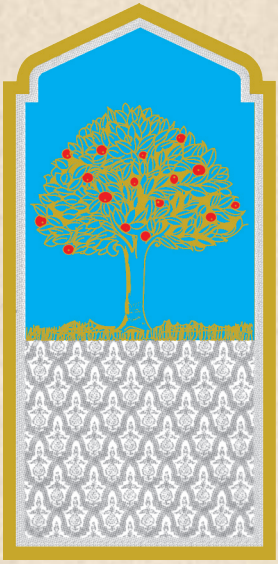

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THE EFFECTS OF ATTITUDES TOWARDS STATISTICS, PERCEIVED ABILITY, LEARNING PRACTICES AND TEACHING PRACTICES ON STUDENTS' PERFORMANCE IN STATISTICS: A REVIEW[1]

Zamalia Mahmud
Nor Zatul-Iffa Ismail
Noor Lide Abu Kassim
Mohammad Said Zainol

Abstract

This paper reviews the literature related to the teaching and learning of statistics and highlights the following variables affecting students' performance in statistics: students' attitudes towards statistics, students' perceived ability in statistics, instructors' teaching practices and students' learning practices. These variables have been chosen as these variables come from the self (student and teacher) where if self is well directed, teaching and learning becomes less complex and understanding will easily be established. Seeking knowledge has been greatly emphasized in Islam. The teaching and learning of statistics is becoming an increasingly important issue in statistical education. One pressing issue is how to continuously improve the teaching and learning of statistics at the tertiary level. Given its importance for the development of statistical literacy, statistical education researchers have attempted to investigate factors that relate to students' learning outcomes in statistics and these researches have shown that a number of factors are indeed associated with student performance in statistics. The Prophet Muhammad (S.A.W) said: "The seeking of knowledge is obligatory for every Muslim".[2] And the civilization of Muslims has been based on lslam's emphasis on teaching and learning.

[1] Article received: September 2018; Article submitted: November 2018; Article accepted: December 2018

[2] *Al-Tirmidhi*, Hadith 74.

Introduction

The ability to organize data, construct and display graphs and tables and work with different representations of data is fundamental to the achievement of statistical literacy.[3] Students need to reason and make sense of statistical information. Statistical literacy ranges from describing and summarizing basic data to understanding and explaining statistically complex concepts such as trends. It requires being able to extract, understand and explain data that are presented in a variety of ways: in words, tables, graphs, and, increasingly, in maps. To be statistically literate, one must understand that how data are organized can contribute to how they are interpreted. A common theme in the literature is that statistical literacy should not just be about understanding statistical concepts, such as distribution, probability and sampling, but should also be about critically evaluating when concepts have been applied without proper statistical foundation.[4] The critical evaluation of statistics essentially requires an understanding of the entire statistical process, from data collection through to data analysis, testing of assumptions and evaluation of results.[5] The ability to evaluate statistical information also requires an understanding that all data and data collection are contextual.

Students may be able to answer some test items correctly or perform calculations correctly, but they may still misunderstand basic

[3] J. Garfield and D. Ben-Zvi, "Research on Statistical Literacy, Reasoning, and Thinking: Issues, Challenges, and Implications," in *The Challenge of Developing Statistical Literacy, Reasoning and Thinking*, ed. D. Ben-Zvi and J. Garfield (Dordrecht, The Netherlands: Kluwer Academic Publishers, 2004), 397–410.

[4] I. Gal, "Statistical Literacy - Meanings, Components, Responsibilities," in *The Challenge of Developing Statistical Literacy, Reasoning and Thinking*, ed. D. Ben-Zvi and J. Garfield (Dordrecht,The Netherlands: Kluwer Academic Publishers, 2004), 47–78; I. Gal, "Adults' Statistical Literacy: Meanings, Components, Responsibilities.," *International Statistical Review* 70, no. 1 (2002): 1–51.

[5] D. Ben-Zvi and J. (Eds.). Garfield, "Goals, Definitions, And Challenges," in *The Challenge of Developing Statistical Literacy, Reasoning and Thinking*, ed. D. Ben-Zvi and J. Garfield (Dordrecht, The Netherlands: Dordrecht, The Netherlands: Kluwer Academic Publishers, 2004); M. Pfannkuch and C. Wild, "Towards an Understanding of Statistical Thinking," in *The Challenge of Developing Statistical Literacy, Reasoning, and Thinking*, ed. D. Ben-Zvi and J. Garfield (Dordrecht, Netherlands: Kluwer Academic Publishers, 2004), 17–46.

ideas and concepts in statistics due to the lack of conceptual understanding of what is being constructed or how statistical concepts are interrelated. For example, Garfield and Ben-Zvi,[6] and Bakker[7] found in their studies that although students may be able to calculate basic statistics, a sound understanding of what were being constructed or how statistical concepts are interrelated is rare. Similarly, Clark et al[8] found that students who receive top grades in a class may not understand and remember the basic ideas of statistics. The lack of conceptual knowledge and understanding of statistical concepts is particularly seen in relation to basic concepts such as reasoning about distributions and graphical representations of distributions,[9] understanding concepts related to statistical variation, such as measures of variability,[10] and sampling distributions.[11] This

[6] Garfield and Ben-Zvi, "Research on Statistical Literacy, Reasoning, and Thinking: Issues, Challenges, and Implications." in *The Challenge of Developing Statistical Literacy, Reasoning and Thinking*, ed. D. Ben-Zvi and J. Garfield (Dordrecht,The Netherlands: Kluwer Academic Publishers, 2004).

[7] A. Bakker, "Reasoning about Shape as a Pattern in Variability," *Statistics Education Research Journal* 3, no. 2 (2004): 64–83.

[8] J.M. Clark et al., *The Fundamental Theorem of Statistics: Classifying Student Understanding of Basic Statistical Concepts* (Unpublished Manuscript, 2003), http://www1.hollins.edu/faculty/clarkjm/stat2c.pdf.

[9] K. Bakker, A. and Gravemeijer, "Learning to Reason about Distribution," in *The Challenge of Developing Statistical Literacy, Reasoning, and Thinking*, ed. D. Ben-Zvi and J. Garfield (Dordrecht, The Netherlands: Kluwer, 2004), 147–68; Ben-Zvi and Garfield, "Goals, Definitions, And Challenges"; J.K. Hammerman and A. Rubin, "Strategies for Managing Statistical Complexity with New Software Tools," *Statistics Education Research Journal* 3, no. 2 (2004): 17–41; C. Konold and T. L. Higgins, "Reasoning about Data," in *A Research Companion to Principles and Standards for School Mathematics*, ed. J. Kilpatrick, W. G. Martin, and D. Schifter (Reston, VA: National Council of Teachers of Mathematics, 2003), 193–215.

[10] R. DelMas and Y. Liu, "Exploring Students' Conceptions of the Standard Deviation," *Statistics Education Research Journal* 4, no. 1 (2005): 55–82, http://www.stat.auckland.ac.nz/~iase/serj/SERJ4(1)_delMas_Liu.pdf; D. Mathews and J. Clark, "Successful Students' Conceptions of Mean, Standard Deviation, and the Central Limit Theorem," in *Paper Presented at the Midwest Conference on Teaching Statistics* (Oshkosh, WI, 1997).

[11] B. delMas, R., Garfield, J., and Chance, "A Model of Classroom Research in Action: Developing Simulation Activities to Improve Students' Statistical Reasoning," *Journal of Statistics Education* 7, no. 3 (1999), http://www.amstat.org/publications/jse/secure/v7n3/delmas.cfm; Mathews and Clark, "Successful Students'

state of affairs is unfortunate given that statistical reasoning is crucial in dealing with the prevalence of statistical data in the media and other sources of information that pervade our daily life.

According to a research study done in two public universities in Malaysia, Abu Kassim et al[12] concluded that the conceptual understanding of basic statistical concepts is more complicated to achieve than statistical competence. Their investigation also found that, most frequently, students overrated their understanding of basic statistical concepts. Teaching basic statistical concepts is indeed a great challenge to many teachers as they must be able to deliver the concepts in a way that the students can grasp the concepts taught and apply what they learnt. Statistical concepts are the basis of learning statistics, and, therefore, should be given extra attention by every educational institution.

Students' performance in statistics can be affected by many factors. Huitt[13] emphasizes that students' performance in the classroom is influenced by the practices of teaching and learning that have taken place. He identifies four variables that have a direct relationship with students' performance, namely, input, classroom processes, output and context. Input refers to those qualities or characteristics of teachers and students that they bring with them to the classroom experience. Classroom processes refer to teacher and student behaviour in the classroom as well as other variables, such as classroom climate and teacher/student relationships. Output refers to measures of student learning taken apart from the normal

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Conceptions of Mean, Standard Deviation, and the Central Limit Theorem"; A. Rubin, B. Bruce, and Y. Tenney, "Learning about Sampling: Trouble at the Core of Statistics," (presentation, Third International Conference on Teaching Statistics, New Zealand, 1990); F. W. Saldanha, L. A. and Thompson, "Students' Reasoning about Sampling Distributions and Statistical Inference," in *Proceedings of The Twenty-Third Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education*, ed. R. Speiser & C. Maher (Snowbird, Utah. Columbus, Ohio: ERIC Clearinghouse, 2001), 449–54.

[12] Noor Lide Abu Kassim et al., "Empirical Understanding of and Perceived Ability in Statistical Concepts: A Rasch Measurement Approach," (presentation, International Conference on Behavioral, Cognitive and Psychological Sciences, Singapore, 2010).

[13] W. Huitt, "A Transactional Model of the Teaching/Learning Process," *Educational Psychology Interactive* (2003).

instructional process. The variable of context includes all those variables outside of the classroom that have an impact on the teacher and student characteristics, classroom processes, and output. The direct sub-variables of context include institution characteristics and processes.

Therefore, it is imperative to investigate how the teaching and learning of statistics can be further improved so that students understand statistics and can perform well. However, to attain these improvements, it requires extensive understanding of various factors involved, such as the curriculum design, teaching and learning strategies, learning environment, attitudes towards the subject and conceptual competencies. While there are multifarious factors affecting students' performance in statistics, this study seeks to investigate student attitudes, perceived ability, learning practices and teaching practices which are believed to be the main factors that contribute to students' understanding of basic statistical concepts and determine students' success in statistics courses.

Teaching and Learning of Statistics

Bakker and Derry[14] suggests three challenges in statistics education which are:

1. to avoid inert knowledge where students have the knowledge but unable to apply the knowledge effectively i.e. good in calculations but fail in reasoning
2. to avoid atomistic approaches in teaching statistics, i.e. topics in the textbook are related and should be taught in relation to one another
3. to sequence topics based on hierarchy of concepts in alternative approaches which aim for coherence from a student perspective.

The teaching and learning of statistics, which focuses on computation skills and discrete statistical knowledge, has come under considerable scrutiny in recent years and a number of recommendations have been made to develop students' conceptual

[14] A. Bakker and J. Derry, "Lessons from Inferentialism for Statistics Education," *MathematicalThi Nking and Learning* 13, no. 1–2 (2011): 5–26.

understanding and statistical reasoning. For example, in 2005, the American Statistical Association endorsed a set of instructional guidelines published in the Guidelines for Assessment and Instruction in Statistics Education (GAISE) project.[15] In the guidelines, the following recommendations for statistics education are made:

- emphasize statistical literacy and develop statistical thinking;
- use real data;
- stress conceptual understanding rather than mere knowledge of procedures;
- foster active learning in the classroom;
- use technology for developing conceptual understanding and analysing data; and
- use assessments to improve and evaluate student learning.

Research into how students learn has evolved in many different directions. A large number of studies have been carried out in areas such as cognitive aspects of learning.[16] Students enter learning processes with different characteristics and backgrounds such as a preference for deep learning versus surface learning, and specific subject attitudes, and different perceptions of the learning context. Most often than not students achieve satisfactory learning outcomes, with different learning paths.[17] Walberg[18] states that student aptitude, instruction, and psychological environment are the major direct causes of learning that require optimization to increase affective, behavioural, and cognitive learning.

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[15] M. Aliaga et al., "Guidelines for Assessment and Instruction in Statistics Education (GAISE) (Project College Report, 2005).

[16] J. Garfield, "How Students Learn Statistics," *International Statistical Review* 63 (1995): 25–34; J. Garfield and B. Chance, "Assessment in Statistics Education: Issues and Challenges 2, 99-125.," *Mathematics Thinking and Learning* 2 (2000): 99–125.

[17] D. Tempelaar, "A Structural Equation Model Analyzing the Relationship Students' Statistical Reasoning Abilities, Their Attitudes toward Statistics and Learning Approaches," (presentation, The 7th Int. Conference on the Teaching of Statistics, ICOTS-7., 2006).

[18] H.J. Walberg, "Improving the Productivity of America's Schools," *Educational Leadership* 41 (1984): 21.

Over the years, there has been much effort to improve the teaching and learning of statistics. Statistics researchers and educators have conducted various investigations on factors that relate to students' learning and understanding of statistics. Among the prevailing issues of concern is how to improve the teaching and learning of statistics at the tertiary level. Despite the great emphasis on the importance of statistics, students are still facing difficulties in learning statistics. Garfield et al[19] propose that desired outcomes of introductory statistics courses include not only statistical learning and understanding, but also students' willingness to persist in their learning and application of skills, and positive attitudes and beliefs about statistics.

Statistical Literacy, Statistical Reasoning and Statistical Thinking

Statistical literacy involves understanding and using the basic language and tools of statistics: knowing what statistical terms mean, understanding the use of statistical symbols, recognizing and being able to interpret representations of data,[20] understanding of statistical concepts, such as distribution, probability and sampling, as well as the ability to critically evaluate the adequacy of concepts that have been applied without proper statistical foundation.[21] Therefore, having statistical literacy means being able to describe and summarize basic data as well as being able to understand and explain statistically complex concepts. In other words, it requires the ability to extract, understand, and explain data that is presented in a variety of ways. To be statistically literate one must understand how data is organized can contribute to how it is interpreted.[22]

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[19] J. Garfield et al., "First Courses in Statistical Science: The Status of Educational Reform Efforts.," *Journal of Statistics Education* 10, no. 2 (2002).

[20] R. C. DelMas et al., "Assessing Students' Conceptual Understanding after a First Course in Statistics," *Statistics Education Research Journal* 6, no. 2 (2007): 28–58.

[21] Gal, "Statistical Literacy - Meanings, Components, Responsibilities"; Gal, "Adults' Statistical Literacy: Meanings, Components, Responsibilities."

[22] Ibid.; J. Garfield, "Thinking about Statistical Reasoning, Thinking, and Literacy," (presentation, First Annual Roundtable on Statistical Thinking, Reasoning, and Literacy, 1999); J. Garfield, "The Challenge of Developing Statistical Reasoning," *Journal of Statistics Education* 10, no. 3 (2002), www.amstat.org/publications/jse/v10n3/garfield.html.

Statistical reasoning refers to the way people reason with statistical ideas by means of interpreting and making inferences of the statistical results based on the sets of data, graphical representations and statistical summaries such as distribution, centre, spread, association, uncertainty, randomness and sampling.[23] Statistical reasoning is widely defined as the ability and skills to deal with statistical contents and make use of them in solving problems. Students need to reason and make sense of statistical information. It involves a three-step processes, beginning with comprehension of the problem, applying appropriate methods to solve the problem and interpreting the outcomes relating to the original problem.[24] Reasoning, unlike literacy which is seen as understanding and interpreting the statistical information presented, is narrowly viewed as working beyond the tools and concepts taught which allow students to spontaneously question and investigate the issues and statistical data in a specific context.[25]

Statistical thinking involves an understanding of why and how statistical investigations are conducted. This includes recognizing and understanding the entire investigative process, how models are used to simulate random phenomena, how data are produced to estimate probabilities, how, when, and why existing inferential tools can be used, and utilizing the context of a problem to plan and evaluate investigations.[26] Statistical thinkers are able to critique and evaluate results of a problem solved or a statistical study.[27] Table 1 summarizes the three instructional domains.

[23] Garfield, "The Challenge of Developing Statistical Reasoning."

[24] N. Chervaney, P.G. Benson, and R. Iyer, "The Planning Stage in Statistical Reasoning," *The American Statistician* 34 (1980): 222–26; N. Chervaney et al., "A Framework for the Development of Measurement Instruments for Evaluating the Introductory Statistics Course," *The American Statistician* 31 (1977): 17–23.

[25] B.L. Chance, "Components of Statistical Thinking and Implications for Instruction and Assessment," *Journal of Statistics Education* 10, no. 3 (2002).

[26] DelMas et al., "Assessing Students' Conceptual Understanding after a First Course in Statistics."

[27] Ben-Zvi and Garfield, "Goals, Definitions, And Challenges."

Table 1. Definition of Statistical Literacy, Statistical Reasoning and Statistical Thinking and Tasks that May Distinguish the Three Instructional Domains

Instructional Domains	Definition	Task
Statistical Literacy	The ability to understand and use the basic language and tools of statistics.	Identify, describe, rephrase, translate, interpret, read
Statistical Reasoning	The ability to choose, generate, and properly interpret appropriate descriptive and inferential method and ability to make inferences and justify conclusions.	Why, how, explain (the process)
Statistical Thinking	The ability to understand why and how statistical investigations are conducted and knowing when and how to apply statistical knowledge and procedures.	Apply, critique, evaluate, generalize

Conceptual Knowledge and Statistical Competence

Conceptual knowledge, on the other hand, has been characterized as knowledge that is rich in relationships, where discrete pieces of statistical knowledge, ideas and concepts are connected to construct a network of interrelated propositions.[28] The construction of interrelated propositions can occur "between pieces of information already stored in the memory or between an existing piece of knowledge and one that is newly learned".[29] Conceptual knowledge

[28] N.J. Broers, "Analyzing Propositions Underlying the Theory of Statistics," *Journal of Statistics Education V* 9, no. 3 (2001); J. Hiebert and P. Lefevre, "Conceptual and Procedural Knowledge in Mathematics: An Introductory Analysis," in *In Conceptual and Procedural Knowledge: The Case of Mathematics*, ed. J. Hiebert (Hillsdale: NJ: Lawrence Erlbaum Associates, 1986), 1–27.

[29] Hiebert and Lefevre, "Conceptual and Procedural Knowledge in Mathematics: An Introductory Analysis," 3-4.

and understanding, therefore, is essential for the development of statistical reasoning and thinking. Without it, students would not be able to make connections and explain the relationships between the different statistical processes or discrete statistical knowledge.[30] The relationship between conceptual knowledge and understanding and statistical reasoning is clearly explicated in the previous definition of statistical reasoning given by Garfield.[31]

Statistical competence is held to include the following components:

(i) data awareness
(ii) an understanding of certain basic statistical concepts and terminology
(iii) knowledge of the basics of collecting data and generating descriptive statistics,
(iv) basic interpretation skills (the ability to describe what the results mean in the context of the problem)
(v) basic communication skills (being able explain the results to someone else)

(Rumsey[32])

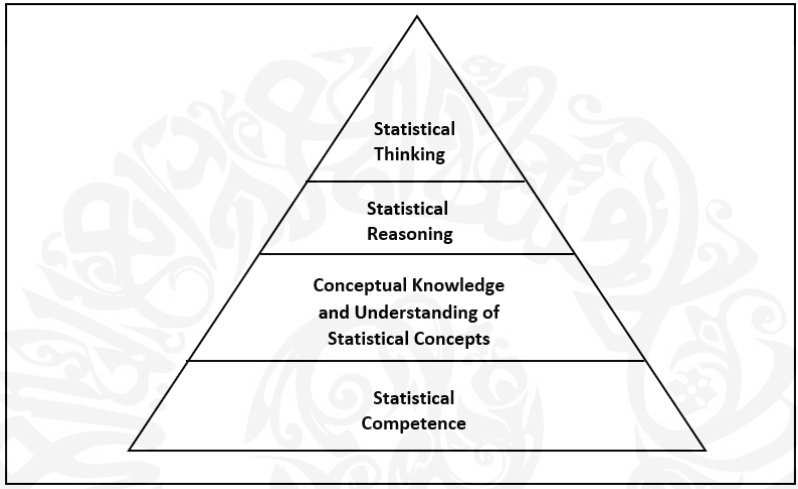
This basic knowledge, Rumsey[33] argues, underlies statistical reasoning and thinking. Thus, statistical literacy, conceptual knowledge and understanding, and statistical reasoning can be thought of as unique areas in themselves and may be represented as a hierarchy, where statistical competence provides a foundation for conceptual knowledge and understanding, and conceptual understanding for statistical reasoning (see Figure 1).

In short, every time students go through the process, they will reinforce their understanding of terms and concepts, and their reasoning and thinking skills. The process begins by developing a basic foundation of knowledge of statistical concepts and ideas, which is called statistical competence where statistical competence

[30] Ben-Zvi and Garfield, "Goals, Definitions, And Challenges," 7.
[31] Garfield, "The Challenge of Developing Statistical Reasoning."
[32] D.J. Rumsey, "Statistical Literacy as a Goal for Introductory Statistics Courses.," *Journal of Statistics Education.* 10, no. 3 (2002).
[33] Ibid.

promotes and develops skills in data awareness, production, understanding, interpretation, and communication.

Figure. 1 Hierarchy of Relationship between Statistical Competence, Conceptual Knowledge and Understanding, and Statistical Reasoning



Findings from Research in Various Fields on Students' Attitudes, Perceived Ability, Teaching Practices and Learning practices

Table 2 shows some of the findings from previous studies in different field related to students' attitudes, perceived ability, teaching practices and learning practices. The findings listed are not meant to be exhaustive but to demonstrate the influence of these variables on performance.

Table 2. Findings from Research in Various Field

Hypothesis: The effect of students' perceived ability on students' performance		
Author (s)	Context	Results
Jaiswal and Choudhuri[34]	615 secondary school students aged 14-17 years session 2016-17 of varanasi city, india.	Positive relationship between academic self-concept and academic achievement.
Tenaw[35]	Second year students in the fall of 2012 in analytical chemistry i (aci) at debre markos college of teacher education (dmcte).	Significant relationship exists between self-efficacy and achievement.
Oblior[36]	300 senior secondary 3 students in Port Harcourt.	Self-concept, Mathematics, and General Academic achievement of students are strongly related that a change in self-concept facilitates a change in achievement.
House[37]	Elementary school-aged students in the United States and Japan who had participated in the Third International Mathematics and Science Study.	Significant relationships between self-beliefs and mathematics achievement.

[34] Sandeep Kumar Jaiswal and Rashmi Choudhuri, "Academic Self Concept and Academic Achievement of Secondary School Students," *American Journal of Educational Research* 5, no. 10 (2017): 1108–13, https://www.researchgate.net/publication/321215133_Academic_Self_Concept_and_Academic_Achievement_of_Secondary_School_Students.

[35] Yazachew Alemu Tenaw, "Relationship Between Self-Efficacy, Academic Achievement and Gender in Analytical Chemistry at Debre Markos College of Teacher Education," *African Journal of Chemical Education* 3, no. 1 (2013), https://www.ajol.info/index.php/ajce/article/viewFile/84850/74836.

[36] Isaac Esezi Obilor, "Relationship Between Self-Concept and Mathematics Achievement of Senior Secondary Students in Port Harcourt," *Journal Plus Education* 8, no. 1 (2012), http://www.uav.ro/jour/index.php/jpe/article/download/928/988.

[37] J.D. House, "Mathematics Beliefs and Achievement of Elementary School Students in Japan and the United States: Results From the Third International Mathematics and Science Study," *The Journal of Genetic Psychology* 167, no. 1 (2006): 31–45.

Table 2 (Continue)

Hypothesis: The effect of students' learning practices on students' performance.		
Author (s)	Context	Results
Awang et al.[38]	103 students of international business course, in Malaysian polytechnic.	No significant difference between learning style and academic achievement of students
Gappi[39]	131 first year college students of the academic year 2012-2013, composing of 118 national youth and 13 young adults.	No significant statistical correlation between the academic achievement and the learning style preferences of the students.
Hassanbeigi[40]	179 male and female junior and senior medical and dental students	Study skills significantly improves students' academic performance.
Christou and Dinov[41]	Undergraduate students enrolled for the introductory course on statistical methods (Statistical Methods for the Life and Health Sciences).	Students' learning styles are important confounds of their final quantitative performance.
Diseth et al.[42]	442 first semester undergraduate psychology students.	Academic performance is directly affected by approaches to learning.

[38] H. Awang et al., "Relationship between the Learning Styles Preferences and Academic Achievement," in *IOP Conf. Series: Materials Science and Engineering* (2017), http://iopscience.iop.org/article/10.1088/1757-899X/226/1/012193/pdf.

[39] L. L. Gappi, "Relationships Between Learning Style Preference and Academic Performance of Students," *International Journal of Educational Research and Technology* 4, no. 2 (2013): 70–76.

[40] Afsaneh Hassanbeigi et al., "The Relationship between Study Skills and Academic Performance of University Students," *Procedia-Social and Behavioral Sciences* 30 (2011): 1416 – 1424.

[41] N. Christou and I.D. Dinov, "A Study of Students' Learning Styles, Discipline Attitudes and Knowledge Acquisition in Technology-Enhanced Probability and Statistics Education," *MERLOT Journal of Online Learning and Teaching* 6, no. 3 (2010).

[42] S. Diseth, Ã., Pallesen, S., Brunborg, G., and Larsen, "Academic Achievement among First Semester Undergraduate Psychology Students: The Role of Course Experience, Effort, Motives and Learning Strategies," *Higher Education* 59, no. 3 (2010).

Table 2 (Continue)

Hypothesis: The effect of instructors' teaching practices on students' performance.		
Author (s)	Context	Results
Yousef[43]	750 undergraduate business students in third- and fourth-year classes at the UAE University (UAEU).	Teaching style has a great influence on the academic performance of UAEU undergraduate business students.
Ganyaupfu[44]	119 business students from private higher education institutions in Gauteng province, South Africa.	Instructor competence, teaching methods and quality of learning materials have a significant positive influence on students' academic achievements in quantitative business courses.
Usmani and Dawani[45]	200 students of BBA (Bachelor of Business Administration) program, enrolled in their second semester at Iqra University, Pakistan.	The performance of the students who were taught through spaced learning was better as compared to massed learning.
Hosal-Akman and Simga-Mugan[46]	Third-year management students in the 2003–2004 spring semester at the business school of a major private university in Turkey.	Teaching methods had no significant effect on academic performance, but mean exam scores of students who were exposed to cooperative learning were higher than the students who were taught by traditional teaching methods.

[43] Darwish Abdulrahamn Yousef, "Factors Influencing Academic Performance in Quantitative Courses among Undergraduate Business Students of a Public Higher Education Institution," *Journal of International Education in Business* 10, no. 1 (2017).

[44] E.M. Ganyaupfu, "Factors Influencing Academic Achievement in Quantitative Courses among Business Students of Private Higher Education Institutions Journal of Education and Practice," *Journal of Education and Practice* 4, no. 15 (2013): 57–65.

[45] Sania Usmani and Kalpina Dawani, "Teaching Methods and Their Impact on Performance of University Students," *South Asian Journal of Management Sciences* 7, no. 1 (2013): 19–30, http://sajms.iurc.edu.pk/issues/2013a/Spring2013V7N1P3.pdf.

[46] Nazli Hosal-Akman and Can Simga-Mugan, "An Assessment of the Effects of Teaching Methods on Academic Performance of Students in Accounting Courses," *Innovations in Education and Teaching International* 47, no. 3 (2010): 251–60, http://repository.bilkent.edu.tr/bitstream/handle/11693/22250/bilkent-research-paper.pdf?sequence=1&isAllowed=y.

Hypothesis: The effect of students' attitudes towards statistics on students' performance.		
Author (s)	Context	Results
Rosli and Maat[47]	173 post-graduate students from the Faculty of Education, UKM, Bangi.	There is a medium and positive relation between attitude towards statistics and students' performance.
Sesé et al.[48]	472 university students enrolled in statistics courses of Health Sciences majors.	Performance in statistics was positively and directly affected by attitudes towards statistics.
Stanisavljevic et al.[49]	417 medical students who were enrolled in an obligatory introductory statistics course	Significant correlations were found between measures of attitudes towards statistics and statistics achievement which indicate that students with positive attitudes have a better test performance.
Christou and Dinov[50]	Undergraduate students enrolled for the introductory course on statistical methods (Statistical Methods for the Life and Health Sciences).	Students' attitudes towards a discipline are important confounds of their final quantitative performance.
Evans[51]	80 female and 35 male students from mathematics, psychology and sociology departments.	Significant correlations were found between student attitudes and achievement in statistics, both at the beginning and end of the course.

Discussion

The assessment of performance in statistics in the undergraduate population has been of interest to researchers over the years. Many

[47] Mira Khalisa Rosli and Siti Mistima Maat, "Attitude towards Statistics and Performance among Post-Graduate Students," in *Proceedings of the International Conference on Education, Mathematics and Science 2016, ICEMS 2016, in Conjunction with 4th International Postgraduate Conference on Science and Mathematics 2016, IPCSM2016* (American Institute of Physics Inc., 2017).

[48] Albert Sesé et al., "Can Attitudes Toward Statistics and Statistics Anxiety Explain Students' Performance?," *Revista de Psicodidáctica* 20, no. 2 (2015): 285–304.

[49] Dejana Stanisavljevic et al., "Assessing Attitudes Towards Statistics Among Medical Students: Psychometric Properties of the Serbian Version of the Survey of Attitudes Towards Statistics (SATS). PLoS ON," *PLoS ONE* 9, no. 11 (2014), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4236124/pdf/pone.0112567.pdf.

[50] Christou and Dinov, "A Study of Students' Learning Styles, . . ."

[51] Brian Evans, "Student Attitudes, Conceptions, and Achievement in Introductory Undergraduate College Statistics," *The Mathematics Educator 2007* 17, no. 2 (2007): 24–30.

efforts have been made to investigate factors that affect students' performance in statistics courses.[52] These factors include instructors' knowledge, teaching/learning environment, attitude, anxiety, perceived ability/self-efficacy, learning practices, teaching practices, use of technology in learning, socio-economic status, gender and age. Keeping in view all the variables on factors affecting performance, only four factors which are deemed as most related to the self are chosen in this literature review which are students' attitudes towards statistics, students' perceived ability, teaching practices and learning practices.

Despite the increased importance of statistics, many students encounter difficulties in learning the subject. Cognitive factors, such as mathematics aptitude and background, and affective factors, such as mathematics and statistics anxiety, attitudes towards mathematics and statistics, and achievement motivation are some of the factors that have been suggested as related to performance in statistics.[53] Several models have also been proposed to explain the inter-relationships. Onwuegbuzie[54] developed a model for predicting statistics achievement among graduate students (Figure 2). Cognitive variables, affective variables and demographic factors were used to predict statistics achievement.

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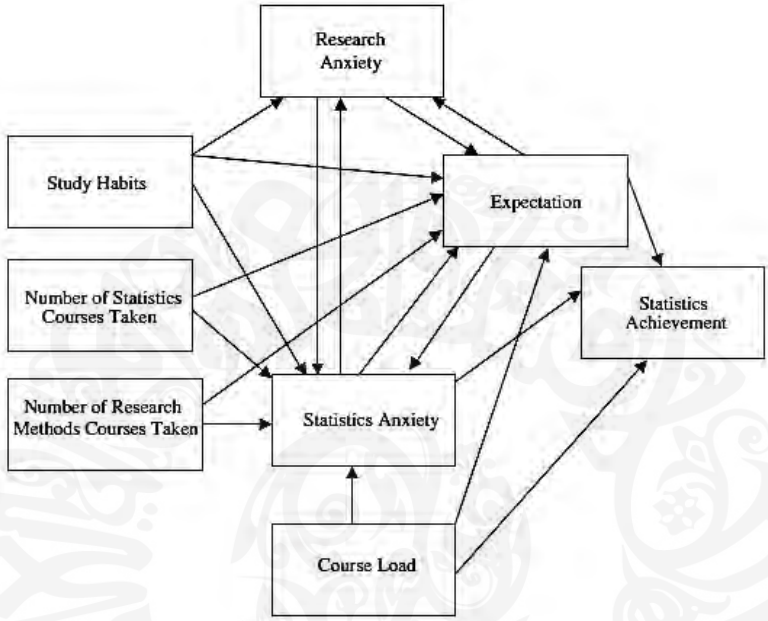
[52] I.D. Cherney and R.R. Cooney, "Predicting Student Performance in a Statistics Course Using the Mathematics and Statistics Perception Scale (MPSP)," *Transactions of the Nebraska Academy of Sciences* 30 (2005): 1–8; C.F. Rochelle and D. Dotterweich, "Student Success in Business Statistics," *Journal of Economics and Finance Education* 6, no. 1 (2007): 19-24; M. Monroe, S, Moreno, A., and Segall, "Student Performance Determinants in a Business Statistics Course at a Large Urban Institution," in *The Academic and Business Research Institute Conference Proceedings* (Las Vegas, NV, 2011).

[53] R.N. Lalonde and R.C. Gardner, "Statistics as a Second Language? A Model for Predicting Performance in Psychology Students.," *Canadian Journal of Behavioural Science* 25, no. 1 (1993): 108–25, https://doi.org/10.1037/h0078792; F. Nasser, "Attitudes toward Statistics and Statistics Anxiety among College Students: Structure and Relationship to Prior Mathematics Experience and Performance in Introductory Statistics Course.," (presentation, Annual Meeting of the Stress and Anxiety Society (STAR), Turkey, Istanbul, 1998).

[54] A. J. Onwuegbuzie, "Modeling Statistics Achievement among Graduate Students," *Educational and Psychological Measurement* 63, no. 6 (2003): 1020–38.

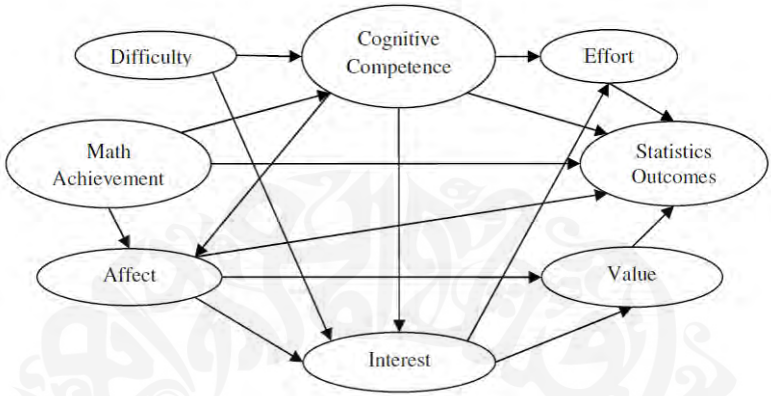
Figure 2. Initial Anxiety-Expectation Mediation Base Model of Statistics Achievement



Emmioğlu [55] later looked into the structural relationships among mathematics achievement, attitudes toward statistics and statistics outcomes using a structural equation model. The conceptual structure of the proposed model is shown in Figure 3.

[55] E. Emmioğlu, "The Relationship between Mathematics Achievement, Attitudes toward Statistics,and Statistics Outcomes: A Structural Equation Model Analysis" (PhD dissertation, Middle East Technical University, 2011).

Figure 3. Conceptual Structure of the Statistics Attitudes-Outcomes Model



Findings of previous research show that students' performance in statistics can be affected by many factors including the complexity of the subject, the teaching methodology, and the way students are being assessed. Assessment must fully evaluate student learning and growth [56] and must truly communicate to the student what is important.[57] Instructors can use alternative assessment methods to better understand and document student learning and motivate them.[58] Attitudes, perceived ability, learning practices and teaching practices are significant performance related factors of students' understanding of statistics. However, the findings may vary due to some of the limitations and differences in methodology used in various studies.

[56] D. Ben-Zvi, "Towards Understanding the Role of Technological Tools in Statistical Learning," *Mathematical Thinking and Learning* 2, no. 1&2 (2000): 127–55; B. Chance, R. DelMas, and J. Garfield, "Reasoning about Sampling Distributions," in *The Challenge of Developing Statistical Literacy, Reasoning, and Thinking*, ed. D. Ben-Zvi and J. Garfield (Dordrecht, The Netherlands: Kluwer, 2004), 295–323; C. Franklin and J. Garfield, "The GAISE Project: Developing Statistics Education Guidelines for Pre K-12 and College Courses," in *Thinking and Reasoning with Data and Chance*, ed. G. F. Burrill and P.C. Elliot (Reston, VA: National Council of Teachers of Mathematics, 2006), 345–75.

[57] Garfield, "How Students Learn Statistics."

[58] Ben-Zvi and Garfield, "Goals, Definitions, And Challenges."

The greatest factor that determines students' success is the influence of teachers.[59] Teachers must support and encourage a broader range of attitudes including appreciation of the power of statistical processes, chance, randomness, and investigate rigour, and a propensity to become a critical evaluator of statistical claims. Schau[60] notes the importance of student motivation and the need to use statistical thinking and statistical knowledge appropriately. Furthermore, it is very important to improve teaching practices and make students understand statistics consistently so that they can perform well.

From the Islamic perspective, a Muslim teacher should follow the way Prophet Muhammad (S.A.W) treated his companions so the students can be motivated and have high interest in their studies. Prophet Muhammad (S.A.W) on many occasions, had also praised and appreciated his companions, which had motivated them in every way. Students must be praised and showered with word of encouragement throughout the learning process.

Teaching practices varies where some instructors lecture, others choose to demonstrate or discuss, some focus on examples, some prone to memorizing and others emphasize on understanding. Factors affecting the ability of instructors to teach statistical topics in a way that improves statistical knowledge or statistical literacy of learners includes instructor's background, level of confidence, appreciation for the value of statistics and knowledge of the subject matter.[61] Most often, collaborative learning group techniques have been recommended to reduce student anxiety and improve statistical

[59] T. J. Lasley, D. Siedentop, and R. Yinger, "A Systemic Approach to Enhancing Teacher Quality: The Ohio Model," *Journal of Teacher Education* 57, no. 1 (2006): 13–21.

[60] C. Schau, "Students' Attitudes: The 'Other' Important Outcome in Statistics Education," in *2003 ASA Proceedings:Papers Presented at the American Statistical Association Joints Statistical Meetings.* (Alexandria, VA: American Statistical Association, Section on Statistical Education, 2003).

[61] D. North, I. Gal, and T. Zewotir, "Building Capacity for Developing Statistical Literacy in a Developing Country: Lessons Learned from an Intervention," *Statistics Education Research Journal* 13, no. 2 (2014): 15–27, http://iase-web.org/documents/SERJ/SERJ13(2)_North.pdf.

skills and knowledge.[62] Peer learning is a way teacher can use to teach statistics, as described by O'Donnell.[63] He explains that cooperative and collaborative learning, peer tutoring, cross-age tutoring, and other teaching approaches intend at forming the way students work together with each other as they study.

Forte[64] and Wilson[65] suggest that applying statistics to real-world situations is helpful in alleviating anxiety in statistics classes. Teaching statistics with student survey data allow for greater continuity and on-going conversation with students. It makes new concepts and techniques easier to teach, and statistics more accessible to students.[66] As Batanero[67] suggests, introductory statistics courses should focus on statistical thinking. Statistical data analysis is not a mechanical process but a way of thinking that helps learners solve problems in science and everyday life. Thus, teaching statistics should begin with real problems through which students develop their ideas, working through the different stages of solving a real problem. Combining new teaching practices with technology could improve students' attitudes toward statistics and therefore enhance the learning process.[68]

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[62] C. J. Auster, "Probability Sampling and Inferential Statistics: An Interactive Exercise Using M&M's," *Teaching Sociology* 28 (2000): 379–85; H.W. Fischer III, "Teaching Statistics from the User's Perspective," *Teaching Sociology* 24, no. 225–230 (1996); D.V. Perkins and R.N. Saris, "A 'Jigsaw Classroom' Technique for Undergraduate Statistics Courses," *Teaching of Psychology* 23 (2001): 259–63; A.M. Potter, "Statistics for Sociologists: Teaching Techniques That Work," *Teaching Sociology* 23 (1995): 259–63.

[63] A.M. O'Donnell, "The Role of Peers and Group Learning," in *Handbook of Educational Psychology*, ed. P.A. Alexander and P.H. Winne, 2nd edn. (Mahwah, NJ: Lawrence Erlbaum Associates, 2006), 781–802.

[64] J. A. Forte, "Teaching Statistics without Sadistic," *Journal of Social Work Education* 31 (1995): 204–18.

[65] V.A. Wilson, "A Study of Reduction of Anxiety in Graduate Students in an Introductory Educational Research Course" (presentation, Annual Meeting of the Mid-South Educational research Association, New Orleans, L.A., 1998).

[66] D. Stork, "Teaching Statistics with Student Survey Data: A Pedagogical Innovation in Support of Student Learning," *Journal of Education for Business* 78, no. 6 (2003): 335–39.

[67] C. Batanero, "Controversies around the Role of Statistical Tests in Experimental Research," *Mathematical Thinking and Learning* 2, no. 1 & 2 (2000): 75–97.

[68] K. Kreijns et al., "Measuring Perceived Sociability of Computer-Supported

Classroom practical and projects have their own advantages and disadvantages. Projects take a longer time period, but the outcomes are very much worthwhile. Projects make statistics more relevant, give more motivation and a greater feel for real data, emphasize the statistics application and usefulness and show that statistics is not solely mathematics.[69] It has been proven that writing an assignment is an effective way to help students to form positive attitudes towards learning statistics.[70] The teaching of statistics concepts in introductory statistics courses as well as the implementation of technology into the statistics classroom has changed the teaching and learning of statistics over the years. The use of computers in the teaching of statistics is getting an increased attention from instructors and researchers as it improves students' attitude towards statistics.[71]

The classroom is a learning environment where interactions occur among students and instructors. Students' perceptions of their classroom learning environments and the factors associated with their perceptions may help us to find out some alternative ways to enhance student learning. Attention from instructors on students' perspectives is needed to make statistics an interesting subject. Ncube and

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Collaborative Learning Environments," *Computers & Education* 49 (2007): 176–92; M. Meletiou-Mavrotheris, C. Lee, and R.T. Fouladi, "Introductory Statistics, College Student Attitudes and Knowledge a a Qualitative Analysis of the Impact of Technology-Based Instruction," *International Journal of Mathematical Education in Science and Technology* 38 (2007): 65–83.

[69] Zamalia Mahmud, "A Study on Teaching Statistical Concepts at the Introductory Level: The Development and Testing of a Teaching Model and an Investigation into the Methodological Techniques" (Ph.D Thesis., 1997).

[70] B. Dolinsky, "An Active Learning Approach to Teaching Statistics," . . *Teaching of Psychology* 28 (2001): 55–56; D. S. Dunn, "Collaborative Writing in a Statistics and Research Methods Course," *Teaching of Psychology* 23 (1996): 38–40; M. Pan, W., & Tang, "Examining the Effectiveness of Innovative Instructional Methods on Reducing Statistics Anxiety for Graduate Students in the Social Sciences," *Journal of Instructional Psychology* 31 (2004): 149–59; S.A. Sgoutas-Emch and C.J. Johnson, "Is Journal Writing an Effective Method of Reducing Anxiety towards Statistics?," *Journal of Instructional Psychology* 25 (1998): 49–57.

[71] R. D. Hannafin and B. N. Scott, "Teaching and Learning with Dynamic Geometry Programs in Student-Centered Learning Environments: A Mixed Method Inquiry," *Computers in the Schools* 17 (2001): 121–141.

Moroke[72] list some of the recommendations by students to develop interest and to help them perform better in statistics course:

- More exercises after each chapter
- Groups assignment and presentations
- Presentations on how statistics can be integrated or applied in a job setting
- Use of statistical software to solve practical questions
- Quizzes

The case study by Tsai and Hsu[73] also lists the elements that students hope the instructor can improve on, which are adjusting teaching style according to the level of students, organization and planning of educational activities, highlighting key points of the course content, managing the progress and flow of classes, providing constructive criticism and comments on student assignments and exams, and objective and reasonable student evaluations.

Students' perceived ability is another important indicator in predicting the level of performance or motivation amongst students. Perceived ability or perceived self-efficacy is referring to one's belief about one's capabilities to produce certain levels of performance or ability in specific situations.[74] Self-efficacy to learn statistics is an individual's confidence in his or her ability to successfully learn statistical skills necessary in a statistics course. Finney and Schraw[75] investigated whether self-efficacy to learn statistics is related to performance in a statistics course and whether self-efficacy to learn statistics increased during a 12-week introductory statistics course.

[72] Bokang Ncube and Ntebogang Dinah Moroke, "Students' Perceptions and Attitudes Towards Statistics in South African University: An Exploratory Factor Analysis Approach," *Journal of Governance and Regulation* 4, no. 3 (2015).

[73] Yu-You Tsai and Ming-Shan Hsu, "Analysis of the Efficiency of Teaching Methods: Using the Variance-Based Method as an Example," *The Journal of Human Resource and Adult Learning* 8, no. 1 (2012).

[74] A. Bandura, "Self-Efficacy," in *Encyclopedia of Human Behavior (Vol. 4, Pp. 71-81). New York: Academic Press. (Reprinted in H. Friedman [Ed.], Encyclopedia of Mental Health*, ed. V. S. Ramachaudran (San Diego: Academic Press, 1998, 1994).

[75] S. J. Finney and G. Schraw, "Self-Efficacy Beliefs in College Statistics Courses," *Contemporary Educational Psychology* 28 (2003): 161–86.

One hundred and three undergraduate students from a large Midwestern university participated in the survey. Finney and Schraw [76] reported a positive relationship between statistics self-efficacy and academic performance as well as an increase in self-efficacy to learn statistics over the duration of the course. Onwuegbuzie[77] also reported students with the lowest levels of perceived competence had the highest levels of statistics anxiety. These findings are in line with other studies conducted at the secondary school level and undergraduate level.[78] Perceived ability might be a particularly important motivational factor for a student in the first year of the course at a university. There exists a relation between students' attitude and their perceived ability at the beginning of the course and certain beliefs do motivate and demotivate the students.[79]

Interest in learning statistics leads to positive attitude and higher perceived ability. The attitudes of students towards learning a subject have a major consideration on the results of their learning processes and are likely to have a considerable effect on their motivation, and, thus, affect learning.[80] It is therefore important to

[76] Ibid.

[77] A. J. Onwuegbuzie, "Statistics Anxiety and the Role of Self-Perception," *Journal of Educational Research* 93 (2000): 323–35.

[78] J.D. House, "The Motivational Effects of Specific Instructional Strategies and Computer Use for Mathematics Learning in Japan: Findings from the Third International Mathematics and Science Study (TIMSS)," *International Journal of Instructional Media* 30 (2003): 77–95; Jaiswal and Choudhuri, "Academic Self Concept and Academic Achievement . . ."; Obilor, "Relationship Between Self-Concept and Mathematics Achievement . . . "; Tenaw, "Relationship Between Self-Efficacy, Academic Achievement . . . ".

[79] M. Dempster and N. K. McCorry, "The Role of Previous Experience and Attitudes toward Statistics in Statistics Assessment Outcomes among Undergraduate Psychology Students.," *Journal of Statistics Education* 17, no. 2 (2009), http://www.amstat.org/publications/jse/v17n2/dempster.html; P. Kloosterman, A. Raymond, and C. Emenaker, "Students' Beliefs about Mathematics: A Three Year Study," *The Elementary School Journal* 97 (1996): 40–56.

[80] Christou and Dinov, "A Study of Students' Learning Styles, Discipline . . . "; Diseth, Ã., Pallesen, S., Brunborg, G., and Larsen, "Academic Achievement among First Semester Undergraduate . . . ; P. F. Tremblay, R. C. Gardner, and G. Heipel, "A Model of the Relationships among Measures of Affect, Aptitude, and Performance in Introductory Statistics," *Canadian Journal of Behavioural Science* 32, no. 1 (2000):

understand students' attitudes and their relationship with teaching and learning of statistics. Researchers also found students' negative attitudes toward statistics is an influencing factor in low student performance in statistics courses.[81] Students' attitudes toward statistics may create a major obstacle for effective learning[82] and as a result, teaching statistics and even research methods can become a major pedagogic challenge. Onwuegbuzie[83] also expressed the concern that non-cognitive issues like students' attitudes, feelings, beliefs and perceptions may counteract the learning environment that statistics instructors are attempting to create. Schau[84] found that students' attitude toward statistics were positively related to their achievement in statistics. Hilton, Schau and Olsen[85] believed that evidence is slowly growing to support the belief that students' attitudes toward statistics affect their course enrolment, persistence, achievement and the general climate in the class. Since students' attitudes toward statistics are important, we must be able to assess them. According to Gal et al.[86] students' attitudes toward statistics

40–48.

[81] L. T. Araki and K. S. Shultz, "Student Attitudes toward Statistics and Their Retention of Statistical Concepts" (presentation, Annual Meeting of the Western Psychological Association, Los Angeles, 1995); P. B. Elmore, E. L. Lewis, and M. L. G. Bay, "Statistics Achievement: A Function of Attitudes and Related Experiences" (presentation, Annual Meeting of the American Educational Research Association, Atlanta, GA, 1993); A. L. Harvey, B. S. Plake, and S. L. Wise, "The Validity of Six Beliefs about Factors Related to Statistics Achievement" (presentation, Annual Meeting of the American Educational Research Association, Chicago, IL, 1985); K. S. Shultz and H. Koshino, "Evidence of Reliability and Validity for Wise's Attitude toward Statistics Scale," *Educational and Psychological Measurement* 82, no. 1 (1998): 27–31.

[82] J. Mills, "Students' Attitudes toward Statistics: Implications for the Future," *College Student Journal* 38, no. 3 (2004): 349–362.

[83] Onwuegbuzie, "Statistics Anxiety and the Role of Self-Perception".

[84] Schau, "Students' Attitudes: The 'Other' Important Outcome in Statistics Education".

[85] S. C. Hilton, C. Schau, and J. A. Olsen, "Survey of Attitudes Toward Statistics: Factor Structure Invariance by Gender and by Administration Time," *Structural Equation Modeling* 11, no. 1 (2004): 92–109.

[86] I. Gal, L. Ginsburg, and C. Schau, "Monitoring Attitudes and Beliefs in Statistics Education," in *The Assessment Challenge in Statistics Education*, ed. I. Gal and J.B. Garfield (Voorburg, Netherlands: IOS Press, 1997), 37–51.

may affect the extent to which they will develop useful statistical thinking skills and apply what they have learned outside the classroom. Presumably, poor attitude will lead to poor skills. Therefore, it is important, for statistics instructors and educational researchers, to thoroughly study the attitudes students have toward statistics and their relationship with performance.

Learning strategies are also substantial in optimising academic performance.[87] Higher achievers report a greater use of most strategies than low achieving students although the strategies may vary among students.[88] Motivational components operate with them such that learners' belief about the likelihood of success affects their degree of self-regulation by influencing the learning strategies they use.[89] The use of certain learning strategies are related to interest in learning, and thus will improve students' understanding or

[87] B. Kizilgunes, C. Tekkaya, and S. Sungur, "Modeling the Relations among Students' Epistemological Beliefs, Motivation, Learning Approach and Achievement, 243-2," *The Journal of Educational Research* 102 (2009): 243–56; J. Rautopuro and P. Väisänen, "'I Did It My Way'. The Impact of Learning Styles and Strategies on Students' Success in Quantitative Research Methods in Educational Sciences," in *European Conference on Educational Research* (University of Hamburg, 2003).

[88] R. Dunn et al., "A Meta-Analytic Validation of the Dunn and Dunn Model of Learning-Style Preferences," *Journal of Educational Research* 88 (1995): 353–361; A. Klavas, "In Greensboro, North Carolina: Learning Style Program Boosts Achievement and Test Scores," *The Clearing House* 67 (1994): 149–51; K. Ablard and R.E. Lipschultz, "Self-Regulated Learning in High-Achieving Students: Relations to Advanced Reasoning, Achievement Goals, and Gender," *Journal of Educational Psychology* 90, no. 1 (1998): 94–101.

[89] Christou and Dinov, "A Study of Students' Learning Styles, Discipline . . ."; Shultz and Koshino, "Evidence of Reliability and Validity for . . ."; B. J. Zimmerman, "Self-Regulated Learning and Academic Achievement: An Overview," *Educational Psychologist* 25, no. 1 (1990): 3–17; P. R. Pintrich and T. Garcia, "Student Goal Orientation and Self-Regulation in the College Classroom," in *Advances in Motivation and Achievement: Goals and Self-Regulatory Processes*, ed. M. Maehr and P. R. Pintrich (Greenwich, CT: JAI, 1991), 371–402; D. H. Schunk, "Goal Setting and Self-Efficacy during Self-Regulated Learning," *Educational Psychologist* 25, no. 1 (1990): 71–86; D. H. Schunk, "Self-Efficacy and Academic Motivation," *Educational Psychologist* 26 (1991): 207–31; B. J. Zimmerman and M. Martinez-Pons, "Student Differences in Self-Regulated Learning: Relating Grade, Sex, and Giftedness to Self-Efficacy and Strategy Use," *Journal of Educational Psychology* 82 (1990): 51–59.

performance.[90] Interestingly, Awang et al.[91] and Gappi[92] contradicting the studies by Christou and Dinov[93] and Diseth et al.[94] found that learning style has no effect on academic performance of students.

Conclusion

Many students perceive statistics as a difficult subject.[95] Students' perceived ability or self-efficacy influences the tasks students choose to learn and the goals they set for themselves which will affect their level of effort and persistence when learning difficult tasks. Students' perceived ability has implications on their performance and motivation levels. Hence, it is essential for instructors to apply appropriate approaches in teaching statistics so that students can learn, understand the subject better and to have interest in learning statistics, and not just to fulfil the requirements of the course enrolment.

However, students' understanding is not only influenced by instructors' teaching practices but also influenced by students' learning practices. Although few studies have found contradicting results, we still believe that this holds true as the context and methodology used differ. On the other hand, Oxford[96] highlighted that researchers have dedicated much time and energy into

[90] House, "The Motivational Effects of Specific . . . "; J. D. House, "Motivational Qualities of Instructional Strategies and Computer Use for Mathematics Teaching in Japan and the United States: Results from the TIMSS 1999 Assessment," *International Journal of Instructional Media* 32 (2005): 89–104.

[91] Awang et al., "Relationship between the Learning Styles Preferences and Academic Achievement . . ."

[92] Gappi, "Relationships Between Learning Style Preference and Academic Performance of Students. . . "

[93] Christou and Dinov, "A Study of Students' Learning Styles, Discipline . . . "

[94] Diseth, Ã., Pallesen, S., Brunborg, G., and Larsen, "Academic Achievement among First Semester Undergraduate . . ."

[95] Norhayati Baharun and A. Porter, "Removing the Angst from Statistics," (presentation, 5th Asian Mathematical Conference 2009, Kuala Lumpur, Malaysia., 2009).

[96] R.L. Oxford, "Language Learning Strategies in a Nutshell: Update and ESL Suggestions," in *Methodology in Language Teaching*, ed. J. C. Richards and W. A. Renandya (Cambridge: Cambridge University Press, 2002).

attempting to define and systematize the wide array of possible learning practices or strategies. Learning practices or strategies are immensely ambiguous phenomena and nothing is clear cut about them.[97]

Attitudes toward statistics also constitute an important part of statistics education and they are regarded as a factor affecting statistical achievement, literacy, or reasoning.[98] Attitudes are taken into consideration specifically for critical evaluation of statistical claims. Attitudes also have an important role in the teaching and learning process during class time, for the statistical behaviour out of the class, and enrolment in further statistics related courses. Students' attitudes towards statistics can help or hinder statistical thinking and they do influence the utilization of knowledge and skills in variety of contexts.[99] Students with low motivation or negative attitudes about statistics perform less in statistical literacy.[100] Using the right instrument in measuring students' attitude toward statistics is critical to ensure accurate results are formulated to address some of the issues in learning and teaching statistics.

In summary, there is still a need for more research in teaching and learning of statistics in order to improve students understanding in statistics and their performance. Researchers should collaborate in creating models, frameworks and assessment tools in contribution towards the reform of statistics education.

[97] Z. Dornyei, *Teaching and Researching Motivation* (Beijing: Foreign Language Teaching and Research Press, 2005).
[98] Gal, "Statistical Literacy - Meanings, Components, Responsibilities"; J. Watson, *Statistical Literacy at School: Growth and Goals* (Mahwah, NJ: Lawrence Erlbaum Associates., 2006).
[99] Gal, Ginsburg, and Schau, "Monitoring Attitudes and Beliefs . . ."
[100] Watson, *Statistical Literacy at School: Growth and Goals* . . .

AL-SHAJARAH

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