approx. Sig.	.329	.871
	Difference in Performance in Question 11 of Physics Knowledge Test	Value	-.023	.018
		Approx. Sig.	.755	.808
	Difference in Performance in Question 12 of Physics Knowledge Test	Value	-.037	.024
		Approx. Sig.	.624	.750
	Difference in Performance in Question 13 of Physics Knowledge Test	Value	-.057	-.105
		Approx. Sig.	.443	.159
	Difference in Performance in Question 14 of Physics Knowledge Test	Value	.024	-.059
		Approx. Sig.	.747	.430
	Difference in Performance in Question 17 of Physics Knowledge Test	Value	.349**	-.061
		Approx. Sig.	.000	.410
	Difference in Performance in Question 18 of Physics Knowledge Test	Value	-.166*	-.057
		Approx. Sig.	.026	.445
	Difference in Performance in Question 19 of Physics Knowledge Test	Value	-.023	-.098
		Approx. Sig.	.755	.188
Phi Cramer’s V	Difference in Performance in Question 20 of Physics Knowledge Test	Value	-.190*	-.081
		Approx. Sig.	.011	.279
	Difference in Performance in Question 21 of Physics Knowledge Test	Value	-.317**	-.089
		Approx. Sig.	.000	.230
	Difference in Performance in Question 22 of Physics Knowledge Test	Value	.216*	.120
		Approx. Sig.	.015	.275
	Difference in Performance in Question 23 of	Value	-.214**	-.105

	Physics Knowledge Test	Approx. Sig.	.004	.161
	Difference in Performance in Question 24 of Physics Knowledge Test	Value	-.264**	-.059
		Approx. Sig.	.000	.430
	Difference in Performance in Question 25 of Physics Knowledge Test	Value	.000	.000
		Approx. Sig.	1.000	1.000
	Difference in Performance in Question 26 of Physics Knowledge Test	Value	-.183*	.048
		Approx. Sig.	.014	.518
	Difference in Performance in Question 27 of Physics Knowledge Test	Value	-.285**	-.081
		Approx. Sig.	.000	.279
	Difference in Performance in Question 28 of Physics Knowledge Test	Value	-.272**	-.023
		Approx. Sig.	.000	.761
	Difference in Performance in Question 29 of Physics Knowledge Test	Value	-.172*	.054
		Approx. Sig.	.021	.466
	Difference in Performance in Question 30 of Physics Knowledge Test	Value	-.216**	-.103
		Approx. Sig.	.004	.167
	Difference in Performance in Question 31 of Physics Knowledge Test	Value	-.274**	-.047
		Approx. Sig.	.000	.529
	Difference in Performance in Question 32 of Physics Knowledge Test	Value	-.270**	.005
		Approx. Sig.	.000	.951
	Difference in Performance in Question 33 of Physics Knowledge Test	Value	-.321**	-.003
		Approx. Sig.	.000	.973
	Difference in Performance in Question 34 of Physics Knowledge Test	Value	-.292**	-.065
		Approx. Sig.	.000	.382
	Difference in Performance in Question 35 of Physics Knowledge Test	Value	-.284**	.011
		Approx. Sig.	.000	.885
	Difference in Performance in Question 36 of Physics Knowledge Test	Value	-.264**	.008
		Approx. Sig.	.000	.911
	Difference in Performance in Question 37 of Physics Knowledge Test	Value	-.298**	-.071
		Approx. Sig.	.000	.338
Phi Cramer's V	Difference in Performance in Question 38 of Physics Knowledge Test	Value	-.298**	-.026
		Approx. Sig.	.000	.732
	Difference in Performance in Question 39 of Physics Knowledge Test	Value	-.271**	.046
		Approx. Sig.	.000	.533
	Difference in Performance in Question 41 of Physics Knowledge Test	Value	-.264**	.054
		Approx. Sig.	.000	.466
	Difference in Performance in Question 43 of Physics Knowledge Test	Value	-.312**	.037
		Approx. Sig.	.000	.616
	Difference in Performance in Question 45 of Physics Knowledge Test	Value	-.342**	-.024
		Approx. Sig.	.000	.746
	Difference in Performance in Question 46 of	Value	-.348**	-.052

	Physics Knowledge Test	Approx. Sig.	.000	.488
	Difference in Performance in Question 47 of Physics Knowledge Test	Value	-.393**	-.031
		Approx. Sig.	.000	.681
	Difference in Performance in Question 48 of Physics Knowledge Test	Value	-.390**	-.026
		Approx. Sig.	.000	.732
	Difference in Performance in Question 49 of Physics Knowledge Test	Value	-.384**	-.064
		Approx. Sig.	.000	.389
	Difference in Performance in Question 50 of Physics Knowledge Test	Value	-.345**	.043
		Approx. Sig.	.000	.567

** Significant at the 0.01 level

* Significant at the 0.05 level

Table 7(a): Group Statistics for the 1st Set of Independent-Samples T-Tests with Group as the Grouping Variable

T-Test Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Difference in Performance in Question 2 of Physics Knowledge Test	Experimental	90	**.83**	.375	.040
	Control	90	**.67**	.474	.050
Difference in Performance in Question 3 of Physics Knowledge Test	Experimental	90	.62	.488	.051
	Control	90	.59	.495	.052
Difference in Performance in Question 6 of Physics Knowledge Test	Experimental	90	.71	.456	.048
	Control	90	.64	.481	.051
Difference in Performance in Question 7 of Physics Knowledge Test	Experimental	90	.62	.488	.051
	Control	90	.58	.497	.052
Difference in Performance in Question 8 of Physics Knowledge Test	Experimental	90	**.73**	.445	.047
	Control	90	**.57**	.498	.053
Difference in Performance in Question 10 of Physics Knowledge Test	Experimental	90	.73	.445	.047
	Control	90	.67	.474	.050
Difference in Performance in Question 11 of Physics Knowledge Test	Experimental	90	.66	.478	.050
	Control	90	.63	.485	.051
Difference in Performance in Question 12 of Physics Knowledge Test	Experimental	90	.72	.450	.047
	Control	90	.69	.466	.049
Difference in Performance in Question 13 of Physics Knowledge Test	Experimental	90	.64	.481	.051
	Control	90	.59	.495	.052
Difference in Performance in Question 14 of Physics Knowledge Test	Experimental	90	.68	.470	.050
	Control	90	.70	.461	.049
Difference in Performance in Question 17 of Physics Knowledge Test	Experimental	90	**.69**	.466	.049
	Control	90	**.96**	.207	.022
Difference in Performance in Question 18 of Physics Knowledge Test	Experimental	90	**.76**	.432	.046
	Control	90	**.60**	.493	.052
Difference in Performance in Question 19 of Physics Knowledge Test	Experimental	90	.66	.478	.050
	Control	90	.63	.485	.051
Difference in Performance in Question 20 of Physics Knowledge Test	Experimental	90	**.77**	.425	.045
	Control	90	**.59**	.495	.052
Difference in Performance in Question 21 of Physics Knowledge Test	Experimental	90	**.81**	.394	.041
	Control	90	**.51**	.503	.053
Difference in Performance in Question	Experimental	90	**.81**	.982	.103

22 of Physics Knowledge Test	Control	90	**.52**	.502	.053
Difference in Performance in Question	Experimental	90	**.78**	.418	.044
23 of Physics Knowledge Test	Control	90	**.58**	.497	.052
Difference in Performance in Question	Experimental	90	**.81**	.394	.041
24 of Physics Knowledge Test	Control	90	**.57**	.498	.053
Difference in Performance in Question	Experimental	90	.80	.402	.042
25 of Physics Knowledge Test	Control	90	.80	.402	.042
Difference in Performance in Question	Experimental	90	**.79**	.410	.043
26 of Physics Knowledge Test	Control	90	**.62**	.488	.051
Difference in Performance in Question	Experimental	90	**.81**	.394	.041
27 of Physics Knowledge Test	Control	90	**.54**	.501	.053
Difference in Performance in Question	Experimental	90	**.73**	.445	.047
28 of Physics Knowledge Test	Control	90	**.47**	.502	.053
Difference in Performance in Question	Experimental	90	**.71**	.456	.048
29 of Physics Knowledge Test	Control	90	**.54**	.501	.053
Difference in Performance in Question	Experimental	90	**.71**	.456	.048
30 of Physics Knowledge Test	Control	90	**.50**	.503	.053
Difference in Performance in Question	Experimental	90	**.74**	.439	.046
31 of Physics Knowledge Test	Control	90	**.48**	.502	.053
Difference in Performance in Question	Experimental	90	**.79**	.410	.043
32 of Physics Knowledge Test	Control	90	**.53**	.502	.053
Difference in Performance in Question	Experimental	90	**.78**	.418	.044
33 of Physics Knowledge Test	Control	90	**.47**	.502	.053
Difference in Performance in Question	Experimental	90	**.72**	.450	.047
34 of Physics Knowledge Test	Control	90	**.43**	.498	.053
Difference in Performance in Question	Experimental	90	**.74**	.439	.046
35 of Physics Knowledge Test	Control	90	**.47**	.502	.053
Difference in Performance in Question	Experimental	90	**.76**	.432	.046
36 of Physics Knowledge Test	Control	90	**.50**	.503	.053
Difference in Performance in Question	Experimental	90	**.77**	.425	.045
37 of Physics Knowledge Test	Control	90	**.48**	.502	.053
Difference in Performance in Question	Experimental	90	**.77**	.425	.045
38 of Physics Knowledge Test	Control	90	**.48**	.502	.053
Difference in Performance in Question	Experimental	90	**.72**	.450	.047
39 of Physics Knowledge Test	Control	90	**.46**	.501	.053
Difference in Performance in Question	Experimental	90	**.76**	.432	.046
41 of Physics Knowledge Test	Control	90	**.50**	.503	.053
Difference in Performance in Question	Experimental	90	**.83**	.375	.040

43 of Physics Knowledge Test	Control	90	**.54**	.501	.053
Difference in Performance in Question 45 of Physics Knowledge Test	Experimental	90	**.78**	.418	.044
	Control	90	**.44**	.500	.053
Difference in Performance in Question 46 of Physics Knowledge Test	Experimental	90	**.81**	.394	.041
	Control	90	**.48**	.502	.053
Difference in Performance in Question 47 of Physics Knowledge Test	Experimental	90	**.77**	.425	.045
	Control	90	**.38**	.488	.051
Difference in Performance in Question 48 of Physics Knowledge Test	Experimental	90	**.81**	.394	.041
	Control	90	**.43**	.498	.053
Difference in Performance in Question 49 of Physics Knowledge Test	Experimental	90	**.83**	.375	.040
	Control	90	**.47**	.502	.053
Difference in Performance in Question 50 of Physics Knowledge Test	Experimental	90	**.69**	.466	.049
	Control	90	**.34**	.478	.050

Table 7(b): Results of the 1st Set of Independent-Samples T-Tests with Group as the Grouping Variable

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Difference in Performance in Question 2 of Physics Knowledge Test	Equal variances assumed	28.607	.000	2.617	178	.010	.167	.064	.041	.292
	Equal variances not assumed			**2.617**	**169.000**	**.010**	**.167**	**.064**	**.041**	**.292**
Difference in Performance in Question 3 of Physics Knowledge Test	**Equal variances assumed**	.813	.369	.455	178	.649	.033	.073	-.111	.178
	Equal variances not assumed			.455	177.961	.649	.033	.073	-.111	.178
Difference in Performance in Question 6 of Physics Knowledge Test	**Equal variances assumed**	3.588	.060	.954	178	.341	.067	.070	-.071	.205
	Equal variances not assumed			.954	177.472	.341	.067	.070	-.071	.205
Difference in Performance in Question 7 of Physics Knowledge Test	**Equal variances assumed**	1.410	.237	.606	178	.545	.044	.073	-.100	.189
	Equal variances not assumed			.606	177.939	.545	.044	.073	-.100	.189
Difference in Performance in Question 8 of Physics Knowledge Test	Equal variances assumed	18.955	.000	2.367	178	.019	.167	.070	.028	.306
	Equal variances not assumed			**2.367**	**175.742**	**.019**	**.167**	**.070**	**.028**	**.306**
Difference in Performance in Question 10 of Physics Knowledge Test	**Equal variances assumed**	3.763	.054	.973	178	.332	.067	.069	-.069	.202
	Equal variances not assumed			.973	177.278	.332	.067	.069	-.069	.202
Difference in Performance in Question 11 of Physics Knowledge Test	**Equal variances assumed**	.382	.537	.310	178	.757	.022	.072	-.119	.164
	Equal variances not assumed			.310	177.965	.757	.022	.072	-.119	.164
Difference in Performance in Question 12 of Physics Knowledge Test	**Equal variances assumed**	.952	.331	.488	178	.626	.033	.068	-.101	.168
	Equal variances not assumed			.488	177.806	.626	.033	.068	-.101	.168
Difference in Performance in Question 13 of Physics Knowledge Test	**Equal variances assumed**	2.234	.137	.763	178	.446	.056	.073	-.088	.199
	Equal variances not assumed			.763	177.865	.446	.056	.073	-.088	.199

Difference in Performance in Question 14 of Physics Knowledge Test	Equal variances assumed	.410	.523	-.320	178	.749	-.022	.069	-.159	.115
	Equal variances not assumed			-.320	177.932	.749	-.022	.069	-.159	.115
Difference in Performance in Question 17 of Physics Knowledge Test	Equal variances assumed	159.683	.000	-4.964	178	.000	-.267	.054	-.373	-.161
	Equal variances not assumed			-4.964	122.939	.000	-.267	.054	-.373	-.160
Difference in Performance in Question 18 of Physics Knowledge Test	Equal variances assumed	18.826	.000	2.252	178	.026	.156	.069	.019	.292
	Equal variances not assumed			2.252	175.031	.026	.156	.069	.019	.292
Difference in Performance in Question 19 of Physics Knowledge Test	Equal variances assumed	.382	.537	.310	178	.757	.022	.072	-.119	.164
	Equal variances not assumed			.310	177.965	.757	.022	.072	-.119	.164
Difference in Performance in Question 20 of Physics Knowledge Test	Equal variances assumed	24.300	.000	2.585	178	.011	.178	.069	.042	.313
	Equal variances not assumed			2.585	174.076	.011	.178	.069	.042	.314
Difference in Performance in Question 21 of Physics Knowledge Test	Equal variances assumed	55.966	.000	4.458	178	.000	.300	.067	.167	.433
	Equal variances not assumed			4.458	168.320	.000	.300	.067	.167	.433
Difference in Performance in Question 22 of Physics Knowledge Test	Equal variances assumed	.278	.599	2.485	178	.014	.289	.116	.059	.518
	Equal variances not assumed			2.485	132.605	.014	.289	.116	.059	.519
Difference in Performance in Question 23 of Physics Knowledge Test	Equal variances assumed	30.384	.000	2.923	178	.004	.200	.068	.065	.335
	Equal variances not assumed			2.923	172.965	.004	.200	.068	.065	.335
Difference in Performance in Question 24 of Physics Knowledge Test	Equal variances assumed	47.672	.000	3.652	178	.000	.244	.067	.112	.377
	Equal variances not assumed			3.652	168.940	.000	.244	.067	.112	.377
Difference in Performance in Question 25 of Physics Knowledge Test	Equal variances assumed	.000	1.000	.000	178	1.000	.000	.060	-.118	.118
	Equal variances not assumed			.000	178.000	1.000	.000	.060	-.118	.118
Difference in Performance in Question 26 of Physics Knowledge Test	Equal variances assumed	23.999	.000	2.481	178	.014	.167	.067	.034	.299
	Equal variances not assumed			2.481	172.965	.014	.167	.067	.034	.299
Difference in Performance in Question 27 of Physics Knowledge Test	Equal variances assumed	52.229	.000	3.972	178	.000	.267	.067	.134	.399
	Equal variances not assumed			3.972	168.586	.000	.267	.067	.134	.399

Difference in Performance in Question 28 of Physics Knowledge Test	Equal variances assumed	23.175	.000	3.774	178	.000	.267	.071	.127	.406
	Equal variances not assumed			**3.774**	**175.473**	**.000**	**.267**	**.071**	**.127**	**.406**
Difference in Performance in Question 29 of Physics Knowledge Test	Equal variances assumed	16.739	.000	2.335	178	.021	.167	.071	.026	.308
	Equal variances not assumed			**2.335**	**176.443**	**.021**	**.167**	**.071**	**.026**	**.308**
Difference in Performance in Question 30 of Physics Knowledge Test	Equal variances assumed	19.308	.000	2.951	178	.004	.211	.072	.070	.352
	Equal variances not assumed			**2.951**	**176.312**	**.004**	**.211**	**.072**	**.070**	**.352**
Difference in Performance in Question 31 of Physics Knowledge Test	Equal variances assumed	27.198	.000	3.794	178	.000	.267	.070	.128	.405
	Equal variances not assumed			**3.794**	**174.825**	**.000**	**.267**	**.070**	**.128**	**.405**
Difference in Performance in Question 32 of Physics Knowledge Test	Equal variances assumed	42.572	.000	3.741	178	.000	.256	.068	.121	.390
	Equal variances not assumed			**3.741**	**171.271**	**.000**	**.256**	**.068**	**.121**	**.390**
Difference in Performance in Question 33 of Physics Knowledge Test	Equal variances assumed	37.812	.000	4.520	178	.000	.311	.069	.175	.447
	Equal variances not assumed			**4.520**	**172.394**	**.000**	**.311**	**.069**	**.175**	**.447**
Difference in Performance in Question 34 of Physics Knowledge Test	Equal variances assumed	16.342	.000	4.080	178	.000	.289	.071	.149	.429
	Equal variances not assumed			**4.080**	**176.212**	**.000**	**.289**	**.071**	**.149**	**.429**
Difference in Performance in Question 35 of Physics Knowledge Test	Equal variances assumed	26.284	.000	3.955	178	.000	.278	.070	.139	.416
	Equal variances not assumed			**3.955**	**174.881**	**.000**	**.278**	**.070**	**.139**	**.416**
Difference in Performance in Question 36 of Physics Knowledge Test	Equal variances assumed	31.471	.000	3.657	178	.000	.256	.070	.118	.393
	Equal variances not assumed			**3.657**	**174.071**	**.000**	**.256**	**.070**	**.118**	**.393**
Difference in Performance in Question 37 of Physics Knowledge Test	Equal variances assumed	34.555	.000	4.164	178	.000	.289	.069	.152	.426
	Equal variances not assumed			**4.164**	**173.291**	**.000**	**.289**	**.069**	**.152**	**.426**
Difference in Performance in Question 38 of Physics Knowledge Test	Equal variances assumed	34.555	.000	4.164	178	.000	.289	.069	.152	.426
	Equal variances not assumed			**4.164**	**173.291**	**.000**	**.289**	**.069**	**.152**	**.426**
Difference in Performance in Question 39 of Physics Knowledge Test	Equal variances assumed	19.239	.000	3.756	178	.000	.267	.071	.127	.407
	Equal variances not assumed			**3.756**	**176.034**	**.000**	**.267**	**.071**	**.127**	**.407**

Difference in Performance in Question 41 of Physics Knowledge Test	Equal variances assumed	31.471	.000	3.657	178	.000	.256	.070	.118	.393
	Equal variances not assumed			**3.657**	**174.071**	**.000**	**.256**	**.070**	**.118**	**.393**
Difference in Performance in Question 43 of Physics Knowledge Test	Equal variances assumed	66.577	.000	4.381	178	.000	.289	.066	.159	.419
	Equal variances not assumed			**4.381**	**164.882**	**.000**	**.289**	**.066**	**.159**	**.419**
Difference in Performance in Question 45 of Physics Knowledge Test	Equal variances assumed	34.638	.000	4.854	178	.000	.333	.069	.198	.469
	Equal variances not assumed			**4.854**	**172.624**	**.000**	**.333**	**.069**	**.198**	**.469**
Difference in Performance in Question 46 of Physics Knowledge Test	Equal variances assumed	55.195	.000	4.955	178	.000	.333	.067	.201	.466
	Equal variances not assumed			**4.955**	**168.373**	**.000**	**.333**	**.067**	**.201**	**.466**
Difference in Performance in Question 47 of Physics Knowledge Test	Equal variances assumed	17.301	.000	5.702	178	.000	.389	.068	.254	.523
	Equal variances not assumed			**5.702**	**174.782**	**.000**	**.389**	**.068**	**.254**	**.523**
Difference in Performance in Question 48 of Physics Knowledge Test	Equal variances assumed	47.672	.000	5.644	178	.000	.378	.067	.246	.510
	Equal variances not assumed			**5.644**	**168.940**	**.000**	**.378**	**.067**	**.246**	**.510**
Difference in Performance in Question 49 of Physics Knowledge Test	Equal variances assumed	68.555	.000	5.555	178	.000	.367	.066	.236	.497
	Equal variances not assumed			**5.555**	**164.744**	**.000**	**.367**	**.066**	**.236**	**.497**
Difference in Performance in Question 50 of Physics Knowledge Test	**Equal variances assumed**	.895	.345	**4.898**	**178**	**.000**	**.344**	**.070**	**.206**	**.483**
	Equal variances not assumed			4.898	177.879	.000	.344	.070	.206	.483

Table 8(a): Group Statistics for the 2nd Set of Independent-Samples T-Tests with Gender as the Grouping Variable

T-Test Group Statistics

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Difference in Performance in Question 2 of Physics Knowledge Test	Male	85	.72	.453	.049
	Female	95	.78	.417	.043
Difference in Performance in Question 3 of Physics Knowledge Test	Male	85	.59	.495	.054
	Female	95	.62	.488	.050
Difference in Performance in Question 6 of Physics Knowledge Test	Male	85	.69	.464	.050
	Female	95	.66	.475	.049
Difference in Performance in Question 7 of Physics Knowledge Test	Male	85	.60	.493	.053
	Female	95	.60	.492	.051
Difference in Performance in Question 8 of Physics Knowledge Test	Male	85	.62	.487	.053
	Female	95	.67	.471	.048
Difference in Performance in Question 10 of Physics Knowledge Test	Male	85	.69	.464	.050
	Female	95	.71	.458	.047
Difference in Performance in Question 11 of Physics Knowledge Test	Male	85	.64	.484	.053
	Female	95	.65	.479	.049
Difference in Performance in Question 12 of Physics Knowledge Test	Male	85	.69	.464	.050
	Female	95	.72	.453	.047
Difference in Performance in Question 13 of Physics Knowledge Test	Male	85	.67	.473	.051
	Female	95	.57	.498	.051
Difference in Performance in Question 14 of Physics Knowledge Test	Male	85	.72	.453	.049
	Female	95	.66	.475	.049
Difference in Performance in Question 17 of Physics Knowledge Test	Male	85	.85	.362	.039
	Female	95	.80	.402	.041
Difference in Performance in Question 18 of Physics Knowledge Test	Male	85	.71	.458	.050
	Female	95	.65	.479	.049
Difference in Performance in Question 19 of Physics Knowledge Test	Male	85	.69	.464	.050
	Female	95	.60	.492	.051
Difference in Performance in Question 20 of Physics Knowledge Test	Male	85	.72	.453	.049
	Female	95	.64	.482	.049
Difference in Performance in Question 21 of Physics Knowledge Test	Male	85	.71	.458	.050
	Female	95	.62	.488	.050
Difference in Performance in Question 22 of Physics Knowledge Test	Male	85	.76	1.019	.111
	Female	95	.58	.496	.051
Difference in Performance in Question 23 of Physics Knowledge Test	Male	85	.73	.447	.048
	Female	95	.63	.485	.050
Difference in Performance in Question	Male	85	.72	.453	.049

24 of Physics Knowledge Test	Female	95	.66	.475	.049
Difference in Performance in Question 25 of Physics Knowledge Test	Male	85	.80	.402	.044
	Female	95	.80	.402	.041
Difference in Performance in Question 26 of Physics Knowledge Test	Male	85	.68	.468	.051
	Female	95	.73	.448	.046
Difference in Performance in Question 27 of Physics Knowledge Test	Male	85	.72	.453	.049
	Female	95	.64	.482	.049
Difference in Performance in Question 28 of Physics Knowledge Test	Male	85	.61	.490	.053
	Female	95	.59	.495	.051
Difference in Performance in Question 29 of Physics Knowledge Test	Male	85	.60	.493	.053
	Female	95	.65	.479	.049
Difference in Performance in Question 30 of Physics Knowledge Test	Male	85	.66	.477	.052
	Female	95	.56	.499	.051
Difference in Performance in Question 31 of Physics Knowledge Test	Male	85	.64	.484	.053
	Female	95	.59	.495	.051
Difference in Performance in Question 32 of Physics Knowledge Test	Male	85	.66	.477	.052
	Female	95	.66	.475	.049
Difference in Performance in Question 33 of Physics Knowledge Test	Male	85	.62	.487	.053
	Female	95	.62	.488	.050
Difference in Performance in Question 34 of Physics Knowledge Test	Male	85	.61	.490	.053
	Female	95	.55	.500	.051
Difference in Performance in Question 35 of Physics Knowledge Test	Male	85	.60	.493	.053
	Female	95	.61	.490	.050
Difference in Performance in Question 36 of Physics Knowledge Test	Male	85	.62	.487	.053
	Female	95	.63	.485	.050
Difference in Performance in Question 37 of Physics Knowledge Test	Male	85	.66	.477	.052
	Female	95	.59	.495	.051
Difference in Performance in Question 38 of Physics Knowledge Test	Male	85	.64	.484	.053
	Female	95	.61	.490	.050
Difference in Performance in Question 39 of Physics Knowledge Test	Male	85	.56	.499	.054
	Female	95	.61	.490	.050
Difference in Performance in Question 41 of Physics Knowledge Test	Male	85	.60	.493	.053
	Female	95	.65	.479	.049
Difference in Performance in Question 43 of Physics Knowledge Test	Male	85	.67	.473	.051
	Female	95	.71	.458	.047
Difference in Performance in Question 45 of Physics Knowledge Test	Male	85	.62	.487	.053
	Female	95	.60	.492	.051
Difference in Performance in Question 46 of Physics Knowledge Test	Male	85	.67	.473	.051
	Female	95	.62	.488	.050
Difference in Performance in Question	Male	85	.59	.495	.054

47 of Physics Knowledge Test	Female	95	.56	.499	.051
Difference in Performance in Question 48 of Physics Knowledge Test	Male	85	.64	.484	.053
	Female	95	.61	.490	.050
Difference in Performance in Question 49 of Physics Knowledge Test	Male	85	.68	.468	.051
	Female	95	.62	.488	.050
Difference in Performance in Question 50 of Physics Knowledge Test	Male	85	.49	.503	.055
	Female	95	.54	.501	.051

Table 8(b): Results of the 2nd Set of Independent-Samples T-Tests with Gender as the Grouping Variable

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Difference in Performance in Question 2 of Physics Knowledge Test	**Equal variances assumed**	3.543	.061	-.945	178	.346	-.061	.065	-.189	.067
	Equal variances not assumed			-.941	171.591	.348	-.061	.065	-.190	.067
Difference in Performance in Question 3 of Physics Knowledge Test	**Equal variances assumed**	.772	.381	-.447	178	.655	-.033	.073	-.178	.112
	Equal variances not assumed			-.447	175.180	.655	-.033	.073	-.178	.112
Difference in Performance in Question 6 of Physics Knowledge Test	**Equal variances assumed**	.785	.377	.441	178	.659	.031	.070	-.107	.169
	Equal variances not assumed			.442	176.658	.659	.031	.070	-.107	.169
Difference in Performance in Question 7 of Physics Knowledge Test	**Equal variances assumed**	.000	1.000	.000	178	1.000	.000	.074	-.145	.145
	Equal variances not assumed			.000	175.774	1.000	.000	.074	-.145	.145
Difference in Performance in Question 8 of Physics Knowledge Test	**Equal variances assumed**	1.899	.170	-.701	178	.484	-.050	.072	-.191	.091
	Equal variances not assumed			-.700	174.324	.485	-.050	.072	-.192	.091
Difference in Performance in Question 10 of Physics Knowledge Test	**Equal variances assumed**	.105	.747	-.162	178	.871	-.011	.069	-.147	.125
	Equal variances not assumed			-.162	175.343	.872	-.011	.069	-.147	.125
Difference in Performance in Question 11 of Physics Knowledge Test	**Equal variances assumed**	.231	.632	-.241	178	.810	-.017	.072	-.159	.124
	Equal variances not assumed			-.241	175.330	.810	-.017	.072	-.159	.125
Difference in Performance in Question 12 of Physics Knowledge Test	**Equal variances assumed**	.399	.528	-.317	178	.752	-.022	.068	-.157	.113
	Equal variances not assumed			-.316	174.867	.752	-.022	.068	-.157	.114
Difference in Performance in Question 13 of Physics Knowledge Test	Equal variances assumed	7.264	.008	1.407	178	.161	.102	.073	-.041	.245
	Equal variances not assumed			1.411	177.360	.160	.102	.072	-.041	.245

Difference in Performance in Question	**Equal variances assumed**	2.490	.116	.785	178	.433	.054	.069	-.082	.191
14 of Physics Knowledge Test	Equal variances not assumed			.787	177.279	.432	.054	.069	-.082	.191
Difference in Performance in Question	**Equal variances assumed**	2.748	.099	.821	178	.413	.047	.057	-.066	.160
17 of Physics Knowledge Test	Equal variances not assumed			.826	177.991	.410	.047	.057	-.065	.159
Difference in Performance in Question	**Equal variances assumed**	2.329	.129	.760	178	.448	.053	.070	-.085	.191
18 of Physics Knowledge Test	Equal variances not assumed			.762	177.168	.447	.053	.070	-.085	.191
Difference in Performance in Question	Equal variances assumed	6.739	.010	1.316	178	.190	.094	.072	-.047	.235
19 of Physics Knowledge Test	**Equal variances not assumed**			1.320	177.534	.188	.094	.071	-.047	.235
Difference in Performance in Question	Equal variances assumed	4.693	.032	1.080	178	.282	.076	.070	-.062	.214
20 of Physics Knowledge Test	**Equal variances not assumed**			1.084	177.564	.280	.076	.070	-.062	.213
Difference in Performance in Question	Equal variances assumed	5.710	.018	1.198	178	.232	.085	.071	-.055	.225
21 of Physics Knowledge Test	**Equal variances not assumed**			1.203	177.560	.231	.085	.071	-.054	.224
Difference in Performance in Question	**Equal variances assumed**	.032	.858	1.579	178	.116	.186	.118	-.046	.418
22 of Physics Knowledge Test	Equal variances not assumed			1.526	118.644	.130	.186	.122	-.055	.427
Difference in Performance in Question	Equal variances assumed	7.869	.006	1.402	178	.163	.098	.070	-.040	.236
23 of Physics Knowledge Test	**Equal variances not assumed**			1.408	177.838	.161	.098	.069	-.039	.235
Difference in Performance in Question	**Equal variances assumed**	2.490	.116	.785	178	.433	.054	.069	-.082	.191
24 of Physics Knowledge Test	Equal variances not assumed			.787	177.279	.432	.054	.069	-.082	.191
Difference in Performance in Question	**Equal variances assumed**	.000	1.000	.000	178	1.000	.000	.060	-.119	.119
25 of Physics Knowledge Test	Equal variances not assumed			.000	175.774	1.000	.000	.060	-.119	.119
Difference in Performance in Question	**Equal variances assumed**	1.631	.203	-.643	178	.521	-.044	.068	-.179	.091
26 of Physics Knowledge Test	Equal variances not assumed			-.642	173.792	.522	-.044	.069	-.179	.091
Difference in Performance in Question	Equal variances assumed	4.693	.032	1.080	178	.282	.076	.070	-.062	.214
27 of Physics Knowledge Test	**Equal variances not assumed**			1.084	177.564	.280	.076	.070	-.062	.213
Difference in Performance in Question	**Equal variances assumed**	.368	.545	.303	178	.762	.022	.074	-.123	.167
28 of Physics Knowledge Test	Equal variances not assumed			.303	176.125	.762	.022	.073	-.123	.167

Difference in Performance in Question 29 of Physics Knowledge Test	Equal variances assumed	2.000	.159	-.726	178	.469	-.053	.072	-.196	.090
	Equal variances not assumed			-.725	174.533	.469	-.053	.073	-.196	.091
Difference in Performance in Question 30 of Physics Knowledge Test	Equal variances assumed	6.816	.010	1.383	178	.168	.101	.073	-.043	.245
	Equal variances not assumed			1.386	177.226	.167	.101	.073	-.043	.245
Difference in Performance in Question 31 of Physics Knowledge Test	**Equal variances assumed**	1.555	.214	.627	178	.532	.046	.073	-.098	.190
	Equal variances not assumed			.627	176.544	.531	.046	.073	-.098	.190
Difference in Performance in Question 32 of Physics Knowledge Test	**Equal variances assumed**	.015	.903	-.061	178	.951	-.004	.071	-.145	.136
	Equal variances not assumed			-.061	175.651	.951	-.004	.071	-.145	.136
Difference in Performance in Question 33 of Physics Knowledge Test	**Equal variances assumed**	.005	.946	.034	178	.973	.002	.073	-.141	.146
	Equal variances not assumed			.034	175.824	.973	.002	.073	-.141	.146
Difference in Performance in Question 34 of Physics Knowledge Test	**Equal variances assumed**	2.749	.099	.870	178	.385	.064	.074	-.082	.210
	Equal variances not assumed			.871	176.524	.385	.064	.074	-.081	.210
Difference in Performance in Question 35 of Physics Knowledge Test	**Equal variances assumed**	.082	.775	-.143	178	.886	-.011	.073	-.155	.134
	Equal variances not assumed			-.143	175.589	.886	-.011	.073	-.155	.134
Difference in Performance in Question 36 of Physics Knowledge Test	**Equal variances assumed**	.049	.825	-.111	178	.912	-.008	.073	-.151	.135
	Equal variances not assumed			-.111	175.599	.912	-.008	.073	-.151	.135
Difference in Performance in Question 37 of Physics Knowledge Test	**Equal variances assumed**	3.555	.061	.955	178	.341	.069	.073	-.074	.213
	Equal variances not assumed			.957	176.988	.340	.069	.072	-.074	.212
Difference in Performance in Question 38 of Physics Knowledge Test	**Equal variances assumed**	.465	.496	.340	178	.734	.025	.073	-.119	.168
	Equal variances not assumed			.341	176.252	.734	.025	.073	-.119	.168
Difference in Performance in Question 39 of Physics Knowledge Test	**Equal variances assumed**	1.416	.236	-.621	178	.535	-.046	.074	-.191	.100
	Equal variances not assumed			-.620	175.082	.536	-.046	.074	-.192	.100
Difference in Performance in Question 41 of Physics Knowledge Test	**Equal variances assumed**	2.000	.159	-.726	178	.469	-.053	.072	-.196	.090
	Equal variances not assumed			-.725	174.533	.469	-.053	.073	-.196	.091
Difference in Performance in Question 43 of Physics Knowledge Test	**Equal variances assumed**	.984	.323	-.499	178	.618	-.035	.069	-.172	.102
	Equal variances not assumed			-.498	174.441	.619	-.035	.070	-.172	.103

Difference in Performance in Question 45 of Physics Knowledge Test	**Equal variances assumed**	.415	.520	.322	178	.748	.024	.073	-.121	.168
	Equal variances not assumed			.322	176.186	.748	.024	.073	-.121	.168
Difference in Performance in Question 46 of Physics Knowledge Test	**Equal variances assumed**	1.907	.169	.690	178	.491	.050	.072	-.092	.191
	Equal variances not assumed			.691	176.844	.490	.050	.072	-.092	.191
Difference in Performance in Question 47 of Physics Knowledge Test	**Equal variances assumed**	.657	.419	.409	178	.683	.030	.074	-.116	.177
	Equal variances not assumed			.409	176.114	.683	.030	.074	-.116	.177
Difference in Performance in Question 48 of Physics Knowledge Test	**Equal variances assumed**	.465	.496	.340	178	.734	.025	.073	-.119	.168
	Equal variances not assumed			.341	176.252	.734	.025	.073	-.119	.168
Difference in Performance in Question 49 of Physics Knowledge Test	**Equal variances assumed**	2.938	.088	.858	178	.392	.061	.071	-.080	.202
	Equal variances not assumed			.860	177.098	.391	.061	.071	-.079	.202
Difference in Performance in Question 50 of Physics Knowledge Test	**Equal variances assumed**	.426	.515	-.570	178	.569	-.043	.075	-.191	.105
	Equal variances not assumed			-.570	175.669	.569	-.043	.075	-.191	.105

Table 10: Nonparametric Correlations Investigating the Association between Group / Gender and the Understanding of Individual Questions - Subtopics of P.E. Fields Test

Nonparametric Correlations

			Group	Gender
Spearman's rho	Difference in Performance in Question-Subtopic 1 of P.E. Fields Test	Correlation Coefficient	-.148*	.070
		Sig. (2-tailed)	.047	.352
		N	180	180
	Difference in Performance in Question-Subtopic 2 of P.E. Fields Test	Correlation Coefficient	-.190*	.107
		Sig. (2-tailed)	.010	.153
		N	180	180
	Difference in Performance in Question-Subtopic 3 of P.E. Fields Test	Correlation Coefficient	-.116	.005
		Sig. (2-tailed)	.119	.951
		N	180	180
	Difference in Performance in Question-Subtopic 4 of P.E. Fields Test	Correlation Coefficient	-.101	.077
		Sig. (2-tailed)	.179	.303
		N	180	180
	Difference in Performance in Question-Subtopic 5 of P.E. Fields Test	Correlation Coefficient	-.193**	.080
		Sig. (2-tailed)	.009	.286
		N	180	180

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Table 10(b): Results from Crosstabs Related to the Association between Group / Gender and the Understanding of Individual Questions - Subtopics of P.E. Fields Test

Crosstabs Symmetric Measures

			Group	Gender
Phi Cramer's V	Difference in Performance in Question-Subtopic 1 of P.E. Fields Test	Value	-.148	.070
		Approx. Sig.	.047	.349
	Difference in Performance in Question-Subtopic 2 of P.E. Fields Test	Value	-.190	.107
		Approx. Sig.	.011	.152
	Difference in Performance in Question-Subtopic 3 of P.E. Fields Test	Value	-.116	.005
		Approx. Sig.	.118	.950
	Difference in Performance in Question-Subtopic 4 of P.E. Fields Test	Value	-.101	.077
		Approx. Sig.	.178	.300
	Difference in Performance in Question-Subtopic 5 of P.E. Fields Test	Value	-.193	.080
		Approx. Sig.	.010	.283

Table 11(a): Group Statistics for the 1st Set of Independent-Samples T-Tests with Group as the Grouping Variable

T-Test Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Difference in Performance in Question-Subtopic 1 of P.E. Fields Test	Experimental	90	**.84**	.364	.038
	Control	90	**.72**	.450	.047
Difference in Performance in Question-Subtopic 2 of P.E. Fields Test	Experimental	90	**.94**	.230	.024
	Control	90	**.82**	.384	.041
Difference in Performance in Question-Subtopic 3 of P.E. Fields Test	Experimental	90	.91	.286	.030
	Control	90	.83	.375	.040
Difference in Performance in Question-Subtopic 4 of P.E. Fields Test	Experimental	90	.94	.230	.024
	Control	90	.89	.316	.033
Difference in Performance in Question-Subtopic 5 of P.E. Fields Test	Experimental	90	**.98**	.148	.016
	Control	90	**.88**	.329	.035

Table 11(b): Results of the 1st Set of Independent-Samples T-Tests with Group as the Grouping Variable

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Difference in Performance in Question-Subtopic 1 of P.E. Fields Test	Equal variances assumed	16.747	.000	2.001	178	.047	.122	.061	.002	.243
	Equal variances not assumed			**2.001**	**170.576**	**.047**	**.122**	**.061**	**.002**	**.243**
Difference in Performance in Question-Subtopic 2 of P.E. Fields Test	Equal variances assumed	30.596	.000	2.587	178	.010	.122	.047	.029	.215
	Equal variances not assumed			**2.587**	**145.601**	**.011**	**.122**	**.047**	**.029**	**.216**
Difference in Performance in Question-Subtopic 3 of P.E. Fields Test	Equal variances assumed	10.246	.002	1.565	178	.119	.078	.050	-.020	.176
	Equal variances not assumed			**1.565**	**166.457**	**.120**	**.078**	**.050**	**-.020**	**.176**
Difference in Performance in Question-Subtopic 4 of P.E. Fields Test	Equal variances assumed	7.540	.007	1.348	178	.179	.056	.041	-.026	.137
	Equal variances not assumed			**1.348**	**162.749**	**.180**	**.056**	**.041**	**-.026**	**.137**
Difference in Performance in Question-Subtopic 5 of P.E. Fields Test	Equal variances assumed	32.137	.000	2.627	178	.009	.100	.038	.025	.175
	Equal variances not assumed			**2.627**	**123.630**	**.010**	**.100**	**.038**	**.025**	**.175**

Table 12(a): Group Statistics for the 2nd Set of Independent-Samples T-Tests with Gender as the Grouping Variable

T-Test Group Statistics

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Difference in Performance in Question-Subtopic 1 of P.E. Fields Test	Male	85	.75	.434	.047
	Female	95	.81	.394	.040
Difference in Performance in Question-Subtopic 2 of P.E. Fields Test	Male	85	.85	.362	.039
	Female	95	.92	.279	.029
Difference in Performance in Question-Subtopic 3 of P.E. Fields Test	Male	85	.87	.338	.037
	Female	95	.87	.334	.034
Difference in Performance in Question-Subtopic 4 of P.E. Fields Test	Male	85	.89	.310	.034
	Female	95	.94	.245	.025
Difference in Performance in Question-Subtopic 5 of P.E. Fields Test	Male	85	.91	.294	.032
	Female	95	.95	.224	.023

Table 12(b): Results of the 2nd Set of Independent-Samples T-Tests with Gender as the Grouping Variable

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Difference in Performance in Question-Subtopic 4 of P.E. Fields Test	Equal variances assumed	3.476	.064	-.933	178	.352	-.058	.062	-.179	.064
	Equal variances not assumed			**-.928**	**170.657**	**.355**	**-.058**	**.062**	**-.180**	**.065**
Difference in Performance in Question-Subtopic 4 of P.E. Fields Test	Equal variances assumed	8.466	.004	-1.434	178	.153	-.069	.048	-.163	.026
	Equal variances not assumed			**-1.414**	**157.349**	**.159**	**-.069**	**.049**	**-.165**	**.027**
Difference in Performance in Question-Subtopic 4 of P.E. Fields Test	Equal variances assumed	.015	.902	-.062	178	.951	-.003	.050	-.102	.096
	Equal variances not assumed			**-.062**	**175.354**	**.951**	**-.003**	**.050**	**-.102**	**.096**
Difference in Performance in Question-Subtopic 4 of P.E. Fields Test	Equal variances assumed	4.333	.039	-1.033	178	.303	-.043	.041	-.124	.039
	Equal variances not assumed			**-1.019**	**159.556**	**.310**	**-.043**	**.042**	**-.125**	**.040**
Difference in Performance in Question-Subtopic 4 of P.E. Fields Test	Equal variances assumed	4.671	.032	-1.071	178	.286	-.041	.039	-.118	.035
	Equal variances not assumed			**-1.055**	**156.535**	**.293**	**-.041**	**.039**	**-.119**	**.036**

Table 14: Parametric Correlations Investigating the Association between Group / Gender and the Understanding of Subtopics of PHYSICS in Pre- and Post-Trial Phases

Parametric Correlations				
			Group	Gender
Pearson Correlation	Performance in FRICTION/ STOPPING DISTANCE (pre)	Pearson Correlation	-.510**	-.082
		Sig. (2-tailed)	.000	.276
		N	180	180
	Performance in FRICTION/ STOPPING DISTANCE (post)	Pearson Correlation	-.495**	-.022
		Sig. (2-tailed)	.000	.769
		N	180	180
	Performance in AIR RESISTANCE (pre)	Pearson Correlation	-.439**	-.080
		Sig. (2-tailed)	.000	.287
		N	180	180
	Performance in AIR RESISTANCE (post)	Pearson Correlation	-.432**	-.116
		Sig. (2-tailed)	.000	.121
		N	180	180
	Performance in UPTHRUST (pre)	Pearson Correlation	-.189*	-.056
		Sig. (2-tailed)	.011	.455
		N	180	180
	Performance in UPTHRUST (post)	Pearson Correlation	-.460**	-.074
		Sig. (2-tailed)	.000	.321
		N	180	180
	Performance in STRETCH (pre)	Pearson Correlation	-.203**	-.059
		Sig. (2-tailed)	.006	.433
		N	180	180
	Performance in STRETCH (post)	Pearson Correlation	-.510**	-.055
		Sig. (2-tailed)	.000	.466
		N	180	180
	Performance in WEIGHT/GRAVITY (pre)	Pearson Correlation	-.004	-.097
		Sig. (2-tailed)	.954	.196
		N	180	180
	Performance in WEIGHT/GRAVITY (post)	Pearson Correlation	-.494**	-.060
		Sig. (2-tailed)	.000	.425
		N	180	180

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Table 15(a): Group Statistics for the 1st Set of Independent-Samples T-Tests with Group as the Grouping Variable

T-Test Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Performance in FRICTION/ STOPPING DISTANCE (pre)	Experimental	90	**.2593**	.18548	.01955
	Control	90	**.0741**	.12268	.01293
Performance in FRICTION/ STOPPING DISTANCE (post)	Experimental	90	**.9685**	.08617	.00908
	Control	90	**.6889**	.33817	.03565
Performance in AIR RESISTANCE (pre)	Experimental	90	**.2667**	.23269	.02453
	Control	90	**.0833**	.13117	.01383
Performance in AIR RESISTANCE (post)	Experimental	90	**.9542**	.14569	.01536
	Control	90	**.7125**	.32749	.03452
Performance in UPTHRUST (pre)	Experimental	90	**.1989**	.22108	.02330
	Control	90	**.1267**	.15050	.01586
Performance in UPTHRUST (post)	Experimental	90	**.9556**	.16767	.01767
	Control	90	**.6656**	.36045	.03799
Performance in STRETCH (pre)	Experimental	90	**.2012**	.22216	.02342
	Control	90	**.1222**	.15629	.01647
Performance in STRETCH (post)	Experimental	90	**.9556**	.14212	.01498
	Control	90	**.5988**	.40379	.04256
Performance in WEIGHT/GRAVITY (pre)	Experimental	90	.1681	.18086	.01906
	Control	90	.1667	.14022	.01478
Performance in WEIGHT/GRAVITY (post)	Experimental	90	**.9528**	.14823	.01562
	Control	90	**.6125**	.39884	.04204

Table 15(b): Results of the 1st Set of Independent-Samples T-Tests with Group as the Grouping Variable

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Performance in FRICTION/ STOPPING DISTANCE (pre)	Equal variances assumed	18.187	.000	7.900	178	.000	.18519	.02344	.13893	.23144
	Equal variances not assumed			**7.900**	**154.364**	**.000**	**.18519**	**.02344**	**.13888**	**.23149**
Performance in FRICTION/ STOPPING DISTANCE (post)	Equal variances assumed	239.631	.000	7.602	178	.000	.27963	.03678	.20704	.35222
	Equal variances not assumed			**7.602**	**100.508**	**.000**	**.27963**	**.03678**	**.20665**	**.35261**
Performance in AIR RESISTANCE (pre)	Equal variances assumed	27.362	.000	6.511	178	.000	.18333	.02816	.12777	.23890
	Equal variances not assumed			**6.511**	**140.375**	**.000**	**.18333**	**.02816**	**.12767**	**.23900**
Performance in AIR RESISTANCE (post)	Equal variances assumed	149.575	.000	6.396	178	.000	.24167	.03778	.16711	.31623
	Equal variances not assumed			**6.396**	**122.899**	**.000**	**.24167**	**.03778**	**.16688**	**.31646**
Performance in UPTHRUST (pre)	Equal variances assumed	8.508	.004	2.562	178	.011	.07222	.02819	.01659	.12785
	Equal variances not assumed			**2.562**	**156.909**	**.011**	**.07222**	**.02819**	**.01654**	**.12791**
Performance in UPTHRUST (post)	Equal variances assumed	177.540	.000	6.921	178	.000	.29000	.04190	.20731	.37269
	Equal variances not assumed			**6.921**	**125.795**	**.000**	**.29000**	**.04190**	**.20707**	**.37293**
Performance in STRETCH (pre)	Equal variances assumed	13.895	.000	2.760	178	.006	.07901	.02863	.02251	.13551
	Equal variances not assumed			**2.760**	**159.766**	**.006**	**.07901**	**.02863**	**.02247**	**.13556**
Performance in STRETCH (post)	Equal variances assumed	251.967	.000	7.907	178	.000	.35679	.04512	.26775	.44583
	Equal variances not assumed			**7.907**	**110.716**	**.000**	**.35679**	**.04512**	**.26737**	**.44621**

Performance in WEIGHT/GRAVITY (pre)	Equal variances assumed	5.848	.017	.058	178	.954	.00139	.02412	-.04622	.04899
	Equal variances not assumed			**.058**	**167.598**	**.954**	**.00139**	**.02412**	**-.04624**	**.04901**
Performance in WEIGHT/GRAVITY (post)	Equal variances assumed	278.218	.000	7.587	178	.000	.34028	.04485	.25177	.42879
	Equal variances not assumed			**7.587**	**113.126**	**.000**	**.34028**	**.04485**	**.25142**	**.42914**

Table 16(a): Group Statistics for the 2nd Set of Independent-Samples T-Tests with Gender as the Grouping Variable

T-Test Group Statistics

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Performance in FRICTION/ STOPPING DISTANCE (pre)	Male	85	.1824	.19007	.02062
	Female	95	.1526	.17474	.01793
Performance in FRICTION/ STOPPING DISTANCE (post)	Male	85	.8353	.29378	.03186
	Female	95	.8228	.27484	.02820
Performance in AIR RESISTANCE (pre)	Male	85	.1926	.22621	.02454
	Female	95	.1592	.19334	.01984
Performance in AIR RESISTANCE (post)	Male	85	.8676	.25174	.02731
	Female	95	.8026	.30158	.03094
Performance in UPTHRUST (pre)	Male	85	.1741	.21885	.02374
	Female	95	.1526	.16493	.01692
Performance in UPTHRUST (post)	Male	85	.8353	.29061	.03152
	Female	95	.7884	.33671	.03455
Performance in STRETCH (pre)	Male	85	.1739	.21099	.02289
	Female	95	.1509	.18114	.01858
Performance in STRETCH (post)	Male	85	.7974	.35060	.03803
	Female	95	.7591	.35198	.03611
Performance in WEIGHT/GRAVITY (pre)	Male	85	.1838	.16090	.01745
	Female	95	.1526	.16122	.01654
Performance in WEIGHT/GRAVITY (post)	Male	85	.8044	.33209	.03602
	Female	95	.7632	.35705	.03663

Table 16(b): Results of the 2st Set of Independent-Samples T-Tests with Gender as the Grouping Variable

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Performance in FRICTION/ STOPPING DISTANCE (pre)	**Equal variances assumed**	.294	.588	**1.093**	**178**	**.276**	**.02972**	**.02719**	**.294**	**.588**
	Equal variances not assumed			1.088	171.460	.278	.02972	.02732		
Performance in FRICTION/ STOPPING DISTANCE (post)	**Equal variances assumed**	.078	.780	**.295**	**178**	**.769**	**.01249**	**.04239**	**.078**	**.780**
	Equal variances not assumed			.293	172.528	.770	.01249	.04255		
Performance in AIR RESISTANCE (pre)	**Equal variances assumed**	1.329	.250	**1.069**	**178**	**.287**	**.03344**	**.03128**	**1.329**	**.250**
	Equal variances not assumed			1.060	166.230	.291	.03344	.03155		
Performance in AIR RESISTANCE (post)	Equal variances assumed	7.704	.006	1.560	178	.121	.06502	.04168	7.704	.006
	Equal variances not assumed			**1.575**	**177.174**	**.117**	**.06502**	**.04127**		
Performance in UPTHRUST (pre)	**Equal variances assumed**	3.035	.083	**.749**	**178**	**.455**	**.02149**	**.02871**	**3.035**	**.083**
	Equal variances not assumed			.737	155.239	.462	.02149	.02915		
Performance in UPTHRUST (post)	**Equal variances assumed**	3.694	.056	**.994**	**178**	**.321**	**.04687**	**.04715**	**3.694**	**.056**
	Equal variances not assumed			1.002	177.779	.318	.04687	.04677		
Performance in STRETCH (pre)	**Equal variances assumed**	2.541	.113	**.786**	**178**	**.433**	**.02298**	**.02923**	**2.541**	**.113**
	Equal variances not assumed			.779	166.584	.437	.02298	.02948		
Performance in STRETCH (post)	**Equal variances assumed**	.139	.710	**.731**	**178**	**.466**	**.03832**	**.05245**	**.139**	**.710**
	Equal variances not assumed			.731	175.948	.466	.03832	.05244		

Performance in WEIGHT/GRAVITY (pre)	**Equal variances assumed**	.333	.564	**1.297**	**178**	**.196**	**.03119**	**.02405**	**.333**	**.564**
	Equal variances not assumed			1.297	175.874	.196	.03119	.02404		
Performance in WEIGHT/GRAVITY (post)	**Equal variances assumed**	1.564	.213	**.800**	**178**	**.425**	**.04125**	**.05158**	**1.564**	**.213**
	Equal variances not assumed			.803	177.724	.423	.04125	.05138		

Table 18: Nonparametric Correlations Investigating the Association between Group / Gender and the Understanding of Subtopics of P.E. in Pre- and Post-Trial Phases

Nonparametric Correlations

			Group	Gender
Spearman's rho	Performance in TRANSFER OF THE BALL (pre)	Correlation Coefficient	-.041	-.058
		Sig. (2-tailed)	.580	.442
		N	180	180
	Performance in TRANSFER OF THE BALL (post)	Correlation Coefficient	-.209**	.038
		Sig. (2-tailed)	.005	.608
		N	180	180
	Performance in AIR RESISTANCE (pre)	Correlation Coefficient	-.043	-.138
		Sig. (2-tailed)	.563	.065
		N	180	180
	Performance in AIR RESISTANCE (post)	Correlation Coefficient	-.222**	.056
		Sig. (2-tailed)	.003	.458
		N	180	180
	Performance in AEROBIC EXERCISE (pre)	Correlation Coefficient	-.054	-.066
		Sig. (2-tailed)	.472	.379
		N	180	180
	Performance in AEROBIC EXERCISE (post)	Correlation Coefficient	-.133	-.077
		Sig. (2-tailed)	.075	.303
		N	180	180
	Performance in FLEXIBILITY (pre)	Correlation Coefficient	.000	-.010
		Sig. (2-tailed)	1.000	.891
		N	180	180
	Performance in FLEXIBILITY (post)	Correlation Coefficient	-.127	.089
		Sig. (2-tailed)	.088	.233
		N	180	180
	Performance in ENERGY BALANCE/BMI (pre)	Correlation Coefficient	.130	-.051
		Sig. (2-tailed)	.082	.499
		N	180	180
	Performance in ENERGY BALANCE/BMI (post)	Correlation Coefficient	-.146	.062
		Sig. (2-tailed)	.051	.408
		N	180	180

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Table 19(a): Group Statistics for the 1st Set of Independent-Samples T-Tests with Group as the Grouping Variable

T-Test Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Performance in TRANSFER OF THE BALL (pre)	Experimental	90	.09	.286	.030
	Control	90	.07	.251	.026
Performance in TRANSFER OF THE BALL (post)	Experimental	90	.93	.251	.026
	Control	90	.79	.410	.043
Performance in AIR RESISTANCE (pre)	Experimental	90	.02	.148	.016
	Control	90	.01	.105	.011
Performance in AIR RESISTANCE (post)	Experimental	90	**.97**	.181	.019
	Control	90	**.83**	.375	.040
Performance in AEROBIC EXERCISE (pre)	Experimental	90	.06	.230	.024
	Control	90	.03	.181	.019
Performance in AEROBIC EXERCISE (post)	Experimental	90	**.94**	.230	.024
	Control	90	**.87**	.342	.036
Performance in FLEXIBILITY (pre)	Experimental	90	.03	.181	.019
	Control	90	.03	.181	.019
Performance in FLEXIBILITY (post)	Experimental	90	.98	.148	.016
	Control	90	.92	.269	.028
Performance in ENERGY BALANCE/ BMI (pre)	Experimental	90	.00	.000	.000
	Control	90	.03	.181	.019
Performance in ENERGY BALANCE/ BMI (post)	Experimental	90	.98	.148	.016
	Control	90	.91	.286	.030

Table 19(b): Results of the 1st Set of Independent-Samples T-Tests with Group as the Grouping Variable

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Performance in TRANSFER OF THE BALL (pre)	**Equal variances assumed**	**1.235**	**.268**	**.554**	**178**	**.580**	**.022**	**.040**	**-.057**	**.101**
	Equal variances not assumed			.554	174.995	.580	.022	.040	-.057	.101
Performance in TRANSFER OF THE BALL (post)	Equal variances assumed	37.860	.000	2.849	178	.005	.144	.051	.044	.244
	Equal variances not assumed			**2.849**	**147.357**	**.005**	**.144**	**.051**	**.044**	**.245**
Performance in AIR RESISTANCE (pre)	**Equal variances assumed**	**1.353**	**.246**	**.580**	**178**	**.563**	**.011**	**.019**	**-.027**	**.049**
	Equal variances not assumed			.580	160.681	.563	.011	.019	-.027	.049
Performance in AIR RESISTANCE (post)	Equal variances assumed	45.107	.000	3.041	178	.003	.133	.044	.047	.220
	Equal variances not assumed			**3.041**	**128.187**	**.003**	**.133**	**.044**	**.047**	**.220**
Performance in AEROBIC EXERCISE (pre)	**Equal variances assumed**	**2.099**	**.149**	**.720**	**178**	**.472**	**.022**	**.031**	**-.039**	**.083**
	Equal variances not assumed			.720	168.377	.472	.022	.031	-.039	.083
Performance in AEROBIC EXERCISE (post)	Equal variances assumed	13.676	.000	1.790	178	.075	.078	.043	-.008	.164
	Equal variances not assumed			**1.790**	**156.008**	**.075**	**.078**	**.043**	**-.008**	**.164**
Performance in FLEXIBILITY (pre)	**Equal variances assumed**	**.000**	**1.000**	**.000**	**178**	**1.000**	**.000**	**.027**	**-.053**	**.053**
	Equal variances not assumed			.000	178.000	1.000	.000	.027	-.053	.053
Performance in FLEXIBILITY (post)	Equal variances assumed	12.537	.001	1.714	178	.088	.056	.032	-.008	.120
	Equal variances not assumed			**1.714**	**138.389**	**.089**	**.056**	**.032**	**-.009**	**.120**

Performance in ENERGY BALANCE/BMI (pre)	Equal variances assumed	13.168	.000	-1.752	178	.082	-.033	.019	-.071	.004
	Equal variances not assumed			**-1.752**	**89.000**	**.083**	**-.033**	**.019**	**-.071**	**.004**
Performance in ENERGY BALANCE/BMI (post)	Equal variances assumed	16.760	.000	1.962	178	.051	.067	.034	.000	.134
	Equal variances not assumed			**1.962**	**133.549**	**.052**	**.067**	**.034**	**-.001**	**.134**

Table 20(a): Group Statistics for the 2nd Set of Independent-Samples T-Tests with Gender as the Grouping Variable

T-Test Group Statistics

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Performance in TRANSFER OF THE BALL (pre)	Male	85	.09	.294	.032
	Female	95	.06	.245	.025
Performance in TRANSFER OF THE BALL (post)	Male	85	.85	.362	.039
	Female	95	.87	.334	.034
Performance in AIR RESISTANCE (pre)	Male	85	.04	.186	.020
	Female	95	.00	.000	.000
Performance in AIR RESISTANCE (post)	Male	85	.88	.324	.035
	Female	95	.92	.279	.029
Performance in AEROBIC EXERCISE (pre)	Male	85	.06	.237	.026
	Female	95	.03	.176	.018
Performance in AEROBIC EXERCISE (post)	Male	85	.93	.258	.028
	Female	95	.88	.322	.033
Performance in FLEXIBILITY (pre)	Male	85	.04	.186	.020
	Female	95	.03	.176	.018
Performance in FLEXIBILITY (post)	Male	85	.93	.258	.028
	Female	95	.97	.176	.018
Performance in ENERGY BALANCE/BMI (pre)	Male	85	.02	.152	.017
	Female	95	.01	.103	.011
Performance in ENERGY BALANCE/BMI (post)	Male	85	.93	.258	.028
	Female	95	.96	.202	.021

Table 20 (b): Results of the 2nd Set of Independent-Samples T-Tests with Gender as the Grouping Variable

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Performance in TRANSFER OF THE BALL (pre)	**Equal variances assumed**	**2.398**	**.123**	**.771**	**178**	**.442**	**.031**	**.040**	**-.048**	**.110**
	Equal variances not assumed			.763	164.096	.446	.031	.041	-.049	.111
Performance in TRANSFER OF THE BALL (post)	**Equal variances assumed**	**1.054**	**.306**	**-.513**	**178**	**.608**	**-.027**	**.052**	**-.129**	**.076**
	Equal variances not assumed			-.511	171.669	.610	-.027	.052	-.130	.076
Performance in AIR RESISTANCE (pre)	Equal variances assumed	14.812	.000	1.854	178	.065	.035	.019	-.002	.073
	Equal variances not assumed			**1.753**	**84.000**	**.083**	**.035**	**.020**	**-.005**	**.075**
Performance in AIR RESISTANCE (post)	**Equal variances assumed**	**2.225**	**.138**	**-.744**	**178**	**.458**	**-.033**	**.045**	**-.122**	**.055**
	Equal variances not assumed			-.737	166.843	.462	-.033	.045	-.123	.056
Performance in AEROBIC EXERCISE (pre)	**Equal variances assumed**	**3.157**	**.077**	**.882**	**178**	**.379**	**.027**	**.031**	**-.034**	**.088**
	Equal variances not assumed			.868	153.888	.387	.027	.031	-.035	.089
Performance in AEROBIC EXERCISE (post)	Equal variances assumed	4.383	.038	1.033	178	.303	.045	.044	-.041	.132
	Equal variances not assumed			**1.045**	**175.919**	**.297**	**.045**	**.043**	**-.040**	**.131**
Performance in FLEXIBILITY (pre)	**Equal variances assumed**	**.076**	**.783**	**.138**	**178**	**.891**	**.004**	**.027**	**-.049**	**.057**
	Equal variances not assumed			.137	173.230	.891	.004	.027	-.050	.057
Performance in FLEXIBILITY (post)	Equal variances assumed	5.880	.016	-1.197	178	.233	-.039	.033	-.103	.025
	Equal variances not assumed			**-1.173**	**145.929**	**.243**	**-.039**	**.033**	**-.105**	**.027**

Performance in ENERGY BALANCE/BMI (pre)	**Equal variances assumed**	**1.851**	**.175**	**.677**	**178**	**.499**	**.013**	**.019**	**-.025**	**.051**
	Equal variances not assumed			.663	144.632	.508	.013	.020	-.026	.052
Performance in ENERGY BALANCE/BMI (post)	**Equal variances assumed**	**2.785**	**.097**	**-.830**	**178**	**.408**	**-.028**	**.034**	**-.096**	**.039**
	Equal variances not assumed			-.819	158.814	.414	-.028	.035	-.097	.040