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Design of a Statistics Lecture for Multidisciplinary Postgraduate Students Using a Range of Tools and Techniques

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***Abstract*—**Teaching statistics is a critical and challenging issue especially to students from multidisciplinary and diverse postgraduate backgrounds. Postgraduate research students require statistics not only for the design of experiments; but also for data analysis. Students often perceive statistics as a complex and technical subject; thus, they leave data analysis to the last moment. The lecture needs to be simple and inclusive at the same time to make it comprehendible and address the learning needs of each student. Therefore, the aim of this work was to design a simple and comprehendible statistics lecture to postgraduate research students regarding 'Research plan, design and data collection'. The lecture adopted the constructive alignment learning theory which facilitated the learning environments for the students. The learning environment utilized a student-centered approach and used interactive learning environment with in-class discussion, handouts and electronic voting system handsets. For evaluation of the lecture, formative assessment was made with in-class discussions and poll questions which were introduced during and after the lecture. The whole approach showed to be effective in creating a learning environment to the students who were able to apply the concepts addressed to their individual research projects.

***Keywords*—**Teaching, statistics, lecture, multidisciplinary, postgraduate, learning theory, learning environment, student-centered approach, data analysis.

I. Introduction

STATISTICS is an essential subject to all fields of research. The advantage of statistics in research is beyond interpreting the results and understanding the outcomes of the research project. It is rather involved in the design of the experiment/ research project and understanding every step of it. Particularly with postgraduate students, statistics is crucial for the whole project. Statistics is often taught to research students not for itself but to support them in their projects [1].

Statistics subject, however, is usually perceived by postgraduate research students as 'boring and dry' and difficult to comprehend [2]. This is due to the fact that the methods in statistics have high complexity and technicality [1]. Additionally, data analysis is often left to the last moment not allowing enough time for interpretation of results. Consequently, in most cases students do not engage in the course which leads to concern regarding their research projects. Thus, the design of a statistics lecture is always critical especially that the lecture should communicate the topic effectively, emphasise important aspects of the topic, extend the student understanding beyond textbooks and enhance the students' knowledge though recent research materials [3].

Particularly with multidisciplinary students from variable backgrounds, teaching a statistics is challenging and a lot of factors need to be incorporated in order to make the lecture appealing and comprehendible. In this case one learning approach is not enough to fit the purpose and address the students learning needs. Subsequently, various aspects need to be taken into account when designing the lecture. These aspects include: Teacher, student, and course-related aspects. The teacher needs to be confident about the course delivered. Students-related aspects are critical in this case and depend on the discipline, cultural perspective and knowledge of each individual [4]. Course-related aspects should present enthusiastic content, clear goals, suitable environment and fits within the suitable time frame [2], [5]. Therefore, designing a statistics lecture for multidisciplinary research students is considered demanding in terms of adopting learning theories, approaches, strategies and using appropriate tools and techniques.

Regarding the learning theories, two approaches have been highlighted lately in the context of higher education. These included teacher- and student-centred approaches. The combination of both approaches was based on statistics being a dry/difficult subject that can be applied in different ways for various disciplines. Teacher-centred approach considered learning as a troublesome concept in relation to defining a problem, finding the best way to deliver it and measuring the assessment [6]. It considered knowledge as an absolute truth that is delivered by the teacher to address certain problems. On the contrary, the student-centred approach considered learning as a threshold concept depending on what the students achieve out of the learning environment [7].

The choice of the learning theory is yet still dependent on the subject area, the teacher's education and the students' learning needs. In this sense, four theories play an important role including: Behaviourism, cognitive, humanism and constructivism/social constructivism [8], [9]. Behaviourism is based on observing a response (students' ideas, skills and competences) occurring from an external stimulus (teacher information). Cognitive theory helps students further think,

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analyse, and critique learning activities. Conversely, humanism theory considers learning as an emotional/sensible thing and sees students as individual human beings. Constructivism considers learning as a collaborative process between the teacher and the students.

Consequently, constructive alignment considers learning as an active process undertaken by the students from the world around them [10]-[12]. It involves setting up accurate and precise learning outcomes, and designing the learning and teaching method(s) on the basis of these outcomes [13], [14]. The teacher in this case is a facilitator who sets up the learning environment for the students.

Two methods were key in this which are: Practice-based and problem-based learning [5]. Practice-based learning provides learners with real-life scenarios to encourage critical statistical thinking among them [15]. Moreover, problem-based learning presents the problem, situation and essential skills to the learners [5]. Then, the learners are expected to apply the necessary knowledge and skills to solve the problems.

In addition, the learning environment plays an important role in applying the theories/approaches. The interactive environment can be promoted using several tools. For instance, in-class discussions make the lecture more exciting and comprehendible to the students than traditional didactic lectures [16], [17]. Moreover, handouts (with written instructions or exercises) offer the opportunity to reiterate and explain important concepts highlighted in the lecture. Additionally, technological tools have emerged as powerful tools for making lectures more appealing. Accordingly, PowerPoint presentation slides deliver clearer and more comprehendible lectures to students [18]. In addition, electronic voting system handsets engage students in the lecture and motivate them to learn and improve results. They also provide the lecturer with instantaneous feedback on concepts that need clarifying during the lecture.

This article challenges the theories, approaches and tools used in teaching statistics to design, implement and assess a statistics lecture for multidisciplinary postgraduate international research students at Bournemouth University. It highlights the importance of the statistics in the design of experiments and the interpretation of the results. Also, it incorporates the use of more than one tool (paper handouts, exercises, PowerPoint, blackboard and electronic voting systems) and techniques (discussion, practice-based exercise and informative assessment). Based on the assessment of the results, the article proposes a set of recommendations to be used in the further teaching of statistics for multidisciplinary postgraduate international students.

II. Procedure for Paper Submission

A. Background

The statistics unit was composed of a series of lectures at Bournemouth University and aimed to help postgraduate research students apply statistics to answer their research questions. The unit is optional and the postgraduate students have the flexibility to sign to one or more lectures. The lecture discussed in this work was the first session given in this unit and was entitled: Research plan, design and data collection. The duration of the lecture was three hours.

B. Settings

The lecture was attended by eight international postgraduate students from three departments: Applied sciences, Design Engineering & Computing and the Business School. Hence, the students had a different knowledge base and levels in research. The students included six females and two male participants. Six were in the age group of 25 – 29 years, one 20 – 24 years and one 35 – 39 years. All the students were PhD level as follows: six in the first year and two in the second year of their PhD studies. Only one student was self-funded; whereas, the remaining students were fully funded. The PhD programme at Bournemouth University is a three-year research programme. It involves working on a research project and submission of a thesis by the end of the three years. The statistics training offered to students is elective. Thus, their knowledge is basic (especially at first year) and it is challenging to make them understand statistics within the suitable time frame.

C. Lecture Design and Tools

The lecture was delivered through Microsoft PowerPoint and used the electronic voting system handsets. These handsets resembled a mini-calculator equipped with numbers - 9. They were connected to the PC through a USB device equipped with Wi-Fi. The poll questions that were answered using the handsets included closed ended questions of numbers ranging between one and nine. Once the question was displayed on the slide, the poll opens and the students select the answer they think was appropriate. Then the poll closes and the percentage answers were displayed on the slide but the identity of each student was kept anonymous.

In addition, the blackboard was used to clarify further difficult terms and concepts that were encountered in the lecture. Moreover, handouts of manuscripts and written exercises were used for interactive discussion.

III. Results

A. Lecture Design

The lecture was designed to make statistics simple, comprehendible and applicable by research students. More specifically, the lecture aimed at transferring research, problem-solving and practical skills to students. By the end of the session, the students were expected to gain the knowledge to choose the appropriate research methods to be used in their individual research projects. Consequently, the learning outcomes of the session and the methods used were adopted to fit with the aims of the lecture. Formative assessment was made during and at the end of the lecture in order to identify what the students have learned out of the lecture. Fig. 1 shows a diagram of the lecture plan.

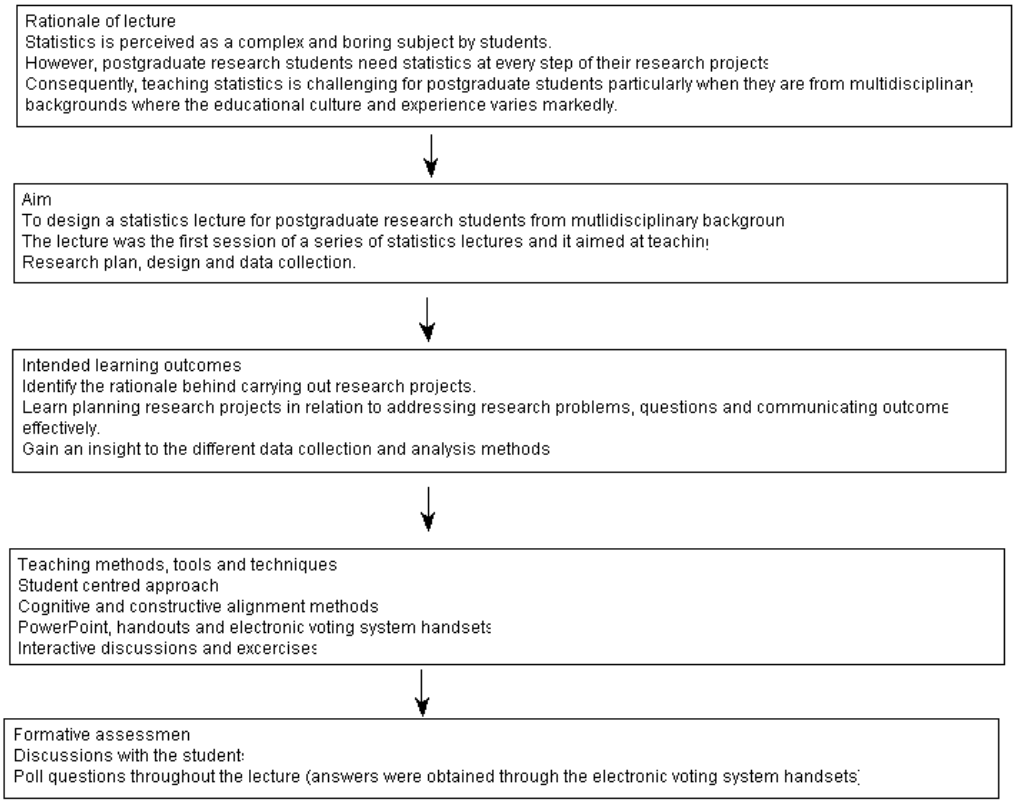

Fig. 1 Diagram showing the lecture plan used

B. Intended Learning Outcomes

The intended learning outcomes (ILOs) were assigned according to the Quality Assurance Academy requirements [19]. Consequently, they were constructed to fit with what the students will gain from and are able to do at the end of the lecture. Thus, the ILOs for this lecture included:

- Identify the rationale behind carrying out research projects.
- Plan research projects in relation to addressing research problems, questions and communicating outcomes effectively.
- Utilise different data collection and analysis methods.

C. Lecture Content

The lecture used the holistic and threshold structures [20], [21]. It was divided into four parts: Research rationale and plan, types of research methods, data collection and data analysis (Table I).

The research rationale and plan offered the students with an insight into the reasons behind doing their research project. The research purposes and design in general were explained to the students; then, they were allowed to write about the aims, specific objectives and research questions of their individual research projects. Then, the research themes were explained and the students were allowed to identify which themes their projects communicated. This was reiterated by providing exercises from the social media and scientific literature that they were required to evaluate.

Then the students were provided with the types of research approaches which were qualitative, quantitative and mixed method (Table I). Qualitative research is inductive non-numerical in nature and involves developing theories that cannot be measured. Qualitative research concentrates on building a theory. To test this theory, quantitative research is adopted. Thus, quantitative research is deductive numerical in nature and aims at measuring outcomes of an experiment. To combine both qualitative and quantitative approaches, the mixed method approach is used [22]. This was followed by exercises including journal articles that employed both qualitative and/or quantitative approaches.

The third part of the lecture compared the different data collection methods that were: Experimental data, prospective observational studies, retrospective studies, questionnaires, interviews and focus groups. The students were presented with samples on each type of the studies and were also allowed to evaluate examples relating to the different types of studies.

This was followed by the last part of the lecture that gave an overview on data analysis. This compared quantitative and qualitative data approaches in relation to how, when and why use each approach.

D. Learning Environment

The lecture combined active and passive learning through the use of presentation, discussion, exercises and multiple-

choice questions. Thus, the students were presented with the knowledge/information that were discussed in class. Then, they were given the opportunity to apply this knowledge to specific examples from the literature and to their own research.

Data were presented to students using PowerPoint slides. Summary bullet points, tables, diagrams, and figures were used to clarify and summarize important characteristics of the lecture. Figures and diagrams simplified the data and made statistics easy to understand by non-statisticians. Each slide was discussed with the students and difficult aspects were clarified using the blackboard. In addition, the knowledge provided was supported by examples from the literature/media which were discussed in details with the students. The examples were presented to the students either through PowerPoint slides or as handouts. In addition, the students were allowed to relate each section to their own research projects. Also, the responses to key questions (in the lecture) were recorded through electronic voting system handsets. In this respect, closed-ended questions were delivered through the slides with multiple-choice answers and the students were allowed to choose one answer.

TABLE I
DETAILS OF THE LECTURE CONTENT

Content	Deliverable
Research rationale	The design of research is decided by the aim of the study: Explore a new phenomenon Describe an existing phenomenon Explain why/how a phenomenon operates Predict a given phenomenon
Research plan	The design of research is implemented in clear statements: Identify research needs and issues Carry out a literature review Outline the research hypothesis and questions Predict the potential outcomes and beneficiaries Design the research proposal
Research Methods types	Research methods are divided to three types: Qualitative methods Quantitative methods Mixed (qualitative and quantitative) methods
Data analysis	Data analysis depends on study aims and objectives and include: Quantitative data analysis: Descriptive statistics (means, percentages, t-test, analysis of variance) Multivariate data analysis Qualitative data analysis: Thematic analysis Content analysis Coding

E. Teaching Method Used

The lecture used a student-centred approach and addressed two theories: cognitive and constructive theories. The students were asked initially to write about their own research project. Then the essential information was provided to the students at each stage where they were allowed to analyse, critique and apply this information to authentic research scenarios. The specific examples of research articles allowed the students to achieve the learning outcomes of the session.

F. Formative Assessment

Formative assessment was achieved through discussion with the students and asking them questions using the electronic voting system during and at the end of the lecture. Issues arising during the discussion were addressed instantly during the lecture. Electronic voting system' questions addressed more details including the background, understanding and satisfaction of the students with the lecture.

Table II displays the responses from sample questions obtained through the electronic voting system. Thus, throughout the lecture the questions were addressed through the electronic voting system in order to assess the students understanding of the material (Table II). The results showed that 62.5% of the students had their research protocol/methods established. Their research projects addressed the following themes: 'Explore and predict' (37.5%), 'Explore and describe' (25%), 'Explain' (25%) and 'Explore and predict' (12.5%) themes. Regarding the methods used, half the students used quantitative and half used mixed method approach. For the mixed method approach, qualitative data was mostly collected using interviews. When asked about software package for quantitative data analysis, a third of the students used SPSS and a third were not sure what to use.

TABLE II
RESPONSES TO QUESTIONS REGARDING THE RESEARCH AND SOFTWARE ADDRESSED THROUGH ELECTRONIC VOTING SYSTEM

Question	Answer(s)	Response (%)
Do you have your research protocol/ methodology prepared and checked?	Yes	62.5
	No	37.5
What theme(s) does your research address?	Explain	25
	Explore and describe	25
	Explore and predict	12.5
	Explore and explain	37.5
What method will you be using in your research?	Quantitative	50
	Mixed method approach	50
What quantitative software package will you more likely be using?	SPSS	16.7
	R	50
	Not sure	33.3
Which qualitative method you are more likely to use in your research?	Questionnaire	16.7
	Interviews	33.3
	Focus groups	16.7
	None	33.3

Answers with no responses were not displayed in the table.

TABLE III
RESPONSES TO QUESTIONS REGARDING LECTURE STYLES ADDRESSED THROUGH ELECTRONIC VOTING SYSTEM

Question	Answer(s)	Response (%)
Have you had previous statistics training/ workshops?	Yes	66.7
	No	33.3
How relevant was the session to your work?	Extremely relevant	33.3
	Very relevant	16.7
	Neutral	16.7
	Slightly relevant	33.3
Would you prefer an online training on statistics (live courses, webinars)?	Yes	66.7
	No	33.3
Would you be interested in a Facebook/ LinkedIn statistics discussion groups?	Yes	100

Answers with no responses were not displayed in the table.

In addition, at the end of the lecture evaluation questions were given out to understand the students' response to the lecture style (Table III). In this respect, the majority of the students (66.7%) had previous statistics training/ workshops that covered the basic level of statistics. A third found the session extremely relevant and a third slightly relevant. In addition, most of them preferred online training. Moreover, all the students were interested in using social media (such as Facebook/LinkedIn) discussion groups. Social media provided information in a stress-free environment and allowed students to gain insight to new concepts and enhance their knowledge.

IV. Discussion

The lecture design was based on the students' needs, capabilities and aims behind attending the course [19]. This lecture was optional and attended by postgraduate students from multidisciplinary and multicultural backgrounds. The students were in schools of 'Applied Sciences', 'Business' and 'Design, Computing and Engineering'. Consequently, their capabilities were variables depending on the learning background, work experience and individual skills.

None of the students was studying statistics as a subject; yet, they needed to apply it to their subject areas. In this respect, transferring the statistics skills were essential and were transferred by addressing key elements in relation to the lecture content, audience, presenter and environment [3]. Thus, the lecture content was clearly communicated via the use of figures and diagrams to demonstrate authentic examples. Technical words were avoided where possible or either explained using the blackboard. The diverse authentic examples and applications addressed what the audience needed to know in relation to the content. Also, the discussion was suitable for the audience number (eight students). Regarding the presenter goals, the lecture was able to deliver the ILOs of the material in the given environment.

In this respect, the ILOs of the lecture were planned to address the aforementioned key elements [19]. Thus, they were written in clear language, future tense, understandable and were doable throughout the lecture [23]. The ILOs agreed with the concept of constructive alignment that assures that the curriculum must have self-defined outcomes acquired through an appropriate learning experience [24]. More specifically, the learning outcomes must include understanding and explanation of facts/ concepts and developing of problem solving skills [3]. This was demonstrated through presenting paper-based and computer exercises after explaining each concept. Also, the discussion in relation to the students' projects and literature material helped in developing the problem solving skills. This was agreed by Trigwell and Prosser (1996) [25] who showed that in-class discussions stimulated the understanding of the students and increased their conceptual knowledge.

The lecture content adopted the holistic and threshold learning styles [26]. This approach considers learning as a precise activity to achieve optimum performance of the students. The learning style was based on providing authentic and concrete examples and comprised four stages [27]: (1) Authentic examples, (2) observation and reflection on the examples, (3) extraction of concepts from examples and (4) testing the examples using suitable tools. The holistic approaches provided the big picture of the data when the students were allowed initially to discuss their research plans. Then, key concepts were introduced at each part of the lecture and students were able to interpret each concept into examples. The ability of the students to share and provide examples was an indicator of the knowledge they gained throughout the lecture.

The overall approach was student-centred to help students achieve, understand and apply the concepts delivered to them [6]. This helped in shifting the role of the tutor to a facilitator and created a student-facilitator and student-student learning environments and created a reflective learning community [28]. The approach adopted the cognitive, learning and constructive alignment theories that enabled the students to analyze concepts, critique them and construct their own knowledge from the learning environment [13].

The theories were applied in a deep learning environment that offered a stress-free and no-blame climate [25]. Thus, the students were allowed to write briefly about their projects and make links to other projects. At times when the students struggled, attempts to overcome struggling were taken through giving examples. If the examples did not clarify the situation, the slides were skipped to the next piece. The authentic examples and interaction created a practice-based learning to the environment. Practice-based learning presented the students with 'real-life scenarios', which allowed them to perceive the relevance and applications of research methods to their projects [1]. Students were further allowed to interact with these examples and perceive them by addressing questions using the electronic voting system as well as discussions.

Additional tools were incorporated into the learning environment to make it interactive in nature and appealing to the students. Interactive lectures were preferred by students as they stimulated thinking, comprehending the material and communicating it [17]. Particularly in statistics field, the discussions are important in making statistics real for the students [29]. The handouts of manuscripts and exercises that were made stimulated the students' interest and engagement in the lecture. Exercises displayed through the slides offered further advantages than handouts, as each individual student's feedback was kept anonymous; yet the correct answer was displayed on the slide when the poll was closed. Thus, the students were able to interact with the questions without the fear of having a wrong answer. However, both exercises allowed instantaneous feedback to the students which helped them to develop their knowledge.

Formative assessment served diagnostic for the students and the teacher as it identified key areas which needed improvement and further explanation [30]. For students, the formative assessment made them self-regulated learners which led them to reconsider their knowledge and strategies [31]. Thus, formative assessments carried out after each section with poll questions highlighted for the students the areas they

needed to concentrate on. They allowed students to reflect on their learning in a quicker time frame [32]. For the teacher, the formative assessment identified the areas that needed further clarification. Moreover, it informed the relevance of the session to the students and the preferences of the students in relation to the learning environment. This was helpful in designing future sessions in the statistics unit.

Several challenges were encountered while designing and delivering the lecture. First, statistics was a dry subject so designing it in an interactive way was a critical issue. Second, the course was a beginner level in statistics so the concepts had to be simplified into layman terms. Also, the students' multidisciplinary backgrounds, variable levels and diverse education required simplification of the lecture material. Moreover, the variability in the backgrounds and level of students made it difficult to apply problem-based learning to the lecture. This was also limited to a degree by the lecture time frame and the settings provided for the lecture.

V. Conclusion

The lecture was designed to teach 'research plan, design and data collection' to postgraduate research students from multidisciplinary backgrounds. The lecture language and presentation were made simple and clear through the diverse examples from real-life scenarios. The overall student-centred approach showed to be successful in creating a learning environment that enabled students to construct their own knowledge from the material. This was facilitated by the diverse interaction tools used which generated a stress-free environment. Thus, the interactive discussion and handouts stimulated the students' engagement in lectures and enhanced critical thinking. Moreover, the electronic voting system handsets triggered further interaction of students with the lecture content and gave a formative assessment for both the students and the teacher.

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