STATISTICS & PROBABILITY EDUCATION IN SOUTH AFRICA: CONSTRAINTS OF LEARNING

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Abstract

The purpose of this empirical study was to investigate the difficulties of learning statistics and probability amongst students pursuing Postgraduate Certificate of Education (PGCE) programme in University of Fort Hare in South Africa.
The approach was a mixed method, sampling 43 students, in which case a quantitative analysis (RM-ANOVA, RM-MANOVA & ANCOVA) dominated to test four propositions.
The findings revealed four conclusions: (1) students receiving deliberate instruction in how to solve problems do become better and are able to 'think statistically' (2) there was good reason to suggest that students' level of specific mathematics skills impact on their statistical ability (3) in contrast, there was not enough supporting evidence to suggest that students' intuitive notions of probability does get stronger with age and lastly (4) efficacy of computers in guiding design of instruction is an important component of statistical learning.
Most important implication of the study was that the use of strategies to improve students' rational number concepts and ratio/proportion reasoning assists to recognise and confront common errors in students' statistical and probability thinking.
Key words: *statistics, probability, mathematics learning, South African education.*

1. Background of the Study

The purpose of this empirical study was to investigate the difficulties of learning statistics and probability (S&P) amongst students pursuing Postgraduate Certificate of Education (PGCE) programme in University of Fort Hare in South Africa.The PGCE is a one-year course in only the department of education in the University of Fort Hare. Generally in South African education, a PGCE course mainly focuses on developing teaching skills, and not on the subject a candidate teacher intends to teach. For this reason, the candidate teacher is expected to have a good understanding of a chosen subject(s), but mathematics compulsory – usually to degree level – before starting training. The study discusses the nature of the discipline in South Africa; which subsequently necessitated the test of four hypotheses. But, first the general consensus regarding learning and for that matter teaching of S & P is as discussed.

Following the inception of the Revised National Curriculum Statement-RNCS (2002) for mathematics, there has been a growing concern to improve learning and teaching of S & P in both General Education Training (GET) and Further Education Training (FET) bands, as part of basic literacy in mathematics in South African education. One of the main reasons as authors (North & Zewotir, 2006:1) maintained is that it can:

> …be attributed to the fact that statistics virtually played no role in the South African school education system at that time. The Associated Mathematics Teachers of South Africa (AMESA) and the South African Statistical Association (SASA) independently held annual seminars, workshops, think tanks and conferences with no interaction between them. It was only in 1998, when South Africa won the bid to host the Sixth International Conference on the Teaching of Statistics (ICOTS-6), that the Education committee of SASA was tasked with reaching out to AMESA, with the intention of including school teachers in some of the proposed ICOTS-6 initiatives. The hosting of ICOTS-6 in South Africa thus dove-tailed beautifully with introduction of statistics into the school curriculum as national and international attention was focused on this initiative.

Ironically, although many articles in the education literature recommend how to teach mathematics better, there is little published research on how students actually learn S & P concepts as literature (North & Zewotir, 2006:1) maintained is that in South Africa,

> scholars were promoted on the basis of a combination of class work and formal summative testing (content-based testing played a progressively larger role in the higher grades). During their twelve years of schooling, students were introduced to graphical methods of data representation in the earlier grades (bar graphs, pictograms, etc.), but this was never developed to the next level! After this very early introduction to graphical displays of data, it was only in the grade 9 mathematics syllabus that some statistics was mentioned again! Here a small section was devoted to basic statistical measures such as mean, median, mode, range, variance and standard deviation.

However, there are two main reasons for the growing concerns as noted by current studies (Stohl, 2005). The first reason is that the experience of psychologists, mathematics educators, and statisticians alike is that a large proportion of students, even in University, do not understand many of the basic S & P concepts they study leading to inadequacies in prerequisite statistical skills (Stohl, 2005). In support of inadequacies in prerequisite statistical skills, survey of literature suggests that at any level, students appear to have difficulties developing correct intuition about fundamental ideas of S & P, especially probability/chance (Stohl, 2005). The difficulty as implied by the literature was that students have an underlying trouble with rational number concepts and proportional reasoning, which are used in calculating, reporting, and interpreting probabilities (North & Zewotir, 2006). Even past studies (DeWet, 2002; Russo & Passannante, 2001; Kent, Hoyles, Noss & Guile, 2004; Ernest, 1984) have long indicated that students are generally weak in rational/irrational number concepts and have difficulties with basic concepts involving fractions, decimals, and percentages.

The second concern as asserted by both local and international studies (North & Zewotir, 2006; Stohl, 2005) was attributable to abstract reasoning as part of the problem. Consistent with this second view, research studies (North & Zewotir, 2006) assert that students have already developed distaste for S & P through having been exposed to its study in a highly abstract and formal way. For this reason, a past study (Freudenthal, 1973) cautioned against teaching any technique of ‘mathematical statistics' even to University first years. This second key reason is consistent with other research studies in cognitive science, which lamented that there is prevalence of some 'intuitive' ways of thinking that interferes with the learning of correct S & P reasoning (North & Zewotir, 2006). This interference of intuitive as argued by recent study (North & Zewotir, 2006) suggested that inability of both teachers and learners in translating verbal problem statements plagues S & P. Thus ideas of S &P often appear to conflict with students' experiences and how they view the world.

In a sharp contrast though, elements of S & P have become requisite for a wide range of fields of study. This is reflected in both print and electronic media, where ordinary readers almost daily find reports of medical, economic, or psychological reports that need to be understood and evaluated only with some understanding of S & P principles.

In the United States (US), S & P were major themes in publications of the US National Council of Teachers of Mathematics (NCTM). The American Statistical Association (ASA) and the NCTM, through their Joint Committee on the Curriculum in S & P, also have emphasised the desirability of such a curriculum. The ASA-NCTM Joint Committee has published a document with recommended guidelines for teaching statistics within the K-12 mathematics curriculum, which includes rudimentary statistics activities as early as Grades 1 to 3. This is an indication that the enthusiasm for S & P in the curriculum among US specialists in both statistics and mathematics education is generally endorsed.

In the United Kingdom (UK), the Schools Council Project on Statistical Education (SCPSE) has published materials for secondary students covering topics that illustrate how S & P are used in meaningful contexts in different subject areas. The emphasis of these materials was on developing concepts rather than carrying out calculations.

Above accounts from US and UK suggest that S & P curricula development projects are being attempted to produce and test sets of materials for students and teachers. Implying that S & P topics are important, thus emphasises should be placed as early as the primary school curriculum. The below sub section elaborates the nature of S & P in South Africa and motivation for research hypotheses.

Statistics and Probability Education in South Africa: Motivation for Research Hypotheses

Data handling as a scientific discipline is usually first taught at the General Education Training (GET) Band[1] level in South Africa (the paper uses the term 'data handling' to refer to the study of S & P, as is common in South Africa). The introductory course is usually divided into three phases: foundation, intermediate and senior phases. The topics typically included in phase are listed in Table 1.

Table 1. Data Handling focus areas in each of the phases of Curriculum 2005 (C2005): Source (North & Zewotir, 2006:3).

GET: Foundation Phase: Grade R (reception year), Grades 1 to 3
At the end of this phase, it is expected that a scholar is able to Sort objects and data in different ways, based on their features (colour, shape, etc.) Represent data or objects in different forms (Bar graphs, pictograghs, etc.) Interpret the representation of data or objects There must be awareness that the selection of attributes used for sorting will influence how the data is represented.

[1] Readers are requested to read Curriculum 2005 (C2005) of the South African Revised National Curriculum Statement (RNCS) for mathematics or North & Zewotir (2006) on different bands of Education in South Africa.

Continued to Table 1

GET: Intermediate Phase: Grades 4 to 6
Different questions reveal different features of a situation Different forms of representation highlight some aspects of data, while hiding others Introduction to the idea of chance (Probability): Developing an awareness of certainty/uncertainty Random experiments and associated events *No calculation of probabilities, just an awareness of the fact that some events might be more likely to occur than others, i.e., grading of levels of uncertainty of outcomes of groupings thereof*
GET: Senior Phase: Grades 7 to 9
Application of tools and techniques already learnt to investigate and solve problems (including design of questionnaires) Critical awareness of use/abuse of data representations and interpretations Further development of probability concepts in order to engage with expressions of change in their daily lives (e.g., true understanding of uncertain in weather predictions, etc.)

Since the year 2002, much of the literature on learning and teaching data handling in South Africa has been at the University level (North & Zewotir, 2006). It is only in recent times that data handling has been introduced into the matriculation exams of the Further Education and Training (FET) Band (Revised National Curriculum Statement for mathematics – RNCS, 2002). The current literature has been filled with comments by instructors about both students and teachers not attaining an adequate understanding of basic data handling concepts and not being able to solve applied S & P problems. In fact authors (North & Zewotir, 2006:2) argued that:

> …reality was that students entered tertiary institutions with no prior exposure to statistics. Statistics, at South African tertiary institutions, very much mirrors what is the case in many countries – a small number of students opt to study statistics as a three year major, possibly followed by further post graduate studies in statistics. The majority of students, registering for statistics courses at tertiary institutions, register for one of the many, varied introductory statistics service courses which are compulsory to students from Engineering, Commerce, Medicine, Pharmacy, etc. These service courses in statistics are often taught by the relevant faculty members themselves and not by statisticians. The result is that these courses are generally taught using the classic formula-based approach, as these lecturers have not kept up with developments in statistics education, and thus teach in the way that they were classically taught. It is thus not surprising that Statistics has a very negative image amongst the majority of students at tertiary institutions in South Africa.

The above cited studies suggest that university students in education (candidate teachers), social and exact sciences in introductory data handling courses do not understand many of the concepts they study. This implies that students often tend to respond to problems involving S & P in general by falling into a ‘number crunching’ mode, plugging quantities into a formula or procedure without forming an internal representation of the problem. Thus, they (students and teachers alike) may be able to memorize formulas and the steps to follow in familiar, well-defined problems, but only seldom appear to get much sense of what the rationale is or how concepts can be applied in new situations. Consequently, within the conceptual underpinnings, the details they have learned or memorised, for whatever use they might be, soon fade.

With reference to the South African mathematics education literature in general, attention has not focused on the processes involved in solving S & P problems and the need for basing statistics courses on problem solving (Stohl, 2005; Vithal, Adler & Keitel, 2005; Mullis, Martin, Gonzalez

& Chrostowski, 2004; Reddy, 2004). This is supported by authors (North & Zewotir, 2006:5), who lamented that in South Africa, "curriculum 2005 recognises the cross-curricular need for statistics literacy and data analysis skills as an anticipated outcome, thus large amounts of statistical material is present in the syllabus. This content however has to be taught by teachers with little or no training in Statistics". Most mathematics education research in South Africa currently focus attention on learning outcomes 1-4 in the mathematics Revised National Curriculum Statement-RNCS[2] (RNCS, 2002).

There does not appear to be substantial evidence yet for improved practice in pre-university level in SA. Most of the recent literature about pre-university data handling instruction falls into two categories of Revised National Curriculum Statement (RNCS, 2002): (1) statements concerning the need for instruction at the pre-university level (Stohl, 2005) and (3) descriptions of the role of statistics curricular (Stohl, 2005).

Only the last category is of interest here, research on students' understanding of statistics is more extensive than research on probability and has developed as an area separately. There has been one distinct line of research on statistics understanding; one that focuses on university students (North & Zewotir, 2006). Despite the enthusiastic development of new instructional materials for learning and teaching of S & P in England and the US, little seems to be known about how to teach and learn S & P effectively in South Africa. For example, in the introduction of the RNCS, it was noted that some problems still remain in learning outcome 5 (LO5) in the RNCS; these include the learning and teaching of S & P. Research (Stohl, 2005) suggest that instructional methods contain different mixes of logical argument on statistics topics in schooling. Thus, S & P learning and teaching is almost entirely taught on experience of what has not worked and speculation about what might work. What may be needed is similar research on statistical instruction and students' ability to 'think statistically'.

Hence, it is the intent of this paper via problem solving technique to test the first proposition that students receiving deliberate instruction in how to solve problems do become better problem solvers and are better able to 'think statistically'. Another proposition includes a students' general mental maturity, thus impact of age and learning of data handling. This proposition steams from the second NAEP mathematics assessment, which produced subjective evidence that students' intuitive notions of probability gets stronger with age, but were not necessarily correct as suggested by (Stohl, 2005). Consistently, a test of hypothesis of, specific mathematics skills and understanding of S & P will be conducted.

Although strong arguments have been made those students learn best when instruction is couched in the context of students' 'real world' knowledge (Stohl, 2005), there is still only a little published research on the effectiveness of this approach or any other. This lack of research is perhaps due, as research (Stohl, 2005) believes, to the difficulty of conducting this type of empirical research. The author (Stohl, 2005) provides a catalogue of problems that have limited the interpretation of empirical research on probabilistic concepts. A related problem is a lack of research on the design and use of instruments to measure statistical understanding (Stohl, 2005). A few instruments have been designed to measure students' attitudes and anxiety toward statistics and some research has appeared that shows the role of factors influencing general achievement in a statistics course (Stohl, 2005).

The aforementioned past and present studies make it clear that far more research has been done on the psychology of statistical than on other probability concepts. In spite of this research, learning and teaching a conceptual grasp of S&P still appears to be a very difficult task, fraught with ambiguity and illusion as noted above.

In conclusion, the hypothetical literature has explained the relationships of various variables and S&P concepts. Indeed, it is difficult to drive and substantiate such ideas without test of hypotheses. These and other research contestations form the basis of formulating the research hypotheses.

[2] For details see Curriculum 2005 (C2005) of the South African Revised National Curriculum Statement (RNCS) for mathematics.

Research Hypotheses

Below are the lists of the main hypotheses to be tested. These include the test of the impact of instructions (problem solving techniques), level of mathematical skills, intuitive notions of probability (maturity) and lastly computerisation of statistics on learning of data handling. With regards to hypothesis 1, studies (DeWet, 2002; Russo & Passannante, 2001) have showed that students receiving deliberate instruction in how to solve problems do not become statistically better. Thus it contradicts with what have been revealed by other literature (Kent, et al., 2004) who suggested the converse is true. For this reason if Ho is proven to be correct then it suggest that students receiving deliberate instruction in how to solve problems do not become statistically better, if not Ha which is converse of Ho is accepted.

Following hypothesis 2, Ho is in tandem with studies (Stohl, 2005) which indicated that students' level of specific mathematics skills does not impact on S&P ability. The author (Stohl, 2005) emphasised that specific mathematics skills does not impact on S & P ability, but this is opposed by other literature (North & Zewotir, 2006). In thid connection if Ho is proven to be correct then it suggest that specific mathematics skills does not impact on S & P ability, if not, Ha which is converse of Ho is accepted. Hypotheses 3 and 4 as contested by both past and present literature have opposing views, these hypotheses for the same procedure as in the case of hypotheses 1 and 2.

Hypothesis 1

Ho= Students receiving deliberate instruction in how to solve problems do not become statistically better.

Ha= Students receiving deliberate instruction in how to solve problems do become better statistically

Hypothesis 2

Ho= Students' level of specific mathematics skills does not impact on S&P ability.

Ha= Students' level of specific mathematics skills impacts on their S&P ability.

Hypothesis 3

Ho= Students' intuitive notions of probability does not get stronger with age.

Ha= Students' intuitive notions of probability does get stronger with age.

Hypothesis 4

Ho= Statistical experimentation with the role of computers does not improve learning of S&P.

Ha= Statistical experimentation with the role of computers does improve learning of S&P.

2. Methodology of Research

The purpose of the study was to investigate whether there are any significant differences in the mechanisms of students statistical learning ability among PGCE (43) students over a period of two-years. Following the context of the study and the hypotheses, the paper investigated individual differences between genders and their interactive nature with the corresponding academic tracks of data handling. Four distinct academic tracks were monitored thus; instructions (problem solving techniques), level of mathematical skills, intuitive notions of probability, and lastly computerisation of statistics.

The approach was a mixed method (quantitative and qualitative) in which case a quantitative procedure dominated due to the hypotheses. The research design was a case study, following the hypotheses, a questionnaire was used to sample 43 students pursuing postgraduate certificate of education programme in University of Fort Hare in the Eastern Cape of South Africa over a period of two academic years. Meanwhile, an interview schedule was prepared for the purpose of in-depth analysis of responses of the unit of analysis. Data analysis was conducted using multivariate analysis of variance (MANOVA) and repeated-measures analysis of variance (ANOVA) including analysis of covariance (ANCOVA). Noting that a reliability test conducted revealed a 0.85 Cronbach's alpha, confidently suggesting a high reliability of instrument (Tabachnick & Fidell, 2001).

The reason for the above data analysis (MANOVA, ANOVA and ANCOVA) is for the purpose of revealing any difference between selected socio-demography factor and statistical ability, inferential analyses such as ANOVA and MANOVA were utilised for determining any relationship between selected sociodemographic factor and statistical ability (Tabachnick & Fidell, 2001).

2.1 Procedures

School of Initial Teacher Education (GET) of faculty of education: University of Fort Hare was used in this study, with a total number of 43 PGCE students admitted in the academic years of 2007 and 2009. The performance was based on a combination of the class tests and assignment conducted over the two years. Additionally, anonymous questionnaires were given to the candidate teachers related to the four distinct academic tracks which were instructions (problem solving techniques), level of mathematical skills, intuitive notions of probability, and lastly computerisation of S&P.

The questionnaire, designed for the purpose of this study, was based on the relative international literature (creswel, 2007; Stohl, 2005; Vithal, Adler & Keitel, 2005; Mullis, Martin, Gonzalez & Chrostowski, 2004; Reddy, 2004) (cf. context of study and hypotheses) and it was adjusted to the special characteristics of the sample of candidate teachers as well as the focal point (purpose), thus teaching and learning of statistics. The questionnaire also included demographic questions (cross reference to section 3.1 for details). The last unit was composed of open questions. The rest of units consisted of closed questions with a 5-point Likert- type (Creswel, 2007; Tabachnick, & Fidell, 2001) scale and the participants were asked to indicate how much each item characterises the teaching and learning of statistics. Due to the instrument used and the scale of measurement used, it necessitated the use of repeated-measures Analysis of Variance (RM-ANOVA) and RM-MANOVA following specific assumptions (cross reference to section 3 for details).

3. Results of Research

Based on the research hypotheses and scale of measurement (ordinal/ranked scale), the analysis of the results were in two halves. While, one-half of the analysis took repeated-measures analysis of variance (RM-ANOVA)- a univariate approach that is most commonly recognised and suitable for this analysis, the second half focused on the multivariate generalisation applying a RM-MANOVA approach to the same data (Tabachnick, & Fidell, 2001). The main purpose was to analyse and represent the results of the research. While the general approaches are fairly similar there are fundamental differences between the assumptions as well as the subsequent follow-up tests (assumptions) needed to be conducted. This section describes the various statistics used and some of assumptions. But first the socio-demographic findings are as described below.

3.1 Socio-demographic findings: Descriptive Statistics

The average age of participants was 24.5 years. The age of participants ranged from 23 to 41 years (M = 24.5, SD = 5.02). The results suggested that age was non-normally distributed, with skewness of 1.69 (SE = 0.05) and kurtosis of 3.80 (SE = 0.11).

3.2 Test of Assumptions

Multivariate normality of the data was investigated using information from two sources. First, the multivariate interrelationship between all response variables was assessed using individual factorial group by-case computed leverage values. Critical cut-off values for these were computed based on the corresponding Mahalonobis Distance critical chi-square values with the appropriate group sample size and an alpha level of .01. The results suggested that none of the group's maximal leverage values exceeded the critical cut-off. From this, the researcher could infer that given the data, there were no multivariate outliers in the dataset for this hypothesis (cross reference section 3.1 for details). Secondly, the multivariate skewness and kurtosis were investigated using normal distribution. Again, the two groups showed no deviation from an assumed multivariate normal distribution. Thus, none of the distributional coefficients were significant, suggesting a multivariate normal distribution of the data. With this particular assessment it was appropriate to proceed with the analysis.

3.3. Hypothesis 1

The first investigation of the data revealed the separate means (M = 65.3, SD = 8.15; M = 64.5, SD = 9.4 and M = 65.1, SD = 9.6) on the problem solving technique (PST) measure for each of the groups respectively; goal of S&P (SP); nature of mathematical activity (NMA); origin of mathematical knowledge (OMK) respectively as seen in Table 1. It followed that there was a significant change in the PST scores across the groups, $F\ (3, 729) = 29.03$, $p < .05$. Both the F and p values suggested and confirmed that there was a significant change between PST and the other groups as aforemention, noting that in this intance socio-demographical data was excluded (this is considered in hypotheses 2 and 3.

Following the above results, the study conclusively rejected the null hypothesis and accepted that students receiving deliberate instruction in how to solve problems do become better able to think statistically.

Table 1. Means and Standard deviations of groups.

Groups	Mean(*M*)	Standard deviation (*SD*)
1. goal of S&P (SP)	65.30	8.15
2. nature of mathematical activity (NMA)	64.50	9.40
3. origin of mathematical knowledge (OMK)	65.10	9.60

3.4 Hypothesis 2

The literature (North & Zewotir, 2006) suggested that students' level of specific mathematics skills impacts on statistical ability. In this analysis, the results were statistically significant. Since the F ratio for this hypothesis was very large [$F\ (2, 143) = 3772.3$, $p = .0001$, $\eta 2 = .56$], the study could confidently reject the null hypothesis and conclude that students' level of specific mathematics skills impacts on statistical ability, with a significant level of effect ($\eta 2 = .56$). The value of $\eta 2$ explains the strength of the significance level, in this case above 0.5 suggesting moderate effect and F ratio very large, indicating a significance level (Tabachnick, & Fidell, 2001). This implies that there is sufficient reason to encourage teachers that students' level of specific mathematics skills impacts on statistical ability. This suggest that it is important students mathematical skills are at par with their statistical ability which is consistent with previous studies (North & Zewotir, 2006).

3.5 Hypothesis 3

The NAEP mathematics assessment produced evidence that students' intuitive notions of S&P get stronger with age. Data was analysed using a mixed-design ANOVA with a within-subjects factor of subscale of ages (23–26 yrs; 27–31 yrs; 32 yrs and more) and a between-subject factor of sex (male, female). The predicted main effect of age was not significant, $F\,(1, 732) = 2.00$, $p = .16$, $\eta2 = .003$, nor was the predicted main effect of intuitive notions of probability, $F\,(1, 732) = 3.25$, $p = .072$, $\eta2 = .004$.

An ANCOVA [between-subjects factor: sex (male, female); covariate: age] revealed no main effects of intuitive notions of probability, $F\,(1, 732) = 2.00$, $p = .16$, $\eta2 = .003$. Thus, the study concluded that students' intuitive notions of probability do not get stronger with age. The value of $\eta2$ explains the strength of the significance level, in this case above 0.5 suggesting moderate effect and *F* ratio very large, indicating a significance level (Tabachnick, & Fidell, 2001).

What the result suggests is that the study accepted the null hypothesis and concluded that students' intuitive notions of probability seemed not to get stronger with age. The above suggest that for many students, a considerable improvement of skills in dealing with abstractions may be necessary before they are ready for much of the S&P reasoning and thus leading to hypothesis testing that underlie basic statistical inference. For some students, teachers may have to be content to forgo abstraction and to convey what statistical ideas they can in simpler and in concrete terms.

3.6 Hypothesis 4

Next, the study turn attention to the null hypothesis that; in an attempt to help students think statistically there should not be experimentation with the role of computers in learning data handling. In this regard, several exercises were given out before and after computerising the teaching of data handling. These exercises were in two forms; firstly this included representing data or objects in different forms using graphs (bar graphs, pictographs, frequency polygon, histograph etc) and secondly exercises related to measures of central tendencies and locations. By examining the Wilks' value for this test (.976) (Tabachnick & Fidell, 2001), its associated *F* value, and p value [$F\,(2, 286) = .859$, $p < .001$, $\eta2 = .81$], the study concluded that any statistical experimentation with the role of computers to a large effect ($\eta2 = .81$) improves learning of data handling. The value of $\eta2$ explains the strength of the significance level, in this case well above 0.5 suggesting high effect and *F* ratio very large, indicating a significance level (Tabachnick, & Fidell, 2001).

Hence the null hypothesis was rejected. An interaction with a respondent (Senior) noted that:

> …the increasing prevalence of computers in schools has already had some influence on learning and teaching and is producing its own statistics students especially data analysis. Computers have been used in several ways to aid in the teaching of introductory courses.

This is an indication that students may access computers and use statistical packages, such as Excel to do the number-crunching operations for them (students). Noting that advance forms such as SPSS, SAS or MINITAB could also be used, but needs caution due to the complexities involved.

4. Discussion of Study

With reference to the results and the hypotheses; firstly, students receiving instruction in how to solve problems do become better to think statistically. Thus, it gives a prediction that to improve learning of statistics and probability; students should receive instruction in how to solve problems. This means that teachers should provide more problem solving opportunities for students in S & P.

Additionally, students' level of specific mathematics skills was proven to impact on statistical ability. The data gained proved that students' level of specific mathematics skills correlates with S&P learning.

In contrast though, there was no supporting evidence to suggest that student's intuitive notions of statistics and probability does get stronger with age. This result suggests that attention should be concentrated more in terms of strengthening their knowledge, and skills as emphasised by author (North & Zewotir, 2006). They (North & Zewotir, 2006) together with this study suggest that the older the students to be, it does not necessarily impact on S&P performance. Previous study (Stohl, 2005) showed that age does not affect statistical ability, thus it is consistent with what have been revealed by this study, whic suggests that difference of age could not be a potential factor for statistical ability.

Lastly, efficacy of computers in guiding the design of instruction is an important component in statistical learning. This is in tandem with previous study (North & Zewotir, 2006) which indicated that there were significant association between computers usage and statistical teaching. Consistent with the previous study (North & Zewotir, 2006), this research has showed that improvement of statistical ability could be improved through the use of computerisation.

5. Conclusion and Implication

From this study, the are four conclusions that are made, thus the results revealed: (1) students receiving instruction in how to solve problems do become better to think statistically (2) additionally, students' level of specific mathematics skills impact on statistical ability (3) in contrast though, there was no supporting evidence to suggest that students' intuitive notions of probability does not get stronger with age (4) efficacy of computers in guiding the design of instruction is an important component in statistical learning. Thus, the study found that any statistical experimentation with computers improves learning of statistics.

While, some of these results are consistent with previous literature, others (H3) were inconsistent with the general notion. Nonetheless, the four conclusions implied that teachers should introduce topics through activities and simulations, not abstractions. Additionally, S & P teachers should try to arouse in students the feeling that mathematics relates usefully to reality and is not just symbols, rules, and conventions. A proposal of this kind may include using the same class's population, height, age or race in teaching mathematics, statistical and probability concepts and as well use them for interpretations. This should be linked with the use of visual illustration and emphasise exploratory data methods with computers. Suggesting that S & P teachers should point out to students common uses of statistics (for instance, in news stories and advertisements). Importantly, there is the need to use strategies to improve students' rational number concepts before approaching proportional reasoning. This could assist to recognise and confront common errors in students' statistical and probability thinking and hence create situations requiring S & P reasoning that correspond to the students' views of the world.

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