THE COMPREHENSIVE, CRUCIAL AND CRITICAL ROLE OF STATISTICS IN ENHANCING THE QUALITY OF HIGHER EDUCATION

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ABSTRACT: It is well-known that Statistics is a very old science and was devised because of the need for it in dealing with a variety of issues related to life. It has developed and continues to develop steadily within itself whilst concomitantly developing other sciences which are themselves related to life's issues.
Most of the governments in the world are establishing different statistical centers/organizations in order to collect data in an efficient manner for preparing development plans for the different sectors of their countries. These development plans require accurate information so that decisions can be based upon the reliable data acquired**.**
Research is one of the most effective and indeed essential tools utilized in higher education. The minimization of research misconduct, the reinforcement of the validity of the methodology, the achievement of trust in the findings, constitutes a trio of standards required of each and every researcher to adhere to as they constitute the recognized research ethics and research integrity as a means of ensuring that the science of Statistics may be recognized as a valid element in providing the realization of dealing effectively with the issues related to life
This paper includes a quick glance at the history of Statistics, and the role of Statistics in higher education – as related to institutions, students and academic staff; and we will notice how the majority of basic and traditional works of higher education depend mainly on Statistics. The role of Statistics in data analysis, data science era, research, internal and external auditing of HEIs, the conclusions and the research directions are also discussed. This paper shows that the role of statistics in higher education is not only important but also comprehensive and significant.

KEYWORDS: Statistics; Data Analysis; Research; Teaching Processes; Quality

MSC: 6200;6201;6203

RESUMEN
Es bien sabido que la Estadística es una ciencia muy antigua y fue ideada por la necesidad de la misma para tratar una variedad de temas relacionados con la vida. Se ha desarrollado y continúa desarrollándose constantemente dentro de sí misma mientras desarrolla concomitantemente otras ciencias que están relacionadas con los problemas de la vida.
La mayoría de los gobiernos del mundo están estableciendo diferentes centros/organizaciones estadísticas con el fin de recopilar datos de manera eficiente para preparar planes de desarrollo para los diferentes sectores de sus países. Estos planes de desarrollo requieren información precisa para que las decisiones puedan basarse en los datos confiables adquiridos.
La investigación es una de las herramientas más eficaces y, de hecho, esenciales que se utilizan en la educación superior. La minimización de la mala conducta en la investigación, el refuerzo de la validez de la metodología, el logro de la confianza en los hallazgos, constituyen un trío de estándares que todos y cada uno de los investigadores deben cumplir, ya que constituyen la ética de la investigación reconocida y la integridad de la investigación como medio. de garantizar que la ciencia de la estadística pueda ser reconocida como un elemento válido para la realización de resolver con eficacia los problemas relacionados con la vida
Este documento incluye un vistazo rápido a la historia de la Estadística y el papel de la Estadística en la educación superior, en relación con las instituciones, los estudiantes y el personal académico; y notaremos como la mayoría de los trabajos básicos y tradicionales de la educación superior dependen principalmente de la Estadística. También se discute el papel de la estadística en el análisis de datos, la era de la ciencia de datos, la investigación, la auditoría interna y externa de las IES, las conclusiones y las direcciones de investigación. Este documento muestra que el papel de las estadísticas en la educación superior no solo es importante sino también integral y significativo.

PALABRAS CLAVE: Estadística; Análisis de los datos; Investigar; Procesos de Enseñanza; Calidad

1. INTRODUCTION AND LITERATURE

It is well-known that Statistics is a very old science and was devised because of the need for it in dealing with issues related to life. It has developed and continually develops steadily within itself, whilst, at the

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same time, developing other sciences which are in themselves related to the issues of life. In addition, it is very clear that Statistics is currently acquiring the same status as other sciences in terms of importance.
In order to understand the nature of this science and evaluate its role, it is necessary to have a simple glance at its historical side. Some historical sources indicate that the **Sumerians** (5200 B.C. (https://www.history.com/topics/ancient-middle-east/sumer) were the first to use Statistics - "the **Sumerians** collected population statistics for taxation purposes" (Bradley, 2007, p.1); in some other references later than the Sumerians "one of the kings of Babylon is credited with having instigated the system of decades of numbers by calling for a count of able-bodied fighting men in his kingdom" (Thomas, et al., 1961). Later on, the Egyptians and Chinese also used Statistics.
It is worth mentioning that the word "statistics" appears eleven times in the Holy Quran and in other issues related to statistics. In addition, it may be worth mentioning in this paper a few names of the pioneer Arab Statisticians. One of the most famous pioneers and one of the pillars in the Islamic heritage is Abu Yusuf Yaqub ibn Ishaq al-Sabbah Al-Kindi (801–873). He was well known in Baghdad as a multi-disciplinary scientist - as a philosopher, astronomer, and mathematician (see, Al-Daffa', 1978; King, 1979; O'Connor and Robertson, 1999a; Zalta, 2006; Broemeling, 2011). He was born in Kufa and educated in Baghdad. He was a pioneer in different sciences including Statistics and the first who developed frequency analyses; while he published a Manuscript "on Deciphering Cryptographic Messages" which explained the method of decoding the "encrypted messages" by the afore-named analyses. The second is Abu Jaafar Muhammad bin Muhammad bin Al-Hassan Al-Tusi (1201-1274). Abu Jaafar lived, studied, and acquired fame in Iraq. In Mosul he studied Mathematics and Astronomy with the Scientist Kamal A-Din Yunus (died 1242 CE). Abu Jaafar was the first to know how to use the concepts of Probability (See, O'Connor and Robertson, 1999b). Also, the third pioneer in Statistics was Bahaa Al-Din Muhammad Bin Al-Hussein Bin Abdul Samad Al-Harithi Al-Hamdani (1547-1629) who was the first to apply the rules of permutations and combinations (See, Al-Ameen, 2018).
In Europe, Statistics was used for a variety of purposes. In Czechoslovakia in 1651 the first classification list was done in Czech for the "vassals by religion by the Czech governors" (The History of Statistics, p.4). Later on in 1654, Statistics was used for the "tax rolls" in Bohemia (ibid, p.5).
In the early modern era, the European countries have actively participated in developing this science and transferring it to new and vast areas. Many pioneers have emerged and transferred the knowledge of Statistics from the level of simple applications to sophisticated levels and to amazing applications through the development of modern principles and solid scientific theories of Statistics. The first English pioneers in the early modern era are John Graunt (1620–1674) and William Petty (1623–1687) these two "were the first who started to investigate social phenomena using numerical records" (ibid, p.2). Thomas Bayes (1701 – 1761) devised the Bayesian Theory which created a new and very important domain of Statistics that developed the Science continuously and sharply right up to the present day. Also, the French pioneer Pierre-Simon Laplace (1749 – 1827) wrote a very good article on Probability in 1812 (Encyclopædia Britannica, 2016).
We can find a plethora of published papers/documents related to the role of Statistics. Generally, the role of Statistics may be divided in several main areas, i.e. in research and in traditional (routine) academic works, data analysis, teaching and learning and in auditing of HEIs; or in normal practices of different organizations which are related to higher education or to other sectors.
Also, the role of Statistics may be summarized by the following four main categories:
First, we can observe that the statistical applications are well articulated in the research of disciplines like geography, economics, management, machine learning, engineering, data science, data mining, pharmacometrics, biology and bioinformatics, …etc (Gibson, 2019). Second, we can observe significant statistical applications with the regular work of national/international bodies which are related to higher education like the international organizations of accreditation and rankings; also with national bodies like the ministries of higher education/education (see, CHEA, 2020; Al-Hemyari, 2019; BAC, 2019; THE, 2019; Al-Hemyari and Al-Sarmi, 2017; Al-Sarmi and Al-Hemyari, 2014a,b); Third, we also observe that the vast statistical applications are embedded in most of the issues and processes of HEIs in the world (ibid). Fourth, we can observe a lot of statistical applications of national/ international bodies/ ministries of Economic, Planning, Health, etc which are not related to higher education (see, Oster, et al., 2018; Barbosab, 2017; Freng, et al., 2011).
In this paper, due to the expansion of the role of statistics in a changing world, and because the importance of statistics appeared in all aspects of life, and by the governments and international organizations such as the United Nations, where they designated a special day for statistics called "World Statistics Day" and

because we are working in an HEI, we must shed light on the applications of Statistics in the higher education sector. In fact, several important applications have been imbedded in all the processes of all HEIs. This paper will focus on the role of statistics in higher education because the topic is very broad and it is very difficult to follow and trace all the higher educational activities. Then some of these aspects will be discussed briefly in this paper.
The aim of this paper is to shed light on several themes; some of which are: in the historical role of statistics, in the present academic arena, in data analysis, in research, and in several important issues of the quality of HEIs.
As we explained above, it is not easy to get acquainted with all the applications of statistics in higher education, so this paper will include the following Sections: the paper objectives are given in Section 2; Section 3 is for answering the question as to why we need statistics in our lives? Sections 4 and 5 are for discussing the role of statistics in traditional (routine) academic works, and the role of statistics in research respectively. The Role of Statistics in Teaching and learning is discussed in Section 6. In Sections 7 and 8 the role of statistics in internal auditing and external auditing are discussed respectively. The conclusions, limitations, and future research directions are given in Sections 9, 10 and 11 respectively.

2. THE OBJECTIVE OF THE RESEARCH

The objectives of this paper are seated as given below [to]:

- give a simple review of the history of Statistics;
- answer the question as to why we need statistics in our lives?
- explain the role of statistics in traditional (routine) academic works;
- discuss the role of statistics in data analysis;
- discuss the role of statistics in data science era;
- discuss the role of statistics in research;
- show the role of statistics in teaching and learning;
- review the role of statistics in internal auditing;
- review the role of statistics in external auditing;
- give some conclusions and limitation, and
- discuss a number of future research directions.

3. WHY DO WE NEED STATISTICS IN OUR LIFE?

The Earth is full of different phenomena, and we cannot find any two things alike, even twins. Is there a reason for this? Let's take the flowers, as an example. The shapes of the flowers and their colors are among the most beautiful of what God created for us. Our gardens and homes give that wonderful aesthetic view. These bright colors are among the most beautiful we see in nature. Poets enrich them a lot. And the "morning of roses" gently rolls every day on the tongues of the world in all its languages. But the question that arises is as to what this bewildering array is in all its diversity of shape, color and fragrance?
Simply, the answer will be that the reason for the diversity of creatures is variability! The variability of the world, and in everything of the world exists, but does not count, and because “not everything that can be counted counts and not everything that counts can be counted” (William Bruce Cameron, 1963) (see, Cullis, 2017)!
Let us imagine another virtual/hypothetical world in which we live, a world other than this one in which humans have lost all differences – a world which is highly undiversified in the similarity of its environment, and the role and the importance of environmental influences on genetic factors is broadly similar. Let us suppose that they live the same number of years in the same types of towns – in fact, everything is the same in such world. Human beings are the same in everything, wearing the same clothes, eating the same food, living in same environment and conditions, and the same in body weight and height. They go to the same schools with similar curricula, they study with the same teachers, and in the same classes and laboratories. Curricula, books, and academic programs are standardized, work starts and ends at the same time, they have the same holidays, they will obtain the same certificates and then they will do the same work. They will marry similar spouses who will be like them in everything, and they will live in houses similar to their fathers/grandfathers in terms of size and style ... etc. Then, they have similar habits, tastes, and personality traits. Many other similarities, and even their intelligence, morals, dreams, what they

like, what they hate, and even their genders, and the shapes of their genes are the same. Now what happened to these humans, also happened to the other creatures, including animals, plants, and inanimate objects.
Therefore, in such a world the research and studies in this society will be very easy and inexpensive, because any unit of this community will carry all the characteristics of the society, and the generalization of those results derived from one single unit for the general community is logically possible and sound, and so we would not need a lot of mathematics and statistics - such as logic, proofs, investigation, inference, deduction, generalization...etc.
Dear reader, mathematically / statistically speaking we say that the characteristics of such a society are fixed and similar. In addition, it is natural and logical to conclude and expect that all the creatures of this virtual community will die one day and at the same time. It's really a disaster, isn't it?
Fortunately, the world is not like this. Variability is an essential feature of creation and for life; and for every living and non-living being in this world it is necessary for the perpetuation and development of life in this universe. It has its own laws according to which it operates, and all these creatures are subject to the hereditary factors just as they are subject to the theory of evolution and gradation in kinds "by Ibn Khaldun". It is a natural gradient based on the integration of the assets, that is, the role of the environment in the formation of the genetic characteristics. Hence, the importance of statistical sciences and the variability of phenomena are the two complementary sides of one object.
What are the purposes of the various sciences in this life? It is to study the changes/variability that occurs in the phenomena pertaining to each of the sciences in an accurate and reliable manner. Hence, the clear and strong relationship between life and the statistical sciences as they both exist.

4. THE ROLE OF STATISTICS IN TRADITIONAL (ROUTINE) ACADEMIC WORKS

It is well known that the traditional works/daily routine and academic works of any HEI is based on the timetable of teaching in any given semester. Usually, the timetable is a schedule which contains all the offered courses to be taught in the institution. In addition, the timetable itself is constructed using statistical concepts (classification of the courses based on discipline/college; and some courses must be offered in an independent way to any other courses and others must be offered dependently in relation to other courses).
The main roles of academic staff are the teaching, research, and community engagement. In addition, the roles of students in higher education are reading, learning, submitting homework and assignments and sitting several tests. If we study the role of the academic staff and the role of the students in detail, we will find statistics and several statistical measures which exist here and there.
Most of the students in any HEI are attending lectures, seminars, and labs. Also, they are discussing their goals, limitations, question papers, homework, grades, etc. with their academic advisors. The students are usually eating in HEIs, doing sports, hobbies, attending student's activities/meetings/debates. They should allocate regular times for reading and learning. All the students are required to allocate a specific time for each course. In order to achieve the students' goals and academic success, students should make good preparation for the exams. Indeed, all the above activities will not be articulated properly and will not to be satisfied without the "business allocation schedule and time", which is again a statistical tool.
The daily/weekly routine of academic staff work contains several activities (attending classes, homework, tests, grading, attending academic and nonacademic meetings, advising students, …) which are designed according to the teaching and assessment plan and academic staff timetable. In addition, this plan is mainly a statistical table, which classifies the course material weekly (classes), distributing the credits/ contact hours for each week (frequencies).
Several other reports have to be submitted by each academic staff member to his department regarding different activities. Some of these are the students' attendance -weekly, the completed syllabus - weekly, grade reports and the completed syllabus at the end of the semester. In addition to these are students course results, field/visit requisition, plan for collaboration with students, student assessment procedure, course coordination report, risk management report, quality teaching and learning management reports, the governance review reports, the performance review reports, …etc. In fact, all these reports' contents are based on statistical measures and indicators.

5. THE ROLE OF STATISTICS IN DATA ANALYSIS

It is well noticed that the role of statistics is unique, comprehensive, crucial, and critical role in data analysis. If we generally talking about statistics, it is the science that is concerned with collecting data, classifying it, verifying its validity and accuracy, analyzing it and interpreting the results. So, in principle, there is no other science concerned with analyzing various data other than statistics in the absolute. Statistics is not just numbers and tables. It is a set of knowledge, theories, methods, standards, and procedures that allow a person to learn from data clearly and reliably.
For all scientific problems, statistical analysis and statistical results allow us to evaluate the various results, procedures and decisions that took place in any problem, and, it is possible to make the necessary recommendations based on the quantitative evidence we reached through the analysis. Statistical Analysis helps us to distinguish between essential and non-essential conclusions.
When designing a statistical analysis process for problem data, statisticians only keep a lot of statistics' problems in their mind before developing any data analysis. Statisticians know how to avoid pitfalls. For example, the result of a single weak correlation may lead to unreliable analysis. Some of the common pitfalls which required significance actions are the "accuracy and precision", "biased samples", "overgeneralization", "causality", incorrect and un suitable analysis", "violating the assumptions for an analysis" etc.

6. THE ROLE OF STATISTICS IN DATA SCIENCE ERA

The role of statistics in the data science era is a problematic issue! In order to explain this issue, the definitions of data science are to be given. The definition of this science changes from time to time and from one researcher to another, and this indicates that this science has not reached the independent academic specialty in order to distinguish it from the other sciences. The definition of data science may be defined as "the field of applying advanced analytics techniques and scientific principles to extract valuable information from data for business decision-making, strategic planning and other uses" (https://www.techtarget.com/searchenterpriseai/definition/data-science). It may be also defined as it "combines mathematics and statistics, specialized programming, advanced analytics, artificial intelligence, and machine learning with specific subject matter expertise to uncover actionable insights hidden in an organization's data" (https://www.ibm.com/cloud/learn/data-science-introduction). The above two definitions are clearly defining the role of data science which is exactly the role of statistics, i.e. It certainly borrows all statistical methods and tools with modern facilities!
In addition, the new definitions of Brodie, 2019 of data science have the same meaning but with different content ("data science is concerned with analyzing Big Data to extract correlations with estimates of likelihood and error"; or "data science is an emerging discipline that draws upon knowledge in statistical methodology and computer science to create impactful predictions and insights for a wide range of traditional scholarly fields."
Thus, and based on the above definitions we have reached the same existing conclusions that "the statistic is the root of science creation" (Ribeiro, et al., 2017) and the statistics and data science are two areas highly related, and the statistics represents the soil of data science (Weihs and Ickstadt, 2019).
Specifically, the role of statistics is very significant in some new fields of computer sciences like data science and artificial intelligence! In order to discuss its substantial role, the conclusions are copied from two papers of the above two fields: "Statisticians are delivering new methodologies and tools, in practical real-world systems dealing with large scale data challenges in areas as diverse as environmental monitoring, systems biology, neuro-imaging, and urban systems - to mention only a few. We are neither irrelevant nor behind the times, and we will continue to work with our colleagues who are creating the new data streams to learn from data" (Scott, 2018, p.12). And "we argue that statistics, as an interdisciplinary scientific field, plays a substantial role both for the theoretical and practical understanding of artificial intelligence and for its future development" and "Statistics is a broad cross-scientific discipline. Statisticians provide knowledge and experience of all aspects of data evaluation: starting with the research question through design and analysis to the interpretation" (Friedrich, et al., 2021, p. 15).

7. THE ROLE OF STATISTICS IN RESEARCH

In Section 3, the role of Statistics in traditional (routine) academic works is discussed; and in this Section we will discuss one of the very important roles of Statistics, which is its role in research.

It is well known that most of the research which is carried out in all disciplines is supported by different statistical methods; and even theoretical studies need statistics in one form or another, and when their models are to be tested with data, statistics plays an important role in this aspect. In addition, all the sciences or disciplines have a strong need for statistics, for three general fundamental reasons:

i. All sciences are developing and growing rapidly due to the existence of computers and statistics;
ii. The need of all the research in all science for realistic and logical explanations for the variability in the phenomena of life can only be provided by statistics, and
iii. Statistics is very important for any research and not because of the variability alone, it is also for providing the research integrity (see, Satalkar and Shaw, 2019), as the research integrity, it is the "means conducting research in such a way that allows others to have confidence and trust in the methods and the findings of the research. It relates both to the scientific integrity of conducted research and to the professional integrity of researchers." (see, The University of Edinburgh, 2020) and statistics is " a key element of research integrity" (see, Gardenier and Resnik, 2002, p.65).

In particular, "statistical methods, theory, techniques, and models play important roles in several stages of the scientific method" (see, Gardenier and Resnik, 2002, p.66). Moreover, at present, any research in any discipline needs a great deal of statistics, for several significant reasons other than the above reasons. Some of these are briefly discussed in this Section:

a. Each form of research has its own specific research methodology, but in order for the methodology to be clear and sound, it is necessary to understand the aspects of the research that need statistics and what the appropriate statistical methods are that should be implemented.
b. In order to investigate and study the hypotheses and the research questions, it is necessary to determine the appropriate method for data collecting, because there are several methods of data collection, and not every method is suitable for the conditions of every type of research. Also, how can you draw a representative sample of the population?
c. Each type of research includes some research questions and accepting/rejecting these research questions means we are achieving answers regarding the objectives of the research. This cannot be done without the use of testing the statistical hypothecs.

The researcher (s) should assure the data quality of his (their) research/project, and free from outliers. Also, there are two types of errors (sampling/non-sampling errors) acquired in any data collection and analysis. How can we control these errors without implementing comprehensive statistical protocols

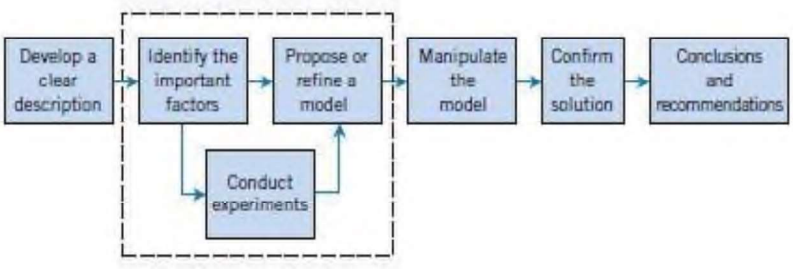

Figure 1 The methodology of engineering.

d. for your data collection steps?
e. The other step of any research is the data analysis. Several statistical methods and techniques are available for analyzing the data, but each technique has its own assumptions and requirements. In order to analyze the data perfectly, we should know when to use this technique and what the data requirements /limitations for this technique are.
f. Assume the researcher (s) has (have) selected an appropriate statistical technique for their data, but most of the inferential/modelling statistical techniques give several statistical results and sequences of numbers in multiple tables. Now a very famous problem is present, how to interpret the statistical results and report the output. Without the support of a statistician, or a good statistical experiment you cannot avoid this problem. (see,

Gardenier and Resnik, 2002; McGinn, 2010; Asher, 2014; Rodriguesa et al. 2017; Gibson, 2019).

In general, "statistical methods, theory, techniques, and models play important roles in several stages of the scientific method" (see, Gardenier and Resnik, 2002, p.66); and in order to explain some of the uses of Statistics and to show the above reasons for the necessity of Statistics for any research in any discipline, we will consider two different methodologies - one for engineering and the second for clinical research. It

may be remarked here that the discipline of clinical research consists of four minors (Epidemiology, Clinical trials, Population genetics, and Systems biology).
The methodology of engineering is shown in Figure 1 (see, Montgomery and Runger, 2010) , and the methodology of clinical research (Barkan, 2015) is shown in Figure 2 also.

It is very clear that in both methodologies that Statistics must be utilized. In Figure 1, Statistics is utilized in steps in conducting the experiment, and in manipulating and refining the model. The utilization is based on data collection and analyses. Also,

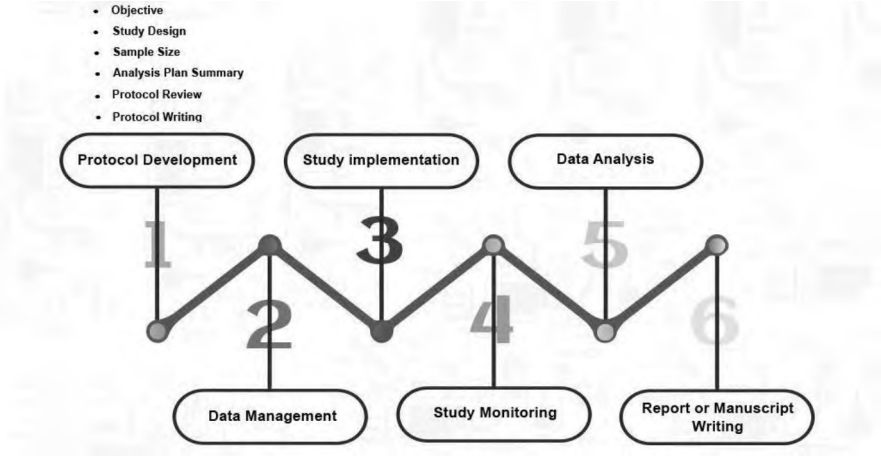

Figure 2 the methodology of clinical research.

Figure 2 shows that in the steps 2-5 Statistics needs to be implemented. Finally, we have to believe the very famous saying "Statistics is the grammar of science" (see, Pearson, 2004).

8. THE ROLE OF STATISTICS IN TEACHING AND LEARNING

The role of statistics in research is discussed in Section 4, and the role of statistics in teaching and learning- the essence of the work of educational institutions, is discussed in this Section.
It is well- known that teaching statistics in schools/HEIs has a positive impact on several competences and skills including that of critical thinking (see, Jones, 2017; Yotongyos, 2015). In order to explain the importance of Statistical Science in teaching and learning, we think it is very appropriate to talk about one of the wars of the USA which is called "math wars." It took place in the USA, starting in the fifties of the last century and ending only in the nineties of the last century (see, Klein, 2003).
The war broke out after many and shocking criticisms of the mathematics curriculum in the USA schools and universities. It is useful to address some of these criticisms, including "The teacher's arbitrary assignment of the next ten pages in history, or nine problems in arithmetic, or certain descriptions in geography, cannot be felt by the pupil as a real problem and a personal problem" (Klein, 2003, p .5); "Algebra...is a nonfunctional and nearly valueless subject for 90 percent of all boys and 99 percent of all girls–and no changes in method or content will change that" (ibid, p.8); and "in the early 1980s, there was widespread recognition that the quality of math and science education had been deteriorating" (ibid p.21).
Finally, the well-known mathematic program standards denoted by K-12 was created and published by the "National Science Foundation" of the USA in the nineties of the last century. In these standards there are several topics of Statistics (statistical literacy, data collections, data analysis, data interpretation, and probability) at all levels of teaching (Aliaga, 2008; Burrill, 2008; Batanero, et al., 2011). In addition, "the goal of teaching statistics is to foster an adult population capable of reasoning from and about data and making informed decisions based on quantitative information …" (Burril, 2008, p.1).
With regard to teaching statistical courses to general students of higher education, it may be noted that all students of academic programs in most HEIs are studying various statistical courses for different levels. In addition, looking for the aims of teaching undergraduate statistical courses in higher education, we will observe several aims for teaching statistical courses which are supporting the student in terms of teaching and learning; but we will find a clear agreement of some aims among a plethora of authors from different disciplines (see, Garfield, 1995; Gardenier and Resnik, 2002; Chance, 2002; Aliaga, 2008; Burrill, 2008; McGinn, 2010; Scott et al, 2011; Batanero, et al., 2011; Blalock, 2012). Some of the goals agreed upon by the above researchers are given below:

a. "overcoming fears, resistances, and tendencies to over-memorize";

b. "the importance of intellectual honesty and integrity";
c. "understanding the relationship between deductive and inductive inferences";
d. "learning to play the role of reasonable critic"; and
e. "learning to handle complexities in a systematic fashion" (see, Blalock, 2012, p.164).

For the purpose of showing the relationship between the above five aims in terms of "core critical thinking skills", and the "statistical literacy"/ "statistical thinking", we will explain the concepts of "core critical thinking skills", and the "statistical literacy". It is well known that the "core critical thinking skills" are "interpretation, analysis, evaluation, inference, explanation, and self-regulation" (see, Facione, 2011). At the same time the traditional undergraduate statistics courses can provide several skills which are known as the "statistical literacy" – these are the "literacy skills, statistical knowledge, mathematical knowledge, context knowledge and critical questions and a dispositional element (comprised of critical stance, beliefs and attitudes)" (Yotongyos, et al., 2015, p.2732). The above discussion shows the high similarity between the aims of teaching undergraduate statistical courses, "core critical thinking skills", and the "statistical literacy" (Chance, 2002; Facione, 2011; Yotongyosa et al.2015; Jones, 2019).
There are also many studies available on some specific points of this topic, and we will discuss some of them in order to investigate the relationship between study statistics courses in undergraduate programs and the performance of students in other courses. Freng, et al., 2011 studied the relationship between the GPA of several courses through "hierarchical multiple regression", and concluded that the "early enrollment and performance in statistics methods predict success in psychology majors' academic careers" (ibid, p.87). Oster, et al. (2018), in their research of medical and health science concluded that "it is very important for medical researchers and health science learners to be literate in biostatistics" (p.137), and "the development, teaching, and assessment of statistical competencies for medical research are essential tasks" (p.137). Finally, the research designed a survey to study a set of statistical competencies; and finalized 19/5 statistical competencies which are necessary for all medical studies/some medical studies respectively.

9. THE ROLE OF STATISTICS IN INTERNAL AUDITING OF HEIS

The role of Statistics in teaching and learning is discussed in Section 5, and in this Section, we will discuss the role of Statistics in internal auditing of HEIs. The internal auditing in HEIs has different types and techniques, and involves broad, complex and continuous work that includes all the activities and process of the institution.
It is known that all the international or reputed HEIs carry out internal accountability or the internal monitoring process annually, and this process is done in a comprehensive manner for all facilities, activities and all levels of the institution, and is carried out in an accurate and reliable manner. Some of the areas of internal audit are: "Budgetary Control"; "Staffing"; "Purchasing Procedures"; "Safety Arrangements"; "University Management Systems"; "All University Departments"; "Data Protection" and "Research Contracts" (see, University of Strathclyde; Wright State University). In addition, "the Internal Audit Service has unrestricted rights of access to all of the University's records, information, staff and assets, which it considers necessary to fulfil its responsibilities" (ibid).
Most of the HEIs in the world use the similar audit instruments/tools for the enteral auditing, where the accuracy of these tools has been established by means of experimentation. Some of the common instruments/tools are: "Internal Audit Plan"; "Departmental Audit Questionnaire"; "Interviews with Staff/Academic staff"; "Student Satisfaction Survey"/ "Student Engagement Survey"; "Staff Satisfaction Survey"; "Academic Satisfaction Staff Survey" / "Academic Engagement Survey"; "Financial Audit Plan"; "Internal Audit REPORT"; "Financial Audit Report"; … (ibid). It may be remarked here that some other instruments/tools are given in Section 4.
Now, if we examine/study the instruments/tools for the enteral auditing that were mentioned above, we will finally observe that they can be categorized under one of the following categories:

- Real Statistical means (instruments/tools) in terms of their components, methods of design, scales of measurement, data collection and analyses. Some of these are as follows: Applications/Surveys: "Departmental Audit Questionnaire"; "Student Satisfaction Survey"/ "Student Engagement Survey"; "Staff satisfaction Survey"; "Academic Satisfaction Staff Survey" / "Academic Engagement Survey". Or

- There are administrative reports immersed (totally full) by/of statistical measures and indicators such as various plans and reports ("Internal Audit Plan"; Financial Audit Plan"; "Internal Audit Report"; "Financial Audit Report").
- Several simple reports used in traditional works/daily routine academic works also contain simple statistical measures (Section 4).

10. THE ROLE OF STATISTICS IN EXTERNAL AUDITING OF HEIS

The institutional auditing is either internal or external. The internal auditing is discussed in the final Section, and the external auditing is to be discussed in this Section. The external auditing of HEIs takes different forms and purposes, and it is always considered as an important issue for the higher education sector/HEIs and the stakeholders in all countries of the world for the purposes of accountability and transparency. Also, these applications have become a reliable source for the students in their choices of universities for the purpose of study. Regarding the issue of this paper, all the types of external auditing included a large and wide quantity of statistical methodology and applications. The external auditing of HEIs is of several different types. In this Section, we will discuss three models related to them.

10.1 The Accreditation of HEIs

The academic accreditation of higher education institutions takes place in most countries of the world, and there are international or national institutions that perform the accreditation process. Academic accreditation for institutions is of many types, some of which are institutional, the others being for academic programming.
The academic accreditation process for institutions is a long process that requires the institution to engage in various accreditation procedures, and supply data of different types. Each accreditation institution has its own accreditation rules, and so, an accreditation process generally depends on a set of standards.
In this Section, we will discuss three of these institutions. Table 1 contains the standards of CHEA (USA), BAC (UK), and OAAA.

Table 1: Accreditation Standards

Accreditation (CHEA)	**Accreditation (UK)**	**Accreditation (OMAN)**
Advances academic quality	Mission and Purposes	Mission, Goals and Objectives
Demonstrates accountability	Organization and Governance	Governance and Administration
Possesses sufficient resources	Students	Learning and Teaching
Employs appropriate and fair procedures in decision making	Library and Other Information Resources	Student Services
Encourages, where appropriate, self-scrutiny and planning for change and for needed improvement	Physical and Technological Resources	Learning Resources
Demonstrates ongoing review of accreditation practices	Planning and Evaluation	Facilities and Equipment
	Financial Resources	Financial Planning and Management
	Integrity	Staffing and Employment Procedures
	Faculty	Community Relationships
	The Academic Program	Research
	Public Disclosure	

All standards enrolled in academic accreditation institutions are divided into a large number of statistical indicators, and the data for those indicators which are collected are based on questionnaires; and the process of assessing the HEIs is carried out through the following methods: Self-study, Peer review, Site visit Action (judgment) of the accrediting organization, Monitoring and oversight (See, BAC & CHEA).
It may be remarked here that CHEA has 6 standards, the UK organization has 11 standards, and OAAA has 9 standards. The number of standards in these organizations are not equivalent, and the number of the indicators in any standard of any organization is not equal.

Thus, we get to the true point which is that the statistical work exists in the folds of the academic accreditation process. When collecting the data of indicators by different editors/observers, the question arises as to how we can ensure that they are identical, and free from human bias and errors. And how can we know that this process is statistically significant? Such questions cannot be answered by a non-statistician.

10.2 The Performance of HEIs

For several reasons, the governments, ministries, or any national bodies want to assess the performance of HEIs by a unified/standardized approach. Indeed, there are several performance-management models available for measuring performance. Some of these are: the "Quality Prizes", "Quality Initiatives", "Quality Models", "Systems of Quality Assurance", "External and Internal Quality Monitoring"; "Balanced Scorecard (BS)"; "European Foundation for Quality Management (EFQM) Excellence Model" (see, Al-Hemyari, 2019).

At the same time, there are several limitations, problems, and many objections regarding the implementation of these international models. Some of these objections are that these models were established for different organizations, goals, polices and, as such, they do not take into account the level of HEIs in developing countries.

For the above reasons, governments deliberately apply models that simulate the national reality, and one of the very realistic and common examples is the "Performance Indicators (2011)/Ranking Indicators (2018) Projects" which were done by the Ministry of Higher Education in the Sultanate of Oman. These projects were implemented in the private HEIs and Colleges of Applied Sciences (See, Al-Hemyari and Al-Sarmi 2018; 2017; 2016; 2015).

The above two projects included a methodology for refining the statistical indicators, several standards for checking the goals/objectives/indicators, a technique for data collection, a procedure for data editing and a mechanism for measuring the indicators. It may be remarked here that all the above stages of the projects are fully at the heart of statistical work. In order to assure the veracity of this remark, a sample of the statistical indicators of the first project are given in Table 2.

Table 2: Some of the Statistical Indicators of the "Performance Indicators Project"

I c.	Indicators
221	Communicating vision and mission of the institution to academic staff
222	Communicating vision and mission of the college to academic staff
223	Communicating goals and objectives of the college to academic staff
224	Communicating core values, strengths, weakness, threats, and opportunities of the department to academic staff
231	"Average class size" for undergraduate students (program/institution)
232	Advisor performance
233	"Student capability"
234	"Teaching strategies"
235	"Assessment strategies"
236	Interaction between students and academic staff
237	Quality of coursework
238	Student-instructor interaction
251	"Student capability (Grade Point Average)"
252	"Perceived Course Quality"
253	"Perceived Teaching Quality"
254	Quality of program/department
255	Quality of institution facilities
256	Total number of national/international awards (for students)
257	Total number of national/international patents (for students)
258	Quality of skills and attributes
259	"Graduate satisfaction & engagement"
261	Ratio of students graduated with in the program duration in relation to all graduates
262	Improvement in student achievement (expansion rate of Grade Point Average)
265	"Students satisfaction and engagement"
271	Performance of executives
272	Performance of heads of academic departments
273	Research capability of executives
274	Performance of the Registrar
275	Communicating the rules and regulations
288	"Academic staff satisfaction & engagement"
289	"Professional developments" /training programs for academic staff
291	Ratio of non-academic/ administrative staff (Omani and non-Omani) relative to all students.
292	Proportion of granted and funded scholarships from institution for master and doctoral studies to non-academic staff/ administrative staff.
293	Proportion of non-academic staff/ administrative staff who have taken part in funded training programs from institution fund
2101	"Average teaching load" for postgraduate studies
2102	Total number of "ISI highly cited researchers" in relation to all academic staff
2103	"Growth Index of postgraduate students"
2113	The effectiveness of ICT systems

21211	"Quality of institutional facilities"
2135	The level of establishing and communicating workload policy
2136	The effectiveness of research groups
2137	The effectiveness of learning groups
2138	The level of instilling national identity and pride values
2139	The level of nurturing institutional and national loyalty and universal values
21312	The level of performance of teaching staff
21313	The level of establishing HEI operational plan

10.3 The Ranking of HEIs

The issue of ranking is not a new one, as several institutions in the previous century have made the ranking for a number of HEIs; and now the issue of ranking is gaining great importance and has a global marketing reputation for HEIs. At the same time, there are several researchers and universities who have studied the issue of ranking and have made many scientific findings that criticized the idea of ranking; it is the methodology and the robustness of ranking's results (see, QS, 2023; THE, 2019; Hazelkorn, 2018; Hazelkorn and Gibson, 2017 and Rauhvargers, 2013). Despite these facts, the topic of ranking remains of great importance for HEIs.

The institutions that make the ranking processes for HEIs are several, and most of them are non-academic institutions. Some of them are international institutions and others are national institutions (ibid). In this paper, we will discuss some of them and their criteria indicators and weights. In Tables 3 and 4 some of the international ranking institutions are given.

Table 3: Some "International Ranking Institutions"

QS	ARWU	THE
"Academic reputation (40%)"; "Employer reputation (10%)";"Staff/ student ratio (20%)"; "Citations per faculty (20%)"; "International faculty ratio (5%)" and "International student ratio (5%)".	"Alumni of an institution winning Nobel Prizes and Fields Medals (10%)"; "Staff of an institution winning Nobel Prizes and Fields Medals (20%)"; "Highly cited researchers in 21 broad subject categories (20%)"; "Papers published in Nature and Science (20%)"; "Papers indexed in Science Citation Index-expanded and Social Science Citation Index (20%)" and "Per capita academic performance of an institution (10%)".	"Staff-to-student ratio (4.5%)"; "Doctorate-to-bachelor's ratio (2.25%)"; "Doctorates-awarded- to-academic-staff ratio (6%)"; "Institutional income (2.25%)"; "Reputation survey (18%)"; "Research income (6%)"; "Research productivity (6%)"; "Citations (research influence) (30%)"; "International-to-domestic-student ratio (2.5%)"; "International-to-domestic-staff ratio (2.5%)"; "International collaboration (2.5%)"; "Industry income (knowledge transfer) (2.5%)".

The papers/documents published on the ranking are numerous; and studies of some of these papers/documents show that there are several observations regarding the several issues of ranking. But some of these observations are highly significant and fall in the most important part of ranking, i.e. in the large amounts of collected data from HEIs for ranking. In addition, these points have a statistical nature which characterize the data that are used on the ranking and fall completely in the essence of statistics. The vast amount of data required by the ranking approaches, the different problems which have arisen from their data, and how they make their results accurate and reliable, show that this work is considered as an essential and basic work in the ranking approaches. Then, the associated statistical problems with techniques of rankings and the required actions for each one is purely specialized statistical work.

Table 4: Some "International Rankings Institutions" of UK

I. The Sunday Times	II. The Complete University Guide	III. The Guardian
"Entry Standards (1.0)"; "Student Satisfaction (1.5)"; "Research Quality (1.0)"; "Research Intensity (0.5)"; "Graduate Prospects (1.0)"; "Student-Staff Ratio (1.0)"; "Academic Services Spend (0.5)"; "Facilities Spend (0.5)"; "Good Honours (1.0)" and "Degree Completion (1.0)".	"Teaching Quality (10%)"; "Assessment & Feedback (10%)"; "Overall Satisfaction (5%)"; "Continuation (10%)"; "Value Added (15%)"; "Student-Staff Ratio (15%)"; "Expenditure per Student (5%)"; "Entry Scores (15%)" and "Career Prospects (15%)".	"Teaching excellence (250 points)"; "Student satisfaction (+50 to -55 points)"; "Research quality (200 points)"; "A-level/ Higher points (250 points)"; "Unemployment (100 points)"; "Firsts/2:1s awarded (100 points)"; "Dropout rate (+57 to -74 points)" and "Peer Assessment (100)".
IV. The Times University Rankings		
"Student experience (%)"; "Research quality (1.5)"; "Entry standards (1.0)"; "Graduate prospects (1.0)"; "Firsts/2:1s (1.0)"; "Completion rate (1.0%)"; "Student-staff ratio (1.0)"; "Services/ facilities spend (1)" and "Library and computing services (1.0)".		

11. CONCLUSIONS

This paper has aimed to highlight the roles of Statistics in higher education, and in order to achieve this aim several related and essential topics were discussed. The first is that the paper provides a short review of the history of Statistics, and other issues appertain as to why we need statistics in our life The role of statistics in traditional (routine) academic works; in research; in teaching and learning; in enteral auditing; and in external auditing, are also highlighted.

This study showed that the role of Statistics is not only important but also comprehensive, crucial and critical in higher education; and it is included in all the processes that take place in higher education and HEIs, and we may not find any process in any HEI devoid of a statistical concept or statistical application. Regarding the role of statistics in education, it is clear; and in many issues of teaching, learning, and training, like time optimization, place management, teaching patterns, study patterns etc. it is prevalent. In addition, the analysis of student feedback on the effectiveness of teaching and learning is completely based on statistical analysis.

Also, the level of the involvement of Statistics in higher education is essential in the sense that many activities are based mainly on Statistics -its great significance having been highlighted in this paper. Regarding research, the paper shows that in several areas of other sciences, if devoid of the use of Statistics, research in these areas could not be performed properly, as statistical input serves to improve the visibility enhancements of researchers' vision and provides a realistic view of research. It maintains and strengthens the research integrity and increases the value of the research output.

At the present time, any research requires the processes of data collection, analysis, findings, and recommendations, but only with the availability of specialists in Statistics to collaborate with the researchers in performing these practices for the researchers. For several reasons, among which include financial constraints, there has arisen the paradox of non-statisticians being involved in the statistical aspects of research processes. This phenomenon, whereby non-statisticians have taken the place of qualified and certified statisticians, has been gaining increasing ground in academia. This has led to a negative impact on the quality of scientific research and a corresponding decrease in the confidence the general public have in Statistics (Gibson, 2019).

12. LIMITATIONS

In fact, there are a number of limitations that surround the applied and analytical aspects of statistics, which are explained in this paper. But among the most important are
the following:

There are many cases, the person who does the statistical analysis is not specialized in statistical analyses and knowing the application of the SPSS is not sufficient to perform the statistical analyzes. In addition, there are many statistical analysis offices in all countries of the world that provide statistical analysis services to different studies or papers of the applicants, and unfortunately, in many of them this work is done by non-specialists in statistics, which has a negative and significant impact on the quality of those studies or research and on the reputation of statisticians.

It was also noted that many published studies or research include various statistical analyses, most of which are inaccurate - the reason may be the absence of any specialist in statistics with the group of researchers for those studies or research. In this case, it is assumed, at a minimum, to seek advice from the statisticians. The common pitfalls in data analysis which require significance and very careful actions are the “accuracy and precision”, “biased samples”, “overgeneralization”, “causality”, incorrect and unsuitable analysis”, “violating the assumptions for an analysis” which will exist in the analysis of a plethora of published studies/papers with high probability due to the above reasons.

13. FUTURE RESEARCH DIRECTIONS

Based on the references reviewed in this paper and through this paper’s work, which is about the coexistence and daily interaction between the author of this paper and academic staff through the traditional (routine) academic works in an HEI, we can seize different and several future research opportunities related to the topic of this paper which is “The Role of Statistics in Higher Education”. Some of which are given below:

Students of arts in general, or students not from mathematical and engineering sciences when studying statistical courses face some difficulties. In order to avoid these difficulties, more research is required to study the perception of Statistics academic staff and students of arts hold in the methods and strategies of teaching Statistics courses in these programs.

It is good to see a lot of statistical tools, procedures and applications implemented by HEIs or in several organizations related or not related to higher education, but the most important issue is to implement such techniques by statisticians, in order to achieve the aims of the implementation of these techniques.

One of the main aims of teaching Statistics courses in higher education should be the development and advancement of "statistical thinking" and "statistical literacy" to all students in all programs. Thus, research is required for assessing the above important aim. Regarding the paradox of the presence and availability of non-statisticians for doing

statistical work and to reduce the negative impact of such on the validity of any scientific research in which qualified statisticians are absent, and thus increase the level of confidence of the general public in Statistics, we should accept the presence of a statistician in any future research project or in any multidisciplinary research. Then, it is possible to study and track the impact of the implementation of this suggestion.

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