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Statistical Thinking Levels of Students in Al-Ghad International College for Applied Medical Sciences in Saudi Arabia and its Relationship to Gender

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Abstract

The purpose of the study was to identify the levels of statistical thinking among students of Al-Ghad International College for Applied Medical Sciences in the Kingdom of Saudi Arabia and the effect of gender differences. The study used quantitative data collection methods for one group such as observation checklists and qualitative data collection methods such as interviews and focus group discussion. Performance tasks were designed to classify students according to Langrall and Mooney (2002) statistical thinking evaluation framework. Each task has its own subtasks and objectives spread over four statistical skills in which validity and reliability were verified. The data was yielded from the measurements of 41 students' statistical thinking levels enrolled in biostatistics course in the first semester of the academic year 2018-2019. The results showed that the level of overall students' statistical thinking abilities was at the transitional level, followed by the idiosyncratic and quantitative levels respectively, while none of them reached the analytical level. The results also showed that there are no statistically significant differences in students' thinking levels attributed to gender. The study recommended the necessity of linking statistical activities to the reality of students' lives and specializations, focusing on the practical aspects rather than the theoretical ones, holding training programs to develop the capabilities of faculty members to classify their students according to their level of statistical thinking, and creating programs to develop statistical thinking among students.

Keywords: Levels of Thinking, Statistical Thinking, Statistical Skills, Frameworks for Measuring Statistical Thinking.

Introduction

In response to the critical role that data plays in the world, there have been widespread calls for reform in statistical education at all levels; learning to do statistics is fundamentally about learning to think and communicate statistically. Given that statistical data take a huge part of modern daily life, it is essential to develop statistical thinking during school education, no student should leave high school without engaging in the study of statistics that is essential for all of them, no matter what profession they may choose to pursue.

Studying statistics is a means and not an end (Minium, 1978), it is an effective tool that makes data meaningful (Peck et al., 2001) and used as a practical instrument to analyze problems objectively (Rasheed, 2003). Actually, the future of business depends on understanding Statistics (John et al., 2001).

The concept of statistics as counting began during the era of the Pharaohs especially during the reign of Ramses II (Abd Rabbo, 2001), while in the modern sense of the world statistics began evolving in the 18th century and developed until it reached its stable and well-known foundations, principles and theories. Statistics has grown into a field of study that involves the development of methods and tests that are used to quantitatively define the variability inherent in data, the probability of certain outcomes, the error and uncertainty associated with those outcomes mathematical and experimental objectives (Abu Zeid, 2003).

Cobb et al, (1991) perceived the need for cognitive frameworks to measure students' thinking and develop mathematics curriculum. Research related to students' thinking and justification is an important part in teaching process to guide teachers to become more creative and effective during lesson planning and implementation. Similarly, many studies related to students' thinking and revolve around numbers; geometry, fractions, ratio and proportion, probability and statistics have been used to guide education, whether at the global or local level (Mooney, 2002).

A strong body of research (e.g., Jones et al., 2000; Langrall and Mooney, 2002; Mooney, 2002; Mooney et al., 2001) concerns with statistical thinking and developed frameworks for that purpose. All frameworks indicate that students' statistical thinking grows over time, and engages in cognitive actions during data-handling processes. The frameworks consisted of a two-dimensional matrix: The first one includes four statistical skills of describing, organizing and classifying, representing, and analyzing and interpreting data. Descriptions of these cognitive actions are based on the general developmental model of Biggs and Collis (1991). Their model incorporates five modes of functioning, within each mode, four cognitive levels (pre-structural uni-structural, multi-structural, and relational) recycle and represent shifts in the complexity of students' reasoning. The second dimension included descriptors that characterize four levels of students' statistical thinking ranging from idiosyncratic, transitional, quantitative to analytical.

The idea of the current study has been formed based on the importance of measuring the levels of statistical thinking among students, in addition to their low achievement and small significantly success rates in statistics which may be attributed to the lack of educational activities they were exposed to and the large number of statistical expressions the teacher use. To the best of the researchers' knowledge, there is a dearth of search conducted on students' statistical thinking levels, which seems to be gap areas. The study findings may contribute to increasing interest in students' levels of statistical thinking, and raising their level of performance (Jones, et al., 2000).

Problem of the Study

Through their experience in the field of teaching statistics, the researchers noticed the lack of interest in the levels of statistical thinking among students, the consistently poor performance exhibited by students in statistics in particular and mathematics in general, lack of interest and the existence of negative attitudes towards these two courses, which may be attributed to the large number of terms, concepts, and theories used. Therefore, Developing students' levels require teachers to use various tasks and skills that depend on the results of research, experiments and educational theories.

Nasser (2000) reported that the most frequently detected errors in students' statistical thinking were the confusing concepts, misinterpreting descriptive information, employing inappropriate procedures, and applying partial information. Analyses reveal that potential sources of students' errors include assimilation of statistical concepts into inappropriate schema, failure to use knowledge sources, and lack of ability to relate and combine knowledge from different sources. While the study of (Capraro et al., 2005) revealed that students exhibited misconceptions and naive conceptions regarding representing data graphically, interpreting the meaning of typicality, and plotting 0 above the x-axis, the study recommended to address these errors and their related misconceptions in order not accumulate.

The recent recommendations also focused on the importance of developing students' awareness of statistical concepts and their applications, in addition to understanding the multifaceted concepts of statistics, which evolve with time, in order to become familiar with the various aspects of the subject matter.

Although the studies that examined students' statistical thinking through frameworks were few at the global and Arab levels, the use of the framework for evaluating students' statistical thinking levels by teachers is necessary in order to build appropriate statistical tasks, monitor and evaluate students' statistical thinking.

Therefore, in this study, the performance tasks developed in Mooney's framework will be used to describe students' statistical thinking at Al-Ghad International Colleges for Applied Medical Sciences and classify them in the light of four levels (idiosyncratic, transitional, quantitative, and analytical), and then to compare male and female students according to their levels of statistical thinking.

This study came in response to the recommendations of some previous global studies such as (Jones et al., 2000; Langrall and Mooney, 2002; Mooney, 2002; Mooney et al., 2001) which called for searching the extent to which the framework developed by (Langrall & Mooney, 2002) is appropriate for students from different cultural and environmental backgrounds and also for preparing various performance tasks.

Questions of the Study

1- What are the levels of students' statistical thinking at Al-Ghad International College for Applied Medical Sciences?
2- Do the levels of students' statistical thinking at Al-Ghad International College for Applied Medical Sciences differ according to gender variable?

Objectives of the Study

1- Identifying the levels of statistical thinking among students of Al-Ghad International College for Applied Medical Sciences.
2- Investigating gender differences in students' statistical thinking performance.

Significance of the Study

The findings are expected to provide potentially significant information on the importance of revealing the levels of statistical thinking skill among students of Al-Ghad International College for Applied Medical Sciences, which is considered one of the main skills in teaching and learning statistics and mathematics. The study came in response to the recommendations of some previous global studies, which called for searching the extent to which the framework used is appropriate for students from different cultural and environmental backgrounds. It could be the first step in conducting more studies related to students' levels of statistical thinking.

Based on the findings and recommendations, the study is hoped to assist decision-makers and curricula designers in the educational field in Saudi universities to take advantage of the framework used in this study in a way that suits the nature of students' thinking, holding courses to qualify teachers in classifying students, designing relevant performance-related tasks and supporting the curricula and textbooks with various examples and activities to suit students' levels.

Definition of Terms

Biostatistics: is a compound term of biology and statistics, sometimes referred to as biostatistics or biometrics. It is the application of statistics to a wide range of topics especially those related to human biology, health, and medicine, through collecting, analyzing and interpreting biological data, therefore, biostatistics is concerned with finding the causes of diseases, and extends to predicting diseases and symptoms before they occur (Abdo, 2017). Al-Ghad International College for Applied Medical Sciences in Saudi Arabia offers biostatistics course within the first level courses in first academic year.

Statistical thinking: Chance (2002) mentioned that statistical thinking was defined in a number of different ways, and while there are similarities, there does not appear to be a single, all-encompassing definition that is embraced by all who engage in it. However, they all agreed on the necessity of developing statistical thinking among learners at all academic levels (Abdel Hamid, 2006).

Snee (1999) defined statistical thinking as a series of interconnected processes, summarized in identifying, characterizing, quantifying, controlling, reducing variation and providing opportunities for improvement. Jaradat (2013) goes in line with Snee and defined statistical thinking as mental processes and skills that an individual performs to develop ideas related to statistical situations and experiences. It is the processes of describing, organizing and reducing, representing, analyzing, and collecting data (Mooney et al., 2001). It is a process of summarizing data, solving a specific problem, building logical inferences and explaining conclusions (Wild & Pfannkuch, 1999). Zieffler et al (2003) see that statistical thinking requires understanding how and why statistical operations are implemented, and understanding the context in which the problem is mentioned, and its impact on reaching logical conclusions.

Langrall and Mooney (2002) define statistical thinking as describing, organizing, summarizing, representing, analyzing and interpreting data. Describing data means knowing the features of presentations and graphs, and assigning data values, while organizing and summarizing data includes sub-processes such as arranging data and using measures of central tendency and dispersion. Data presentation involves creating presentations and graphics for data. Analyzing data means to interpret and compare it, and then make inferences and conclusions.

The researchers believe that all statistical thinking definitions can be summarized as mental processes and skills carried out to develop ideas related to statistical situations and experiences, through the use of induction, deduction, interpretation skills, in addition to collecting, describing, organizing, summarizing, representing, analyzing and interpreting data to reach logical and correct conclusions.

Levels of Statistical Thinking: are the development stages of students' thinking in statistics, and determined according to Mooney's (2002) statistical thinking framework describing four thinking levels (*idiosyncratic, transitional, quantitative, and analytical*) across four different statistical thinking processes (*describing, organizing and classifying, representing, analyzing and interpreting data*). For revealing these levels among students, they will be procedurally defined as follows:

1- **Idiosyncratic Level**
Students justify their answers based on their own opinions and imperfect experiences, demonstrate little awareness of display features of a table, chart or graphical representation, misinterpret or do not identify units of data values, make no attempt to group or order the data in a summative form and do not use relative thinking to describe data or make comparisons.

2- **Transitional Level**
Students move between subjective and quantitative judgment, demonstrate some awareness of display features of a table, chart or graphical representation, identify the units of data values incompletely, groups or orders data but not in a summative, make partially correct comparisons based on only one dimension.

3- **Quantitative Level**
Students use systematic strategies in dealing with data, group or order data in a summative form, representative of the data, demonstrate complete awareness of display features a table, chart or graphical representation, Identify the units of specific data values, uses measures of central tendency and range, but the justification is not complete, and they use quantitative justifications.

4- **Analytical Level**
Students use systematic strategies in dealing with data, and deal with measures of central tendency and range correctly and justifiably, demonstrate complete awareness of display features a table, chart or graphical representation including features that are irrelevant or cosmetic, identify the units of general data values, group or order data in a summative form.

Statistical Skills: It refers to four basic skills in statistics, which were defined in Mooney's framework as follows:

1- Describing data: entails the explicit reading of data presented in tables, charts, or graphical representations.
2- Organizing and classifying data: involves arranging, categorizing, or consolidating data into a summary form.
3- Representing data: involves displaying data in a graphical form.
4- Analyzing and interpreting data: consists of identifying trends and making inferences or predictions about the data.

Statistical Thinking Framework: it is conceptual representation that summarizes information, data or educational phenomena (Amira, 1986), it is a construction from one or more dimensions that clarifies the relationship between the system components and its procedures and shows the possibilities of its paths (Al-Qalla, 1989).

Based on the foregoing, the researchers believe that statistical thinking framework indicates a simplified conception that describes, clarifies, summarizes and analyzes the nature of statistical thinking, its skills, levels, and the relationship between them, furthermore, it clarifies the processes of planning, implementing and evaluating statistical thinking according to sequential or separate steps to achieve the goals.

According to statisticians and educators, statistical thinking frameworks are ways of thinking, both statisticians and teachers model the intellectual activity in the statistical field by observing and trying to understand the patterns of students' ideas during their work individually or collectively, therefore, statistical thinking frameworks must be developed based on previous frameworks (Namrawi and Bayoumi, 2019).

Literature Review

There are studies investigating school students' statistical thinking via different methods. Rufiana et al (2019) built a conceptual framework to classify students according to their levels of statistical thinking with predictive skill. Al-ameer and Pasha (2018) identified statistical thinking, logical intelligence and the relationship between them. Chan et al (2016) conducted a study to find out a framework for measuring descriptive levels of statistical thinking. Sabbag (2016) investigated the correlation between statistical literacy and statistical thinking. Al-Refai's (2015) determined the levels of statistical thinking skills among university students. Koparan and Guven (2014) examined the level of statistical thinking for middle school students. Chan (2014) measured the statistical thinking ability of high school students in descriptive statistics. Chan & Ismail (2014) designed a test to evaluate descriptive statistical justification. Jaradat (2013) identified the level of statistical thinking among students of scientific departments at the university. Fitzallen (2012) designed a framework concerned with the statistical skills related to analyzing the data of the graphs program. Abu Awwad (2010) revealed the students' possession of statistical thinking skills. Akkas and Ucar (2010) revealed statistical thinking among middle school students. Makar and Rubin (2009) developed a framework that helps students and teachers to develop statistical thinking through practical and applied life issues. Zieffler et al (2008) designed a framework for measuring informal deductive statistical thinking. Al-Absi (2008) examined the prevalent aspects of mathematical thinking among primary school students. Groth (2003) described the

statistical thinking of high school students. Rupick (2002) revealed the types of statistical thinking that exist among middle school students. Valecillos and Moreno (2002) conducted a study to create a framework for characterizing and evaluating the learning of primary statistical inference for basic data. The studies of (Jones et al., 2000; Mooney's, 2002) evaluated statistical thinking among middle school students. Mooney et al (2001) refined and developed a model for classifying Statistical thinking among students. Langrall and Mooney (2002) built a framework for measuring statistical thinking, which all seem to go in line with the purpose of the current study.

The study is also consistent with some previous studies that revealed students' difficulties in studying statistics. Woodard (2020) investigated the role of homework in evaluating statistical thinking and monitoring errors and difficulties that students encounter. Maryati and Priatna (2018) monitored the misconceptions in statistical justification committed by students while solving statistical problems. Alkas and Kayhan (2017) analyzed the errors of school teachers with statistical skills. Wahiby (2013) revealed the type of students' conceptual errors through solving problems and tasks that require statistical justification. Garfiel et al (2015) evaluated students' difficulties in developing their statistical thinking and inferring about samples and their variables. Parke (2008) identified the difficulties that graduate students face in thinking and communicating in the language of statistics. Sharma (2006) determined the difficulties that students face in understanding statistical concepts. Capraro et al (2005) revealed the errors and misunderstandings among sixth-grade students in statistical thinking. Hirsh & ODonnell (2001) monitored conceptual errors in statistical justification. Nasser (2000) detected errors committed by students in solving multiple-choice questions about descriptive statistics and basic concepts in research methods.

The current study benefited from previous literature in designing the appropriate performance tasks to measure the levels of statistical thinking among university students, or developing the tasks found in previous studies to become appropriate to students at a university age level.

There is a dearth of search conducted on students' statistical thinking and their levels, and also little research was conducted on developing and evaluating educational programs to describe the nature of students thinking in situations involving statistics. If it is possible to determine the level of learners' thinking, it becomes possible to help them develop and progress by designing appropriate experiences and activities that suit the development process. Therefore, literature reviews were supportive to the current research problem.

The framework of study was modeled based on Langral and Mooney's framework developed for primary school students to classify the study sample members according to their levels of statistical thinking.

In light of the forgoing and upon reviewing theoretical literature, the problem and objectives of the current research were identified. The researchers extend the existing literature (e.g., Jones et al., 2000; Mooney, 2002; Mooney et al., 2001) which called for investigating the levels of students' statistical thinking, and the extent to which the framework is appropriate for those from different cultural backgrounds.

The current study differed from previous research since it examined the levels of statistical thinking among undergraduate students, unlike some previous studies, which investigated the levels of statistical thinking among school students, in addition to investigating the differences between the levels of students' statistical thinking according to gender variable.

In the current study, students' responses on papers and interviews, discussions during and after tasks performance were recorded on pre-specified response checklists, and then the completed formats are most often analyzed quantitatively which express students' statistical thinking levels, while previous studies have decided to correct only students' answers, and based on the interview without using checklists.

Study Methodology and Variables

The study is a qualitative comparative survey for one group with two variables:

- Four-level categorical dependent variable: statistical thinking with four levels: idiosyncratic – transitional-quantitative-analytical with the numerical values of one, two, three, four respectively)
- Two-level categorical independent variable (gender: male-female).

Study Sample and Population

The study population consisted of male and female students in Al-Ghad International College for Applied Medical Sciences (N = 304) enrolled in Biostatistics (BIOS 101) for the first time - the first level in the first semester of the academic year 2018-2019, distributed over eight branches in the following regions of the Kingdom of Saudi Arabia: Riyadh, Jeddah, Dammam, Medina, Tabuk, Qassim, Najran, and Abha. The study sample was selected by the purposive sampling method. The subjects in the study were 41 students: (20 males and 21 females) and constituted 13.49% of the study population, which is considered acceptable for such a qualitative study (Gharib, 2012).

Study Instruments

To achieve the study objectives, the following instruments were used: performance tasks, interviews, observation, attached forms and Mooney's framework for measuring and classifying statistical thinking levels.

- **Performance Tasks**

Upon reviewing the previous literature related to mathematical thinking in general and statistical thinking in particular, the performance tasks were prepared bearing in mind a fine balance in taking a genuine interest in students' life and surroundings. A problem situation that can be viewed real by the students when engaging in statistical thinking was created in the task such as measuring blood pressure, white blood cells, sports medals and elapsed time of a run and students' ages. The tasks should suit students' current and previous experience in statistics and biostatistics, and cover all four statistical skills and its objectives included in Mooney's framework: describing, organizing and classifying, representing, and analyzing and interpreting data. The tasks vary in their degrees of difficulty, ranging from one-step solution that focused on one axis, and gradually evolved into multi steps solution and more complex tasks that focused on several axes.

The main performance tasks consisted of 12 tasks, with 110 subtasks, spread over four statistical skills. They are inclusive for all sub-statistical skills objectives identified through the framework used in the study.

- **Interview and Individual Observation**

After interviewing the first and second pilot study, five to seven sessions interviews were agreed upon, each session lasting approximately one hour. Accordingly, the students were interviewed individually by the researcher and another faculty member and the responses were documented on a private performance task sheet prepared for each individual to collect study data, students were allowed to give their justifications on the subtasks questions. Students' writings and drawings were adopted, in addition to the notes of the researchers and the faculty member. For in-depth interviewing, the audio-visual recording was used, after obtaining consent from respondents. To control the interviews and observation process, the researchers designed several tools to be used in unloading interview data such as:

- A form for classifying the statistical thinking levels for each student during the interview.
- An aggregate form to unload the results of students' classifications on the performance tasks and for each statistical skill, according to their prevalent thinking levels in each skill separately.
- An aggregated form for unloading the classification results for all students on all statistical skills according to their prevalent thinking levels.

The previous forms were used to collect study data obtained through interviewing, listening, watching and noticing students' performances and justifications, then data were analyzed and evaluated through reading each question verbatim and at an appropriate pace and conducting follow-up probes for some questions in order to determine the levels of students' statistical thinking, more attention was paid to their answers during the final interview.

- **Framework for Measuring the Levels of Statistical Thinking**

To achieve the study objectives which is revealing the levels of students' statistical thinking at Al-Ghad International College for Applied Medical Sciences, the researchers reviewed previous literature related to frameworks for measuring different levels of statistical thinking and developed a framework based on (Langral & Mooney, 2002) which further refined to describe students' thinking in statistical situations and how to predict it. The framework consisted of a two-dimensional matrix: The first one includes four statistical skills of describing, organizing and classifying, representing, and analyzing and interpreting data. The second dimension consists of four levels of statistical thinking development ranging from idiosyncratic, transitional, and quantitative to analytical.

Validity of the Study Instrument

After reviewing previous and related literature, the study instruments were developed. A panel of 23 educational experts reviewed the instrument. According to The teams' comments and recommendations, the pre-final version of the study instrument was built and then applied on the first pilot study. Later and based on the observations of the researchers and two members of the teaching staff regarding the content of the instruments, its paragraphs, appropriateness to the purposes of the current study, the language clarity, suitability for all levels, its validity to achieve the study objectives, and how well they represent students'

statistical thinking levels, some paragraphs were deleted and modified in amending the final version of the study instrument.

Reliability of the Study Instrument

After developing the final version of the study instrument, it was applied on the second pilot study that consisted of 10 students taken from the study population and from different levels of achievement. To verify its reliability and validity, the classification of the pilot study was unloaded by the researcher and a faculty member who has been trained to use the study framework during and after students' performance and how to deal with their interviews and justifications that express their levels of statistical thinking in each statistical skill.

The reliability coefficients for Holisti, Cohen's Kappa coefficient, and Cooper's coefficient were used. (994) of second pilot study questions out of (1100) were involved.

Holistic reliability coefficient reached (90.36%), which is considered one of the high reliability coefficients because it exceeded the cutoff value (0.70), and considered acceptable in such a study (Al-Samarrai, 2015),

To ensure the reliability of the performance tasks, Cohen's Kappa coefficient (Kappa K) was calculated, using the following criterion: giving one mark to students who answer subtask correctly with an acceptable justification, and zero mark to student who get an answer wrong or answer correctly but with unacceptable justification (Chan et al., 2016; Chan & Ismail, 2016; Chan & Ismail, 2014; Chan & Ismail, 2013; Mooney, 2002; Langrall and Mooney, 2002; Garfield, 2002; Mooney, et al., 2001; Jones, et al., 2000). Subsequently, the percent of agreement between the researcher's evaluation and the faculty member's evaluation was calculated, 110 subtasks of each student at the pilot study were evaluated. Cohen's kappa coefficient reached (83.9%), which is considered one of the high reliability coefficients because it exceeded the cutoff value (0.70) and considered acceptable to measure the study objectives (Chan et al., 2016).

The Cooper coefficient was also calculated to find the stability of classification among the evaluators for the levels of statistical thinking for each individual and according to each statistical skill. The evaluators agreed on the classification of 34 thinking levels out of 40 (40 = members 10 x 4 skills). The coefficient of the agreement to calculate the reliability of the analysis using the Cooper equation reached 85%, and considered high and acceptable for such a study because it exceeded the cutoff level 0.70 (Leech, 2011).

Study Procedures

The following procedures were carried out in the course of the study

- The researchers reviewed the related literature to narrow the topic and aggregate the theoretical and empirical research related to the topic.
- The instruments of the study were designed (performance tasks, interview and observation tools, a framework for measuring the levels of statistical thinking).
- Determining the study population and sample, and obtaining an official letter to facilitate the researchers' task to start applying the study instruments on the two pilot studies and the main sample.
- Applying the study instruments on the first pilot group in order to know the extent to which the instruments are clear, how well the study sample respond to them, the possibility of classifying students, and training the evaluators for that purpose.

- A panel of educational experts reviewed the instrument whose comments and recommendations were studied carefully and taken into account in amending the final version of the instrument.
- Applying the study instruments on the second pilot group (the reliability sample) after being judged in order to verify their psychometric properties.
- Applying the study instruments on the study sample which consisted of (41) students of Al-Ghad International College for Applied Medical Sciences.
- Conducting individual interviews and taking observations for all students separately, to classify each one according to his level of thinking, and according to the statistical skill. Then, the related forms were used to unload the evaluation results and to collect study data.

Study Results and Discussion

The first research question sought the levels of statistical thinking among the students of Al-Ghad International College for Applied Medical Sciences. The level of thinking was determined for each student and for each subtask skill, the four ranks of statistical thinking (idiosyncratic – transitional-quantitative-analytical) were given the numerical values of one, two, three, four respectively.

Mean score was calculated for each individual and for each statistical skill by collecting the degrees of the subtasks for each statistical skill and dividing them by the number of subtasks (questions in that skill), for each individual separately and for all members of the study sample together, and then the students were classified according to their statistical thinking levels as follow:

Interval	**Statistical thinking levels**
1.00-1.49	Idiosyncratic
1.50-2.49	Transitional
2.50-3.49	Quantitative
3.50-4.00	Analytical

The classification of each individual on each subtask was unloaded, then compiling all classifications based on the type of the statistical skill, and on all statistical skills, to classify them according to the level of their general statistical thinking using the forms that have already been prepared. The levels of total statistical thinking on the compiled statistical skills were calculated as shown in Table 1 below:

Table 1
Levels of total statistical thinking on the compiled statistical skills

#	**Statistical thinking Levels**	**No.**	**%**
1	Idiosyncratic	9	22.0
2	Transitional	26	63.4
3	Quantitative	6	14.6
4	Analytical	0	0.0
Total		**41**	**100.0**

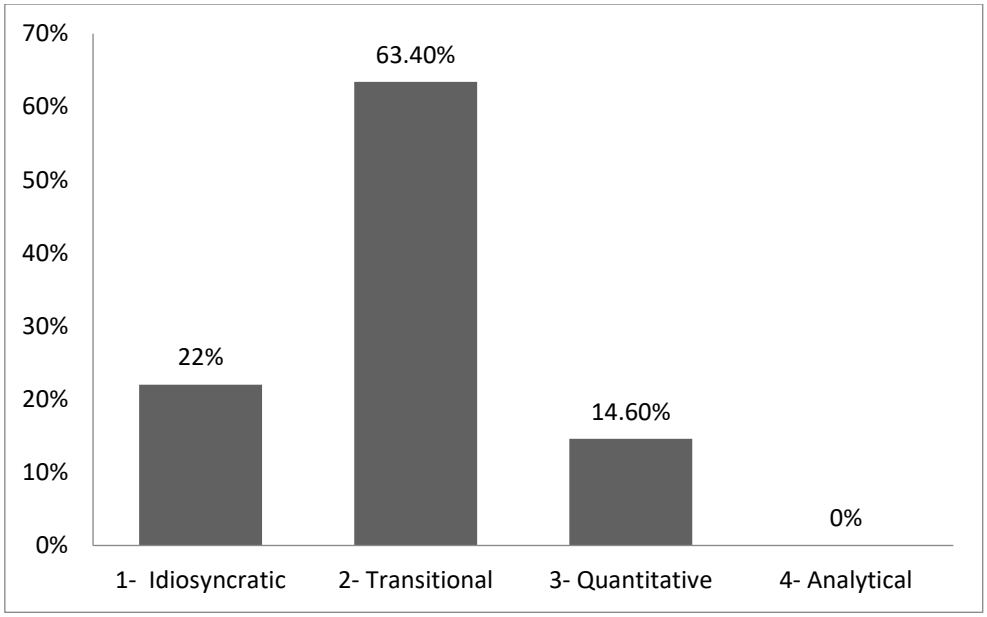

Fig1: Distribution of the study sample members according to the levels of total statistical thinking

Table 1 displays that students exhibit three levels of statistical thinking: 22.0% in the idiosyncratic level, 63.4% in the transitional level, which is the prevalent level for most students, 14.6% in the quantitative level, while no one reached the analytical level.

The researchers believe that students' inability to reach the fourth (analytical) level may be attributed to the fact that students face difficulties in writing appropriate statistical arguments, as well as they typically have limited experience in communicating in the language of statistics, both verbally and in written form , which results from poor statistical background , language barriers, or conflict with statistical concepts, which is consistent with the studies of (Woodard et al., 2020; Parke's, 2008).

For example, in task 9 (measuring diastolic blood pressure) there was difficulty expressing the normal distribution of the data either orally or in the written form, although students' answers indicates a general understanding that the data are distributed normally, but they are unable to report that in a clear statistical way.

Failure to reach the analytical level may also be attributed to students' poor statistical inference which goes in line with the study of (Maryati & Priatna, 2018), which showed that statistical inference skill is the process of using data analysis to draw conclusions about a population or process beyond the existing data. Students assume that statistics is just the ability to calculate and use formulas; they still have negative attitudes towards statistics subject. The study also showed that nearly half of the students have common statistical misconceptions and their statistical levels are relatively low.

In task 8 (*Measuring the number of white blood cells WBCs*), despite finding the variance and the standard deviation of WBCs, students could not justify the relationship between their values, some of them could not justify what the standard deviation value is, and how it can be used in describing the measurements of WBCs.

Furthermore, the researchers believe in the low level of statistical thinking might be referred to a set of statistical conceptual errors, the most notably are: misunderstanding the mean scores, inability to read and interpret graphs and percentages, errors in understanding the sample, and the failure to distinguish between correlation and causation. This was confirmed by the study of (Hirsh & O'Donnell, 2001; Wahiby, 2013), which showed that (36%) of their

sample were in the low level of statistical inference, (59%) in the medium level, and only (5%) in the high level, which attributed to the statistical conceptual errors.

Nasser's study (2000) concluded that the low level of statistical thinking among students is due to the inappropriate representations of statistical concepts in their memories and failing to use the different sources of knowledge coherently.

In task 10 (*the relationship between doctors' ages and their monthly incomes*), students were able to find the value of the correlation coefficient, but they were unable to report what it means and how it could be justified. They were unable to determine the type, direction, and strength of the relationship between doctors' ages and their monthly income.

The researchers believe that a large number of students make their decisions based on intuition, personal beliefs and previous experiences in daily and social life, many of them were unable to explain the reason for their answers or conclusions, which was confirmed by (Sharma, 2006).

task 11 (*diffusion and the relationship between two variables*) asks students to determine the shape that could represent the relationship between a person's income and height, some students answered based on their intuition, and selected Figure No. (8)) justifying that it is a vertical shape and the length is vertical as well.

Task 6 (*sports medals*), asks students to compare between Saudi colleges in terms of total number of medals won. Students from Qassim College, answered that their college has the most number of medals depending on personal beliefs and intuition without referring to the given data, although there are three collages rank better than Qassim collage in medal count.

The researchers also believe that the low levels of statistical thinking can be assigned to the fact that learners in many countries have a narrow view of the importance of statistical thinking in daily life; moreover, teaching statistics is limited to equations and laws and rarely addresses its practical usages. It is consistent with (Alston-Knox, 2019) who pointed out that giving awareness to statistics is fundamental for both teachers and students in addition to the critical role of statistical thinking in varied aspects of everyday life.

In task 3 (*drawing the flow graph, Part A*) the graph of some students, which represents the time needed to empty the swimming pool, was not related to reality. The graph was completed and descended to the bottom of the zero towards the negative y-axis, which may be attributed to students' lack of exposure to issues concerned with reality. Similarly, in Part B students could not connect between the temperature and the daylight of winter.

This is consistent with substantial research evidence (e.g., Le, 2017; Refai, 2015; Khamis, 2015; Chan, 2014); Jaradat, 2013; Abu-awwad; 2010; Sovak, 2010; Mentz, 2010); Al-absi, 2008; Mooney, 2002) which showed students' low levels in statistical thinking, and their lack of statistical thinking ability, absence of analytical level and that pre-service teachers are not pedagogically equipped to provide effective teaching in statistics and statistical thinking. On the contrary (Akkas & Ucar, 2010) showed that middle school students were classified at all levels of statistical thinking according to Mooney's framework.

The second research question sought whether the levels of statistical thinking among students of Al-Ghad International College for Applied Medical Sciences differ according to gender variable or not. The frequencies and percentage of the study sample members were calculated, by classifying students' levels of statistical thinking according to their gender as shown in Table 2 below:

Table 2
Levels of Statistical Thinking According to Gender Variable

Gender	Male		Female	
Levels of statistical thinking	**No**	**%**	**No**	**%**
Idiosyncratic	4	20.0	5	23.8
Transitional	11	55.0	15	71.4
Quantitative	5	25.0	1	4.8
Analytical	0	0.0	0	0.0
Total	20	100.0	21	100.0

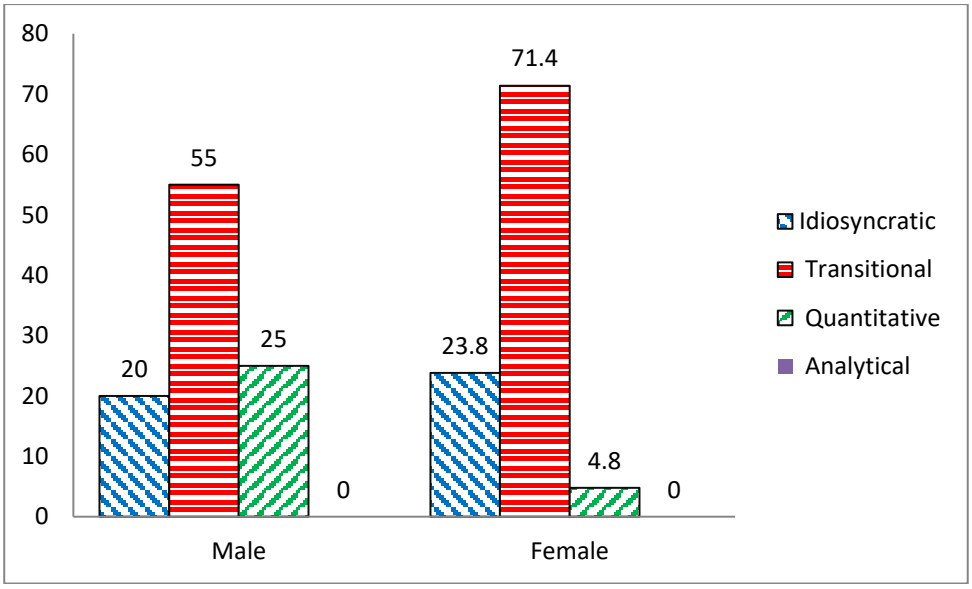

Fig 2: Levels of statistical thinking according to students' gender

Table 2 shows that the transitional level seems to be prevalent among the study sample. Male-to-female percents are almost the same in the idiosyncratic level, females were less in quantitative level in comparison with their male counterparts, while they tend to have higher percent in the transitional level. On the contrary, none of them was classified the analtical level.

The researchers believe that the convergence of statistical thinking levels between males and females can be explained in the light of Piaget's theory of cognitive development which defined thinking as a chain of synaptic connections and invisible cognitive activitiies, consciously using brains to make sense of the world and decide how to respond to it , these activities grow and develop according to the individual' experience and maturity (Al-Atoum et al., 2011; Ghanem, 2017).

Additionally, male and female students at the Al-Ghad International College are newcomers, they have the same maturity and experience that come with age. they share the same knowledge and motives towards learning, they also have similar preparations towards

developing their academic skills and achieving the best results in this similar age period. Therefore, all students went through the same stages of cognitive development in the same order which expresses the similarity in the levels of statistical thinking between males and females, and that the differences between them were not large.

In order to detect the statistically significant gender differences in the levels of statistical thinking among students of Al-Ghad International College, the nonparametric Mann-Whitney U test was used instead of t-test for independent (unrelated) pairs, because the sample size is small in each gender category, and could result in non-normal distribution. as shown in the Table 3 below:

Table 3

The results of the Mann-Whitney test to detect gender differences in the levels of statistical thinking

Statistical Skills	Gender	N	Mean Rank	Sum of Ranks	Mann-Whitney U	Z	Asymp. Sig. (2-tailed)
1- Describing Data (D)	Male	20	19.95	399.00	189.00	-.608	.543
	Female	21	22.00	462.00			
2- Organizing and Reducing Data (O)	Male	20	19.03	380.50	170.50	-1.12	.259
	Female	21	22.88	480.50			
3- Representing Data (R)	Male	20	22.58	451.50	178.500	-.912	.362
	Female	21	19.50	409.50			
4-Analytical and Interpreting Data (A)	Male	20	21.43	428.50	201.500	-.256	.798
	Female	21	20.60	432.50			
Total	Male	20	23.00	460.00	170.000	-1.220	.223
	Female	21	19.10	401.00			

Table 3 shows that there are no gender significant difference between students on the tasks measuring their levels of statistical thinking ($p > 0.05$) , which means that male and female students do not differ in their levels of statistical thinking.

Ben Trad (2017); Razouki & Karim (2013) concluded that the similarity of statistical thinking levels among students' can be explained in the light of the Gestalt theory that looks at the human mind and behavior as a whole. Minds tend to perceive objects as part of a greater whole and as elements of more complex systems rather than focusing on every small component. It is also called insight theory which refers to a completely cognitive experience that requires the ability to visualize the problem and the solution internally before initiating a behavioral response.

According to insight theory, there are several factors affecting indiviual's thinking: Physical maturity (refers to that condition of the body wherein an individual is able to carry out his lifestyle activities with greater ease to reach goals), mental maturity, (refers to the use of reason, objectivity and commonsense in thinking and behavior) and experience (the practical knowledge, skill, derived from previous direct observation or participation in events and particular activities).

Young minds think alike, male and female students belong to the same age group, there is a degree of similarity in the thought patterns amongst the younger subjects, their brains tend to light up in similar ways. the same level of physical maturity, mental maturity, and the same previous experiences in statistical skills led to the absence of differences in levels of statistical thinking.

The results goes in line with (Ramey, 2015; Khamis, 2015; Wahiby, 2013) which showed that there are no gender differences in the levels of statistical thinking.

Potential differences in achievement between female and male students have always been an interesting topic in statistical research. However, the effect of gender on the level of statistical thinking is still matter of controversy. Research (see, for example, Al-Absi,2008; & Martin et al., 2017) showed an effect of gender variable on the level of statistical thinking among third-grade students. Martin et al (2017) presented an evidence that there is a gender gap in statistical thinking in favor of males and attributed to the different level of anxiety and confidence between male and females.

Furthermore, multiple factors should be taken into cinsredartion when studying gender and statistical thinking, such as: the level of individual' interest in statistical thinking, cognitive processes, socialization, students' beliefs, attitudes, motives, and expectations, which profoundly influence the levels of statistical thinking.

Conclusion

Based on the results and discussion, it can be concluded the transitional level is predominant among the study sample while none of them reached the analytical level. The findings also revealed that there are no gender significant difference between students with regard to their levels of statistical thinking.

Recommendations

Based on the results of the current study, the researcher recommends the following:

1- Due to the average levels of statistical thinking among students, it is recommended to pay more attention to statistic courses, and prepare students to start their academic journey at university with statistical thinking levels that qualify them to follow their courses in statistics or majors related to statistics.
2- The necessity of reviewing the teaching and evaluation processes, the learning environment of biostatistics courses in Al-Ghad International College for Applied Medical Sciences, bearing in mind that biostatistics courses should include various activities about the skills, dimesions and levels of statistical thinking.
3- Developing study plans in the Al-Ghad International College and adding statistical courses to address the problems of low statistical thinking levels among students.
4- Focusing on the use of performance tasks as one of the most important instruments for assessing students' statistical thinking levels.
5- Amending biostatistics study plans in universities and focusing on students' statistical thinking levels with various statistical skills.
6- Identifying university faculty training needs in order to improve their skills and achieve the desired quality in classifying students according to their statistical thinking levels through employing the framework used in the current study.

7- Due to students' weakness in statistical thinking, universities should focus first on developing their cognitive aspects and providing them with the basic skills and concepts in statistics from the beginning of their collage enrollment, away from abstract form of laws that disrupt understanding.
8- Linking statistical activities to the reality of students' lives and specializations, and focusing on practical aspects rather than theoretical ones.
9- Biostatistics faculty members should take into account the statistical and mathematical backgrounds of university students during their presentation of statistical concepts.
10- Encouraging students to develop statistical thinking skills by understanding, organizing, summarizing and presenting data in their own ways, giving them the opportunity to analyze, interpret and justify data, through enrichment activities that clarify students' thinking and encourage them to communicate verbally or in written form.
11- Conducting further research on MA and PHD students in other colleges and universities.
12- Applying the framework of statistical thinking and the performance tasks used in the study on students from different cultural backgrounds, to verify their validity to measure what they were prepared for.
13- Creating teaching programs and measuring their effectiveness in developing the levels of statistical thinking among university students.
14- Revealing the levels of statistical thinking among faculty members, and the degree of their teaching practice in order to develop these levels among their students and finding the extent to which this reflects on their development.

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