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DECISION SUPPORT SYSTEM DESIGN: REFLECTIONS ON TEACHING DECISION THEORY AND STATISTICS WITHIN AN INFORMATION TECHNOLOGY DEGREE

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INTRODUCTION

Institutes of technology focus on vocational education and training. Application and qualification in computing degree courses aim to develop technical and academic skills for further study and employment. Information Technology (IT) is concerned with capturing, creating, storing, and manipulating data to generate useful information for businesses. The systems that are widely used to support decision-makers are known as Decision Support Systems (DSS). Since the development and widespread application of complex, global IT systems, data are plentiful. However, the challenges involved in harnessing data to support decisions are not trivial. The prevalence of Big Data presents substantial challenges to analysts due to its volume, velocity, variety, and variability (Naeem et al., 2022).

The value of data analysis, modelling and using the outputs from models to generate Business Intelligence (BI) forms a crucial part of IT teaching at the Southern Institute of Technology (SIT). The demand for skilled and experienced data analysts and business intelligence specialists is strong and likely to be sustained for the foreseeable future (Schroeder, 2021). However, there is value in educating information technology students to use smaller and simpler data sets, and to develop thinking about Decision Theory (DT) and statistics on the pathway to Big Data (Choi, 2019). Decision theory concepts are essential to educate IT students in decision support systems and include aspects such as decision type, risks, probabilities of decision outcomes and the underlying assumptions about how decisions are made. Decision support systems form part of the content of an elective final-year Bachelor's degree course in Information Systems for Management (ISM) at SIT.

This article reflects on how effective the explicit application of critical thinking is when connecting subject theory to practice, during an assessment task in which students design a decision support system based on a small data set.

The assessment task involved the student and teacher engaging with a simple business scenario, where client data ranging from age and estimated annual income, to employment category and reported gender, had been collected by a questionnaire and input into an Excel spreadsheet. The data was already organised into appropriate variables; for example, client age as measured data and employment category as nominal data. The teacher completed a walkthrough of each formative assessment sub-task, ranging from selecting variables of interest to analyse, generating numerical and graphical output, and evaluation of the models produced for validity. Summative tasks, in this context, are assessments where student performance is graded and contributes to the student's final mark. However, formative tasks aim to develop the student's academic performance, without the high stakes of a summative assessment. Thus, this formative task, which forms the basis of the reflective research which follows, is a trial run for the student, since it is based on a very similar scenario, but with a different data set.

First, the context and content of the reflection are outlined. Second, the need to prepare students to think critically for decision support system design is outlined. Third, the theoretical concepts of decision theory are navigated. Fourth, the challenges involved in teaching statistics to IT students are described. Finally, the conclusion reflects on the effectiveness of integrating statistics, decision theory and critical thinking for the students' future work readiness.

CONTEXT AND CONTENT

In the context of IT education at degree level, real-life challenges include computational thinking which, as a core skill, is more than just following or coding an algorithm. Doleck et al. (2017, p. 4) identify five computational thinking competencies: algorithmic thinking, cooperativity, creativity, critical thinking, and problem solving. It would be possible, but not desirable, to teach decision theory in isolation from decision support systems and its problem-solving aspect – but why not explore decision theory during ISM systems studies and support both present and future benefits for our students? We need students who are informed by decision theory and use decision support systems to solve problems and support effective decision-making. Such decisions may have potential for creating benefits for businesses. In this context, a DSS can be defined as "a computerised system that gathers data from identified sources, synthesises it, and makes it available to users in accordance with specified decision processes to support quality decision making on specific semi-structured and unstructured decision problems" (Sivapalan et al., 2020, p. 16). This article outlines the teaching strategies forming the basis for a series of lessons on decision support systems, students' responses, teacher reflections and ways of connecting, critiquing, and applying decision theory within the context of an ISM course.

PREPARING THE FOUNDATIONS

Established decision theory can be readily applied to given DSS tasks to produce meaningful and applicable solutions to complex real-world problems. The application of critical thinking can lead to better appreciation of the benefits that decision theory can bring to decision support systems design. In the context of the ISM course, critical thinking "entails the examination of those structures or elements of thought implicit in all reasoning: purpose, problem, or question-at-issue; assumptions; concepts; empirical grounding; reasoning leading to conclusions; implications and consequences; objections from alternative viewpoints; and frame of reference" (The Foundation for Critical Thinking, 2019, para. 4). Our data-rich world requires the application of decision theory, decision support systems and critical thinking to empower individuals to manage their lives and careers. A proper grasp of concepts around decision-making, including rationale, underlying assumptions, positive and negative aspects, will support current and future career readiness for information technology degree students.

The concepts associated with decision support systems and their associated statistical procedures are the vital link to asking: why does decision theory help us in our quest for business intelligence? Or perhaps, why should DT be relevant to DSS and ultimately BI? What are the logical, technological and mathematical bases for such concepts? We may even ask, why does it matter if we understand the decision theory and decision support systems concepts underlying the ISM course content, if we believe we can generate adequate solutions to data analysis and make pragmatic decisions without them? However, IT degree students need to base their learning and professionalism on research since "Theory without practice is empty; practice without theory is blind" (Ako Aotearoa, 2021).

DECISION SUPPORT SYSTEMS CONCEPTS AND SKILLS IN THE CLASSROOM

The first session on this topic area started on a Tuesday afternoon on campus with 20 Bachelor in Information Technology (Level 7) students. Noting that there were several mature students with prior computing and work

experience among the other younger students in the class, I could see an opportunity to draw on work and life experiences to inform a fresh approach to teaching decision theory and statistics within the context of decision support systems studies. Some students would be revisiting semi-familiar material and others would be returning to education after some years of employment, and perhaps had never dealt with these topics in an academic context. This seemed to be an ideal opportunity to present the material with a questioning approach at the outset, to enhance student engagement and make theory and practice more relevant. It was also a situation in which to foreground decision theory and decision making in everyday situations. Those more familiar with statistics would have to revisit why and what assumptions we start with, rather than just consider how to start; those returning to study, having had responsibility to make business decisions, would bring with them a questioning approach based on life experience (Why do I need to learn this? What for?).

The lesson commenced with an overview of decision types, ranging from structured decisions to unstructured decisions (Bourgeois et al., 2019), followed by a prompt to the class to comment on what these meant in a practical, everyday sense. This revealed the assumptions that were made (or had to be made) to create some agreed meaning about decision categories. We then observed that some decisions do not readily fall into either category, or thus could usefully be classed as semi-structured decisions. The categorising of decisions framed our shared understanding of what we assumed to make sense and be practically useful. Thus, "learning takes place when new information is built into and added onto an individual's current structure of knowledge, understanding and skills" (Pritchard, 2009, p. 17).

Logically, this approach led on to further sessions involving detailed considerations about the underlying constraints and factors involved in decision making within organisational contexts. Such considerations involved decision priority, decision familiarity, authority to make decisions, preferred styles of decision making, risk aversion and many other facets. The apparently abstract and 'irrelevant' decision theory became even more important in when it came to designing a simple decision support system.

CHALLENGES IN TEACHING DATA ANALYSIS, DATA MODELLING AND STATISTICS

The next class began with illustrating fundamental statistical knowledge including levels of data measurement, descriptive statistics and linear regression. The demonstration activity used a data set with similar characteristics to that used in the summative assessment, but with a different scenario. Setting the summative assessment task within a simple business scenario helped structure the students' thinking in relation to the types of decisions that their decision support systems might support. A selection of relevant statistical capabilities within Excel was explained and applied to the formative assessment data set.

Navigating the statistical terminology proved challenging for the students. Focusing on the graphical output from the data analysis helped quell their anxieties. It seemed that having a clear grasp of the three levels of data measurement (scale, ordinal and nominal) would logically determine which statistical operations would be appropriate (and which would not be appropriate). A demonstration of using Excel to calculate an average value for a nominal variable highlighted the need to ask: what kind of data were we analysing? Why would Excel allow the user to perform such an inappropriate (and meaningless) calculation? Critical thinking again surfaced, with students gradually becoming aware that decision support systems are only as good as the data input, the limitations of the DSS model used and the interpretation of the DSS outputs as they relate to decisions to be made. Simple linear regression formed the core of the DSS model. Despite the somewhat abstract statistical concept that this kind of line-fitting was about, the teacher used a more tangible example of types of mechanical engineering fit to de-mystify the content. Questions about mechanical surface quality control in terms of consistency of fit (distribution of residuals) and the tightness of fit (size of residuals) seemed to work very well and helped students realise that these concepts occur in other fields and do have real and practical consequences.

By this time, the class was beginning to get curious about which variables in the summative assessment data set to select for analysis. What decisions about the variables would be needed before we proceeded with statistical analysis and applied simple linear regression appropriately? The need for decision theory and deciding what types of decisions we wished to make became more evident. So, one possible flow of events in decision theory application and decision support systems design started to emerge in the class. Perhaps if we began by asking what kind of decisions to make, then decided which variables were likely to provide relevant input to the simple linear regression model, this would be a good start. Next, it seemed that with the selected variables, performing appropriate statistical calculations would make sense. For example, for a café business scenario, exploring a possible linear relationship between an income variable (in thousands of dollars) and café spending (in dollars) might be useful to target specific income groups with coffee specials to optimise income from sales.

As the Excel line fit graph was analysed critically, it became evident that the simple linear regression model had serious issues with validity. The graph had large residuals with a very non-linear distribution. The students began to develop their critical thinking in this decision support systems context and observed that, while some data points coincided with the line of best fit, for many others it did not. The students also saw that there were outlying values that did not seem to belong to this model. Perhaps they were spurious? Could we exclude them from our analysis to make the DSS task easier? Was this correlation present or did we impose this on the plot? We began to see just how valuable critical thinking is, even in the middle of 'statistical number crunching.' In the context of experiential learning theory, teachers, acting in the subject expert role, "often teach by example, modelling and encouraging critical thinking" (Kolb & Kolb, 2017, p. 18).

We finished the week with a view to further decision support systems development. As students began to experiment with the variables in the formative assessment data set, a need arose to filter data by grouping them into meaningful categories. Each category could then be analysed for descriptive statistics with a view to exploring possible correlations between various measured variables. Providing a free-thinking and safe teaching environment supported the students' motivation to value trial and error in their learning. This helped the students to grasp the rationale for standard statistical procedures, while acknowledging that experience, instinct, and guesswork still have a role to play in analysis and design of DSS. This approach tapped into their creativity and problem-solving dispositions.

Slowly but surely, the students' awareness of the interconnectedness of decision theory, decision support systems and critical thinking stimulated an approach to apparently abstract topics, such as statistics and data modelling, marked by a more open, and sometimes playful, disposition. It was encouraging to see the students making conceptual links among the DSS theory, decision theory, statistics, and business intelligence. Also, it was reassuring to sense that the sessions catered for different learning styles (Honey & Mumford, 1986) including those who prefer to learn by doing (activists), those who stand back and observe (reflectors), those who like to see how things fit into frameworks and concepts (theorists) and learners who are happy if a method works (pragmatists). Use of a ubiquitous application like Excel made the learning process sufficiently smooth and immediately useful, without students having to learn a completely new and complex decision support system which might feed on big data, with all its attendant demands.

CONCLUSION

The embedding of critical thinking in teaching and learning at SIT encourages students to challenge themselves and their often-hidden assumptions about the topics they study, the concepts that are needed and the dispositions that accompany them. This article has outlined some of the teaching and learning approaches where decision theory is foregrounded and reflected on various perspectives relating to the application of decision theory, decision support systems and statistics. All the students involved achieved their learning outcomes with enhanced critical thinking to take with them on their academic or employment journeys. Not only did the

students graduate with their Information Technology degree, but this course prepared them for postgraduate study and beyond. Thus, the students could build on these foundations when using more complex analytical platforms and applications

This result was achieved by the teacher and students collaboratively building the foundations of a simple decision support system by using decision theory and statistics supported by critical thinking, within the context of an elective final-year Bachelor's degree course in Information Systems for Management (ISM) at the Southern Institute of Technology.

John Mumford is an IT lecturer at the Southern Institute of Technology. His research interests include teaching innovation, mathematics education, adult literacy and numeracy, and postgraduate IT education. John has a Master of Adult Literacy and Numeracy and is committed to empowering learners to develop their critical thinking capabilities.

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