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# THE IMPACT OF MATH MANIPULATIVES AS A MULTISENSORY TEACHING TECHNIQUE ON STUDENTS' STATISTICS PERFORMANCE AT A SOUTH AFRICAN UNIVERSITY

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**ABSTRAK**

Banyak mahasiswa dalam ilmu sosial memiliki sikap negatif terhadap mata kuliah statistik, yang seringkali terlalu kaku, abstrak, dan menggunakan pendekatan pengajaran yang mengambil banyak kesenangan dari pembelajaran. Banyak penelitian telah menunjukkan bahwa otak manusia belajar dan bekerja lebih baik dalam situasi di mana informasi terintegrasi di beberapa modalitas sensorik. Penelitian juga menunjukkan bagaimana pendekatan pengajaran multisensori penting dalam pembelajaran bahasa dan literasi, serta untuk anak-anak dengan ketidakmampuan belajar seperti disleksia. Selain itu, banyak penelitian telah menunjukkan bagaimana matematika manipulatif berkontribusi pada pengalaman siswa dengan memberi mereka pengalaman belajar langsung dan konkret. Saat ini, tampak terdapat kekurangan penelitian yang menggabungkan matematika manipulatif sebagai teknik pengajaran multisensori dalam mata kuliah pengantar statistika. Tujuan dari penelitian ini adalah untuk mengetahui apakah penggunaan matematika manipulatif sebagai teknik pengajaran multisensori berdampak pada prestasi akademik mahasiswa pada mata kuliah Statistik II di Universitas Afrika Selatan. Sebuah desain *posttest pretest* non-ekuivalen digunakan untuk melihat apakah kinerja *posttest* siswa dengan strategi pengajaran multisensori (dalam Statistik II) berbeda dari siswa yang menerima pengajaran tradisional (dalam Statistik Bisnis). Hasil penelitian menunjukkan bahwa siswa yang diberikan teknik pengajaran multisensori menggunakan matematika manipulatif mencapai nilai Statistik II yang lebih tinggi ($\mu = 70.18$) dibandingkan siswa yang diajar melalui pengajaran tradisional ($\mu = 56.56$). Studi ini memiliki implikasi yang signifikan pada pendidikan, khususnya untuk statistik pengantar dan probabilitas.

**Kata kunci:** siswa yang beragam, pengajaran multisensori, matematika manipulatif, statistika.

**ABSTRACT**

Many students in social sciences have negative attitudes towards statistics courses, which are often excessively rigid, abstract, and employing teaching approaches that take much of the fun out of learning. A great deal of research has shown that the human brain learns and performs better in situations where information is integrated across several sensory modalities. Research also shows how multisensory teaching approaches are valuable in the learning of language and literacy, as well as for children with learning disabilities like dyslexia. Furthermore, many research studies have pointed out how math manipulatives contribute to students' experiences by providing them with hands-on and concrete learning experiences. Currently, there seems to be a lack of research that incorporates math manipulatives as a multisensory teaching technique in introductory statistics courses. The purpose of this research is to investigate whether the use of math manipulatives as a multisensory teaching technique has an impact on students' academic performance in *Statistics II* at a South African university. A non-equivalent pretest posttest design was employed to see if the posttest performance of students exposed to the multisensory teaching strategy (in *Statistics II*) differed from that of students who received traditional instruction (in *Business Statistics*). The results of the study showed that students who were exposed to the multisensory teaching technique using math manipulatives achieved higher scores in *Statistics II* ($\mu$ = 70.18) than the students who were taught through traditional instruction ($\mu$ = 56.56). The study has significant implications on education, specifically for introductory statistics and probability.

**Keywords:** diverse students, multisensory teaching, math manipulatives, statistics

## INTRODUCTION

Although South Africa has adopted an inclusive education policy to overcome learning difficulties in the school system, its implementation is hampered by a lack of teacher skills and experience in adapting the curriculum to accommodate a diverse range of learning abilities (Dalton, Mckenzie, and Kahonde, 2012). "With students enrolling at universities in larger number than ever before, classrooms are becoming less interactive as teachers most frequently lecture students on the necessary material and provide worksheets to drill content" (Stoffers, 2011, p. 5). Introductory Statistics as a learning area at universities is no exception. Students of social sciences often dislike statistics and are unable to exploit statistics adequately (Prayoga & Abraham, 2017). Apart from students' unfavorable attitudes and concern regarding statistics, many university statistics courses are frequently criticized for being too rigid and abstract, as well as for employing teaching techniques that take much of the fun out of learning (Garfield & Ahlgren, 1988; Hogg, 1991; Willet and Singer, 1992; Ramsey, 1999; Tremblay, Gardner, and Heipel, 2000; Onwuegbuzie and Wilson, 2003; Wilson, 2013; Touchton, 2015; Kranzler, 2017). When students are introduced to new statistical concepts, they are expected to understand the content. However, not all students will be able to comprehend key statistical concepts at the same time (Kamii and Rummelsburg, 2008). As a result, education institutions bear a greater responsibility to successfully teach students with diverse learning styles using inclusive education approaches. Teachers must therefore find new strategies to reach each and every student in the classroom and assist them in understanding and mastering new educational content.

"Because of statistics' high-level abstractness", Katai and Toth (2010, p. 245) suggests the use of "multisensory teaching approaches". According to Stoffers (2011, p. 4), "multisensory education focuses on a variety of teaching strategies that appeal to different type of learners". The multisensory approach, as the name implies, maximizes the use of the many senses, particularly integrating seeing, hearing, and feeling. "Multisensory techniques allow many students, by assimilation, to grasp elusive concepts and keep up with their peers" (Rains, Kelly, and Durham, 2008, p. 239). Furthermore, students perform statistically better when they are taught in a way that appeals to their own learning style (Kritsonis, 1997). According to Rains, Kelly, and Durham (2008, p. 241), "multisensory supplements, such as math manipulatives, support the child's use of visual, tactile, and/or auditory interactions with the material".

Research shows that multisensory teaching and learning approaches are very beneficial for children, as well as students, with learning disabilities such as dyslexia. Although multisensory teaching techniques have proven to be highly effective in language and literacy acquisition, as well as teaching students with learning disabilities, little is known about its contingent efficiency in introductory statistics courses. Currently, there seems to be a lack of research that incorporates math manipulatives as a supplementary multisensory teaching technique in introductory statistics courses. The research on which this article is based, attempts to provide a possible solution for filling this gap and to make available to novice and experienced lecturers a concrete hands-on technique which may contribute to students' learning in a statistics-related subject. As such, the primary objective of this study is to investigate if the use of math manipulatives as a multisensory teaching technique may improve students' academic performance in the *Statistics II* module at a South African institution. To shed light on the problem statement, the following research question was set:

> *Are the posttest scores of students (Statistics II) who received the multisensory teaching, with math manipulatives, any different from those of students who received traditional instruction (Business Statistics) at a South African university?*

In order to address the research problem, the following research hypotheses were tested:

$H_0$: The posttest score in *Statistics II* is equal to the posttest score in *Business Statistics.*

$H_1$: The posttest score in *Statistics II* is different than the posttest score in *Business Statistics*.

The significance of this study is twofold. Firstly, the study advances teaching and learning in higher education as it considers both a multisensory teaching approach as well as math manipulatives as a supplementary technique in the teaching and learning of a statistics related subject at a South African university. Multisensory teaching is an effective method of instruction, especially for students with diverse learning styles and who struggle with the high degree of abstraction seen in introductory statistics courses. Math manipulatives contributes to students' experiences by providing them with hands-on and concrete learning experiences. By supplementing students' multisensory instruction with math manipulatives, student's use of visual, tactile and auditory interactions are supported. It is feasible to attain both affective and cognitive engagement by designing interactive courses that appeal to all learners through their senses.

Secondly, the study seeks to add to the body of literature by investigating whether the use of math manipulatives as a multisensory teaching technique could positively affect student's academic performance in a statistics-related subject at a South African university. Facilitating the use of a multisensory teaching intervention will provide insight into current practice, which could help to determine future initiatives. The results of this research should be of wide interest and can offer some broad guidelines to other academics at higher education institutions in South Africa on how to make the most of math manipulatives as a multisensory teaching supplement technique so that students can benefit from and enjoy it. The challenges posed by statistics education is a great concern worldwide. As such, an international audience may also benefit from the findings of this research. The findings are based on a quantitative study conducted at the Central University of Technology, Free State. The results of this study confirm the need to inorporate maths manipulatives as a multisensory teaching technique in introductory statistics courses, which can both make a significant contribution to higher education in South Africa, as well as globally.

## REVIEW OF LITERATURE

Although most people use five senses to interact with the world around them, they process information in distinct ways (Taljaard, 2016). Joshi, Dahlgren, and Boulware-Gooden (2002) explain multisensory education as an "instructional method which uses visual, auditory, kinaesthetic and tactile ways to educate students" (Taljaard, 2016, p. 48). This "involves teaching through hearing and speaking, seeing and perceiving, and touch, movement and action" (Taljaard, 2016, p. 48). A common thread among researchers is the belief that educators need to include at least three basic learning modalities in each presentation to meet the needs of most students (Saswandi, 2014; Pavlidou & Bogearts, 2019; Yunus, Tawil, Muhiddin, Muhidden & Alim, 2021). According to Obaid (2013, p. 77), "these modalities have different capacities for memory storage; while the verbal modality is limited, the visual modality is nothing short of phenomenal." Jones, Jones, and Jones (2000) contend that the visual modality appears to be capable of providing immediate comprehension almost effortlessly - thus the following saying: "A picture is worth a thousand words." Auditory learners mostly need to hear themselves speak what they are learning. According to Jubran (2012, p. 51), kinesthetic refers to "perceiving through touch and an awareness of body movements." These students need to be able to learn by using their hands. They create meaning by rearranging or manipulating items that represent the concepts they are learning.

In education, the belief that learning through all senses is beneficial in reinforcing memory has come a long way (Jubran, 2012, p. 51; Shams & Seitz, 2008). Permanent memory, according to scientists, is retained in the form of imagens, which are made up of mental images, smell, taste, and kinesthetic experiences (Ewy, 2003). Suryaratri, Prayitno, and Wuryani (2019) assert that the human brain functions optimally when the information it receives is integrated across multiple sensory modalities. From the first teaching guides, educators have adopted a variety of multisensory approaches to make learning richer and more engaging for students (Montessori, 1912). As mentioned earlier, research have demonstrated the benefits of multisensory learning for young children and children with learning difficulties such as dyslexia (Kast, Meyer, Vogeli, Gross, & Jancke, 2007). Thorton, Jones, and Toohey (1983) investigated the implementation of a multisensory teaching program on grade two through to grade six students' learning. The program incorporated visual learning through pictures. "The majority of students showed marked improvements from the pretest to the posttest. Also, students retained their knowledge of the concepts after a three-week period, although these students had not reviewed the information before the follow-up test" (Jubran, 2012, p. 53). Other research investigated the effect that multisensory approaches have on reading skills (Celik Korkmaz and Karatepe, 2018; Suryaratri, Prayitno, & Wuryani, 2019). In one study, Jubran (2012, p.54) found that "first grade children at special education level improved enough in their reading abilities to advance them out of the special education level". Multisensory learning approaches have also been shown to aid in the mastery of a foreign language (Turner, 2018).

Although multisensory approaches are particularly effective in the learning of language and literacy, it's effectiveness has also been shown in higher education setting for students with visual disabilities (Fernandez, Ocampo, Costantino, & Dop, 2019) as well as students' reading achievement (Syahputri, 2019). Recent research indicates that multisensory teaching also provides opportunities for learning in students without speech and language disorders (Morgen, 2019). The success of the Making Math Real curriculum is a good example of how multisensory approaches may have a positive impact on the teaching-learning process on all levels (Berg and Knop, 2008). With regard to mathematics as a teaching and learning discipline, Obaid (2013) employed a multisensory teaching method on students in grade six with learning disabilities with regard to their mathematics achievement in Jordanian public schools. To assess students' mathematical achievement, a pre/posttest was constructed. The experimental students were taught the multisensory method, whereas the control students used the traditional method. The study's findings revealed a statistically significant difference in posttest scores between the experimental and control groups of students.

**Traditional teaching vs multisensory teaching**

According to Douglas, Burton and Reese-Durham (2008), direct instruction has been summarised as rigorous drill and practice for the information of a content area. Learning is taught and controlled by the teacher under this approach, and it is sometimes compared to a "banking process," in which teachers solely impart knowledge to students rather than offering them opportunities to express their creativity or make use of their abilities (Hoerr, 2002). Many classrooms, according to Skoning (2010), seem to become teacher-directed instead of constructivist.

Multisensory education, on the other hand, is a technique that allows instructors to include interaction within student-centered lectures. The learning theories of Piaget, Bruner, and Vygotsky support the use of multisensory teaching techniques (Rains, Kelly, and Durham 2008, p. 241). Bruner (1973), a prominent constructivist advocate, argues that the child should be an active participant in the learning process and that learning should entail hands-on activities. Bruner (1973) believes that a child's development is responsive to his or her learning environment. What important is that the appropriate presentation technique is utilized to help a student move through the various stages of learning. According to Rains, Kelly, and Durham (2008, p. 241), “multisensory approaches can facilitate development in general and math in specific by providing tools for the students to relate to until they fully embrace the concept”.

Table 1 summarises the difference between traditional teaching and the multisensory teaching approach that was followed in the study.

Table 1. Traditional Teaching vs The Multisensory Teaching Approach

| Traditional method of teaching | The multisensory teaching approach |
|---|---|
| • Lecture-centered fashion<br>• Students make use of visual and auditory senses<br>• Students do not use math manipulatives<br>• The teacher holds all the power<br>• Students do activities from the prescribed textbook by modelling from the textbook.<br>• Students work on their own in a non- collaborative setting.<br>• Students are passive recipients of knowledge. | • Student-centered classroom<br>• Students are learning with math manipulatives, which involve all three modalities of learning<br>• Students share power and learn about their own capabilities.<br>• Students are encouraged to question learning content and to think critically.<br>• Students are self-regulated learners.<br>• Students are responsible for their own learning and participate actively in classes. |

Direct instruction was given to students in the control group, which comprised teacher-directed lectures, note-taking, and worksheet practice problems. Students in the experimental group received multisensory instruction and were taught with math manipulatives, such as playing with a dice, cards and coloured balls, when introducing probability concepts in statistics.

## Manipulatives in math: a specific type of multisensory tool

Math manipulatives can be defined as "any concrete, physical object used by teachers for math instruction with the purpose of helping students understand abstract math" (Zandakis, 2019, p. 8; Liggett, 2017). The history of manipulatives dates back since ancient times, where people used physical objects to help them solve everyday math problems. "The Romans, for example, created the first abacus based on counting board. The abacus was made of beans or stones which moved in grooves in sand or on tables of wood, stone, or metal" (Boggan, Harper, and Whitmire, 2010, p. 2).

Educational research indicates that "the most valuable learning occurs when students actively construct their own mathematical understanding, which is often accomplished through the use of manipulatives" (Boggan, Harper, and Whitmire, 2010, p. 2). According to Carbonneau and Marley (2012), math manipulative-based teaching strategies are methods that allow students to physically interact with objects in order to acquire specific information. "Manipulatives are often used to introduce, practice, or remediate a math concept" (Boggan, Harper, and Whitmire, 2010, p. 2). Researchers such as Piaget emphasize the use of experiential materials in assisting learning. According to Piaget (1952), children lack the mental maturity to comprehend abstract mathematical concepts conveyed solely in words or symbols. Therefore they need experiences with concrete materials and drawings for learning to occur, "where the term concrete refers to physical objects that students can grasp with their hands" (Sarama and Clements, 2009, p. 146). The assumption, according to Campbell, Campbell, and Dickinson (1999), is that students who can see and manipulate objects in their own surroundings would learn in ways that students who simply read and listen to lectures will not be able to accomplish. Obaid (2013, p. 78) argues that "when students can manipulate and experience conceptual information through activities, only then, will they learn and retain information more readily." "By actively manipulating these materials, learners are developing a repertoire of images that can be used in the mental manipulation of abstract concepts" (Moyer, 2001, p. 176). Although abstract concepts can be recited, they are not really grasped until imagery is elicited (Evy, 2003). Imagery is what helps us understand and recall information. Visual stimulation is thus necessary for learning since comprehension necessitates it. According to Stein (2009), "visual aids can improve learning up to 400%.". Ramsey (1999, p. 3) stresses the importance of "illustrating random outcomes through a variety of physical mechanisms". For example, the instructor can throw a dice in front of students so they can directly observe the outcomes. Ball (1992, p. 16) argues that "whether termed manipulatives, concrete materials, or concrete objects, physical materials are widely touted as crucial to the improvement of mathematics learning" and "can make even the most difficult mathematical concepts easier to understand" (Kennedy and Tipps, 1994, p. 71). With regard to statistics and probability, a few suggested examples include coins, a deck of cards, a dice or coloured balls to illustrate concepts.

For more than a decade, the use of manipulatives in mathematics has become very prominent. Many research studies have pointed out the importance of using manipulatives in teaching mathematics (Carbonneau, Marley, & Selig, 2013; Furner & Worrell, 2017, Vang, 2017) and how manipulatives could enrich the student's learning experience and help teachers narrow the gap between concrete and abstract concepts in mathematics (Suydam and Higgins, 1977; Parham, 1983; Suydam, 1985; Raphael and Wahlstrom, 1989; Sowell, 1989; Pham, 2015; Ligett, 2017). For example, Ligett (2017) showed that students who received math intervention with math manipulatives obtained higher posttest scores in comparison to their classmates who have not. Several studies showed that students who use manipulatives during mathematics instruction outperform students who do not (Suydam and Higgins, 1977; Greabell, 1978; Driscoll, 1980; Raphael and Wahlstrom, 1989; Sowell, 1989). Furthermore, "the increase in performance seems to be evident in all grade levels, ability levels, as well as topics" (Obaid 2013, p. 78). In addition to increased performance, students' attitudes toward mathematics improved when they were taught with concrete objects.

A review of the literature demonstrates unequivocally that educators who effectively target more than one sense in every lesson are likely to have a greater percentage of student comprehension than educators who do not depend on the potential of multisensory teaching. Furthermore, the use of math manipulatives in the teaching and learning of mathematics shows promising results. With regard to statistics education, the study of Ma, Karkelanova, and Rayens (2018) shed some light of whether there are any differences between the use of virtual manipulatives and physical manipulatives in learning outcomes of undergraduate statistics students. The findings of their study revealed that, whether using virtual or physical manipulatives, students' statistics performance had a positive impact on their Grade Point Average one year later. However, little is known about the effect of concrete or physical math manipulatives in the teaching and learning of introductory statistics courses.

## METHODOLOGY

### Research design

The study investigated whether the use of math manipulatives as a multisensory teaching technique could have a positive effect on the academic performance of students in the module *Statistics II* at a South African university. In order to investigate whether there was a difference in the posttest performance of *Statistics II* students who received the multisensory teaching strategy and the students in *Business Statistics*, who received only traditional instruction, the researcher utilised a quasi-experimental approach. The following hypotheses were tested to answer the research question.

$H_0$: The posttest score in *Statistics II* is equal to the posttest score in *Business Statistics.*

$H_1$: The posttest score in *Statistics II* is different than the posttest score in *Business Statistics*.

Numerical data from both tests were used to assess the performance of students in the statistics modules. Traditional instruction in this study referred to one-way teaching or direct instruction as explained previously (Table 1).

### Population

The study endeavor included all 98 third-year CUT students enrolled in the National Diploma in Cost and Management Accounting and Internal Auditing. Students who were enrolled for these diplomas took *Business Statistics (BSS22AB) and Statistics II (STC22AB)* as a compulsory module. The researcher used a non-probability sampling approach since the participants were not chosen at random. The researcher used convenience sampling "as the subjects were available and formed part of the lecturer's classes" (McMillan and Schumacher, 2006, p. 125).

The study followed a "non-equivalent pretest posttest control group design involving an experimental group and a control group" (Leedy and Ormrod 2001, p. 236). The experimental group of students (n = 55) was enrolled for the National

Diploma Internal Auditing and took *Statistics II*. They received multisensory instruction. The students (n = 43) who took *Business Statistics* were enrolled for the National Diploma in Cost and Management Accounting served as the control group and received traditional instruction.

Both groups got the same academic instruction (although through different teaching techniques) and used the same instructional material, which was the module's prescribed textbook. Over the course of 12 weeks, students from both groups attended two theory lectures twice a week. Each theory lecture took an hour and a half. Students from both groups were assessed at the same time, on the same day, and at the same location. The same test was also given to both groups. In terms of age, color, and gender, both groups were equal.

**Data collection method**

The quantitative paradigm was used for this study because it included the systematic collection of measurable data. The quantitative data was obtained using two self-developed instruments (pretest and posttest) intended to generate highly reliable and valid scores in order to evaluate the effect of the multisensory teaching method on students' academic performance in the module *Statistics II*.

The pre- and posttest was written during the end of July and September. The researcher administered the pretest to both groups of students before the multisensory teaching strategy intervention. The pretest consisted of 25 multiple-choice questions, each with five options, which were collected from the specified textbook from which students were required to work from. The pretest focussed on introductory statistical calculations and was used to examine if both groups were similar initially.

Following the pretest, the experimental group of students received multisensory instruction, while the control group received traditional instruction. Eight weeks after the intervention began, the students were tested again (posttest). The second posttest was a test paper with 25 multiple-choice items and focussed on elementary probability. The pretest and posttests were administered to all students on the same day and at the same time.

To ensure content validity, the researcher included only selected questions from the prescribed textbook that are significant to a certain topic domain. Generalisation was a threat to the external validity of this research, as the study was done at a single University of Technology (the CUT) and no randomisation was utilised. As such, the findings may not be applicable to all statistics students at other institutions (Saunders, Lewis, and Thornhill, 2003). Participants agreed to participate in the study willingly and were assured that all data would be kept confidential.

**Statistical techniques and analysis of data**

The purpose of the study is to investigate whether the use of math manipulatives as a multisensory technique supplement could have a positive effect on students' academic performance in *Statistics II* at a South African university. The independent variable in this study was identified as the multisensory teaching strategy. The posttest scores of students' performance in the modules *Statistics II* and *Business Statistics* served as the dependent variable. Test results in the statistics module were used to assess students' performance.

To address the research questions, descriptive statistics (means and standard deviations) were utilized to assist explain and allow reflection on the pretest and posttest performance of the two groups of participants. The *t*-test for independent samples was conducted to determine whether a statistically significant difference exists between the two groups of students.

**RESULTS AND DISCUSSION**

Before the test scores were analysed, both groups of students were tested for equivalence. Both groups were African, had a mean age of 25 years and were equivalent with regard to gender ($p = 0.68$)

**Analysis of the pretest and the posttest**

A summary of students' academic performance in the pretest and posttest in the modules *Business Statistics* and *Statistics II* are presented.

Table2. Descriptive Statistics of the Pretest and Posttest for the Experimental and Control Group of Students

| | Group | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| PreTest | Control | 43 | 68.84 | 9.54 | 1.46 |
| | Experimental | 55 | 67.87 | 14.69 | 1.98 |
| PostTest | Control | 43 | 56.56 | 19.36 | 2.95 |
| | Experimental | 55 | 70.18 | 13.32 | 1.80 |

The pretest focussed on introductory statistical calculations and was used to examine if both groups were similar at baseline. The control group consisted of 43 students and received traditional instruction in the module *Business Statistics*. The experimental group consisted of 55 students and received the multisensory instruction after the pretest. An independent sample *t*-test was performed to compare the pretest means between the two groups of students (68.84 for the control group versus 67.87 for the experimental group). The results of the independent sample *t*-test in SPSS showed no significant difference between the pretest performance of both groups of students ($t$ = 0.373, $df$ = 96, $p$ = 0.710). This indicates that both groups were equivalent at baseline before the intervention. An independent sample *t*-test was performed to determine if the posttest score of the control group (56.56) was significantly different that the posttest score of the experimental group (70.18). The posttest focussed on elementary probability and involved more conceptual understanding than the pretest. Furthermore, the control group of students did not receive instruction with math manipulatives. This may explain why students in the control group did worse in the posttest than the experimental group of students. The results of the test showed a significant difference between the two groups of students ($t$ = -4.120, $df$ = 96, $p$ = 0.00008). As such, the null hypothesis is rejected and it can be concluded that there was a significant difference in posttest scores between the experimental and control group of students. The difference indicates that the Multisensory Teaching approach that was supplemented with math manipulatives may have had a positive impact on student’s academic achievement in the module *Statistics II*.

Although it was not part of the main research question, the researcher was curious to see whether students retained their knowledge by testing their immediate comprehension when taught with math manipulatives. The researcher administered a small test to the participants in both groups immediately after the first lecture the day the teaching strategy intervention started. On that specific day, only a few students from both groups attended class. The researcher selected the pretest scores for only those students who attended class that day from the list of pretest scores. The results of the class test then served as the posttest. As students were not aware of the test, the test did not contribute to their course mark, and was only used for research purposes. This test covered only one chapter about basic probability concepts and comprised 10 questions about elementary probability.

Table 3. Descriptive Statistics for the Pretest and Posttest of the Experimental and Control group directly after the intervention

| | Group | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| PreTest | Control | 26 | 69.73 | 9.61 | 1.88 |
| | Experimental | 44 | 69.86 | 11.52 | 1.74 |
| PostTest | Control | 26 | 38.46 | 19.17 | 3.76 |
| | Experimental | 44 | 50.34 | 12.36 | 1.86 |

Table 3 shows that the control group consisted of 26 students who attended class that day, while 44 students in the experimental group attended the lecture. An independent sample *t*-test was performed for comparing the pretest means (69.73 for the control group versus 69.86 for the experimental group). The results of the independent sample *t*-test in SPSS showed no significant difference with regard to the pretest scores between the two groups of students ($t = -0.052$, $df = 68$, $p = 0.959$). Since $p > 0.05$, there was no significant difference between the control group of students and the experimental group of students with regard to the pretest. In other words, these two groups were assumed equivalent before the demonstration with math manipulatives in class. The control group of students had an average mean score of 38.46, while the experimental group of students had an average mean score of 50.34. The posttest was written directly after the lesson with math manipulatives and students did not study for the test. This may explain the overall low scores with regard to the posttest. Students who received multisensory instruction did much better in the posttest than students who received traditional instruction. The results of the independent sample *t*-test in SPSS showed a significant difference between the experimental and control groups' performance on the posttest ($t$ = -3.155, $df$ = 68, $p$ = 0.002). This difference indicates that the multisensory teaching approach that was supplemented with math manipulatives may have had a positive impact on student's academic achievement in the module *Statistics II*.

## CONCLUSION

Research point out that multiple representations, which include visual, auditory, as well as kineasthetic modalities are beneficial in the learning of mathematics. The multisensory teaching approach employed in this study focused on the introduction of math manipulatives to explain statistical concepts. The research question of the study was:

*Are the posttest scores of students (Statistics II) who received the multisensory teaching, with math manipulatives, any different from those of students who received traditional instruction (Business Statistics) at a South African university?*

After analysing the data, it was discovered that students who received the multisensory teaching strategy, supplemented with math manipulatives, performed significantly better in the posttest ($\mu$ = 70.18) than students who received only traditional instruction ($\mu$ = 56.56). The results of the independent *t*-test showed a significant difference in the posttest scores between two groups of students ($t$ = -4.120, $df$ = 96, $p$ = 0.00008).

The findings of this study support previous research that shows educators who effectively target more than one sense in every lesson have a higher percentage of student comprehension than teachers who do not harness the potential of multisensory education. What was also interesting is the results of the class test directly after the multi-strategy teaching intervention was implemented. Students who were taught with math manipulatives ($\mu$ = 50.34) outperformed students who were not shown this strategy in class ($\mu$ = 38.46). The independent t-test confirmed a significant difference in the posttest scores between the two groups ($t$ = -3.155, $df$

= 68, $p$ = 0.002). The posttest results confirm previous research findings that the visual modality seems capable of producing immediate comprehension almost effortlessly (Jones, Jones, and Jones, 2000; Jubran, 2012). As students did not review or studied the information before the test, it seems that the experimental group retained their knowledge. This finding correlate with research done by Rains, Kelly, and Durham 2008, p. 247).

A limitation of this study was the small sample size. Only 98 students participated in this study. Therefore, the findings of this study may not be generalised to all statistics students at other universities.

Statistics lecturers are encouraged to present abstract statistical concepts to students through all three modalities: auditory, visual, and tactile. The positive results that emanated from this research can provide other lecturers with one more teaching technique, which in turn will allow them to meet the diverse needs of all students who study introductory statistics at universities. Educators should be aware of studies demonstrating the benefits of multisensory instruction as well as math manipulatives, and they should be encouraged to implement this creative teaching technique in their own introductory statistics classes.

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