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"*Useful, not just in the professional world but in everyday life*"- Exploring a non-STEM student's experience in a tertiary-level data analytics unit

Samuel K. Teague[A] [A] *Career Learning, Murdoch University, Perth, Australia*

Kim L. Hudson[B] [B] *Career Learning, Murdoch University, Perth, Australia*

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Correspondence

Samuel.Teague@murdoch.edu.au [A]

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Abstract

This study investigates the transformation in student knowledge pertaining to the study area of 'data analytics', and the building of confidence, specifically in non-STEM students, to analyse, interpret, manipulate, and present data to a range of stakeholders using *Microsoft Excel*. The context of the study is a newly developed, centrally delivered undergraduate data analytics unit, within which a pre-and post-course survey was embedded. These surveys were administered to students across three separate semesters: S2 2022, S1 2023, and S2 2023. The confidence of both non-STEM and STEM students in conducting data analysis was captured. The findings indicate that students benefit from an immersive curriculum where they are exposed to both an understanding of data analytics in a broad global and social context, characterised by rapid technological change, as well as opportunities to master technical skills utilised through *Microsoft Excel*. The results demystify the notion that non-STEM students are less capable of expanding their depth of knowledge and technological skill development outside their discipline of choice. These results are important in the context of graduate employability and the importance of digital literacy in a rapidly changing world of work.

Introduction

According to the Australian Government Department of Education (2023), the world of work continues to change rapidly, defined by advancing technology and increased automation of tasks and roles. Adapting to this change requires those studying at Australian universities to be more proficient in Science, Technology, Engineering, and Mathematics (STEM)-based skill areas, and in the context of the present study, skills that fall under the broad umbrella of data analytics. This need has become more significant and urgent for Australian graduates as we near the second quarter of the twenty-first century. In 2003, only four countries significantly outperformed Australia in mathematics-based skill proficiency at the tertiary level, and by 2018, this number had reached 23 (Australian Government Department of Education, 2023).

To address this issue, Murdoch University has drawn on funding from the National Priorities and Industry Linkages Fund (NPILF), which is the Australian Federal Government's allocation of grants to Australian universities to develop programmes, units, initiatives, and industry partnerships that support the development of job-ready graduates, and specifically, the development of STEM skills in those graduates. As part of Murdoch University's utilisation of this funding, a 'data analytics unit' was designed specifically for non-STEM students to boost employability skills for enhanced career readiness. This unit was delivered for the first time in August 2022.

The unit, MSP202 *The search for everything: Data analytics and storytelling in the twenty-first century*, while developed for predominantly non-STEM students, did not exclude those undertaking STEM degrees. It was an opportunity to not only develop data analytics literacy but also to examine and understand the impact of data analytics in the context of their own career and the world of work more broadly. The unit exposes students to some of the ethical issues that surround data collection, operationalising of data, and data surveillance, as well as providing a learning space within which the development of technical skills in data manipulation and conversion of data to meet the expectations and needs of key stakeholders can flourish. The unit is unique because these opportunities for skill development sit outside what non-STEM students would normally be exposed to within their undergraduate degree. Foregrounding rapid social change and a broad cultural shift towards appreciation for the weight and influence of data, the principal emphasis of the unit is on social impact, ethics, and being able to apply data analysis skills and present data-driven insights using *Microsoft Excel*.

Considering the non-STEM target cohort, students traditionally unfamiliar with data-driven platforms such as PowerBI and Tableau, *Microsoft Excel* was chosen as the software central to the student's learning experience. From a teaching and pedagogical perspective, *Microsoft Excel* was judged as a robust platform for students unfamiliar with formulae, numerical functions, and mathematics, while also being universal enough and proficient for the needs of those undertaking STEM degrees, who would likely form a moderate-sized percentage of the cohort each semester. Further, *Microsoft Excel* is convenient due to its availability, low cost, and ubiquitous nature in contemporary workplaces (Rubin & Abrams, 2015). It can be used to clean, manipulate, organise, and present data. This offered students a supported introduction to the world of data analytics, constituting a readily identified, industry-preferred digital literacy platform.

Aim

Foregrounding student self-assessment, the broad aim of this study was to examine the extent to which a unit designed to support and facilitate data analysis skill development in a predominately non-STEM cohort could offer a learning environment and set of resources that would meet this objective. The core aim was to assess how a cohort of students studying both entirely online (external) and in a face-to-face (internal blended learning) environment perceived and understood the growing influence of data analytics in both their professional and personal spheres.

Broadly, the study constitutes an exploratory analysis of:

1. Non-STEM students' capacity to develop data analysis skills.
2. Growth and transformation in the cohort's understanding of the growing importance of data analytics in the context of the world of work and rapid technological development.
3. Growth and transformation in the cohort's capacity and confidence to apply data analytics.

The analysis that follows is divided into five sections. The first comprises a review of relevant literature outlining the key concepts underpinning this study. Within this section, the research covering employability and employability skill development, curriculum design, digital and data literacy, as well as student self-perception is presented. The second section summarises the methodology, including a comprehensive participant profile. Following this, 'findings' presents the analysed data from the pre-and post-surveys offered to students as part of the delivery of MSP202. The paper concludes with an appraisal of the significance of these findings, recommendations for future research, and an acknowledgement of the study's limitations.

Literature review

Widespread and rapid advances in technology have impacted production processes and social structures and altered the way we live, engage, work, and learn (Bikse et al., 2022; Khan et al., 2022). The context of major technological advancement – automation, robotisation and artificial intelligence – has invoked a new way of perceiving the world and triggered a change in economic and social structures (Bikse et al., 2022). The advent of generative AI in tertiary education has been particularly transformative, sparking analysis concerning how to respond to rapidly advancing technology from a teaching standpoint, in the context of academic misconduct, and even for academics reviewing literature (Ismail et al.,

2023; Mills et al., 2023; Sullivan et al., 2023). The way we work requires new and quickly changing skillsets for both established workers and university graduates seeking entry into the job market. As technology takes over routinised and automatable processes, work turns towards more human-centred, meaningful, and creative applications with rapid growth in the need for highly skilled workers who can both use and create new technologies (Bikse et al., 2022; Khan et al., 2022). These changes constitute a significant ontological shift that forms the practical basis for this study.

Underpinning the increasing labour market demand for 'work-ready' 'digitally literate' graduates is a strong industry narrative that suggests students transitioning to the workplace are not well prepared (Xu et al., 2022). Industry and government stakeholders expect graduates with skills such as communication, creative thinking, problem-solving, self-management, and adaptability to ensure economic competitiveness (Siivonen et al., 2023). This gap between labour market demand and university graduates' ability to arrive on the job with the skills needed to perform has placed an increased need for higher education to offer employability-focused pedagogies for meeting the immediacy of these changes (Bikse et al., 2022; Paterson, 2017; Suleman, 2017). In this way, employability embedded in higher education courses can be construed as a direct response to industry needs and a distinct pedagogical shift from 'knowing' to 'doing' (Paterson, 2017). As such, employability and employability skills (also known as 'soft' or 'human' skills) have become an area of international relevance with growing academic interest (Ruge & McCormack, 2017).

Employability

While university stakeholders such as governments and industry employers increasingly demand work-ready graduates, students also expect positive career and work outcomes as a direct result of their educational investment (Siivonen et al., 2023; Ruge & McCormack, 2017). Employability is a broad multidimensional concept mostly related to the ability to secure and remain in employment (Xu et al., 2022). While not straightforward and lacking consensus, definitions of graduate employability involve a set of assumptions about ability and the requirements of employment (Nghia et al., 2022; Suleman, 2017). Yorke (2017), however, emphasises that employability is not the same as employment. Nghia et al. (2022) agree and stress that graduate employability is a lifelong process of developing and using various forms of capital to attain employment, thrive, and remain competitive and employable as individuals progress through their careers. As such, graduate employability should consider all aspects that make graduates able to attain lifelong employment as well as the ability to create jobs for themselves and others.

To understand and conceptualise the employability domain, various frameworks have been developed to broaden the understanding of graduate employability and to enhance student transition from higher education to the job market. Ali (2016) collates three sets of employability skills based on basic academic skills (reading, writing, oral communication and listening, science and mathematics), higher-order thinking skills (learning, reasoning, creative thinking, decision making and problem-solving) and personal qualities (self-confidence, self-control, social skills and so forth). Tomlinson (2017) conceptualises the multidimensionality of employability in terms of capital – human, social, cultural, identity and psychological – as a useful way of highlighting the various components held within it. Nghia et al. (2022) focus on human capital development, that is, the abilities or expertise that enhance work performance and personal attributes such as age, education, training, and skills, which are often considered the foundation of graduate success.
Despite such perspectives being highly contested (Yorke, 2017), employability as the 'possession of skills' is the most dominant adoption by several stakeholders, including employers, policymakers, and academics (Nghia et al., 2022). In the Australian context of this study, a prevailing belief in the 'possession of skills' appears to underpin the creation of the National Priorities and Industry Linkages Fund (NPILF) as a way to meet a STEM-based area of need in non-STEM graduates.

Employability skills

A focus on defining employability skills, placing them in specific social and cultural contexts, and assessing their importance for university graduates, continues to garner attention in both the education sphere and the world of work more broadly. A crystallised and consistent list of employability skills used across Australian universities has not yet been developed, with most tertiary institutions adapting a globally recognised list to suit their student body. The influences are varied. The World Economic Forum's Future of Jobs Report (2023) lists the top ten employability skills on the rise: creative thinking, analytical thinking, technological literacy, curiosity and lifelong learning, resilience, flexibility and agility, systems thinking, AI and big data, motivation and self-awareness, talent management and service orientation and customer service (p. 39). Each skill can be considered part of a broader mosaic and should be understood as coalescing with other skills, depending on the time and place within which they are employed.

Acknowledging that these skills are various connections and sub-sets, there have been several attempts to develop employability skill frameworks incorporating the skills and personal attributes necessary for work success (Scarinci et al., 2023). Frameworks defining employability skills or graduate attributes generally derive from national skills frameworks (Jackson, 2014). The Australian Chamber of Commerce and Industry (ACCI), for example, developed an employability skills framework with eight key skills and personal attributes for worker success, which includes communication, teamwork, problem-solving, initiative and enterprise, planning and organisation, self-management, learning, and technology skills. Murdoch University adapted the Work Skill Development Framework for student employability skills developed by Bandaranaike and Wilson (2009) to focus on the eight subsets of Self-Management, Initiative, Enterprise and Entrepreneurship, Teamwork and Leadership Potential, Critical/Creative Thinking and Problem Solving, Communication and Interpersonal, Learning and

Applying Knowledge, Planning and Organisation and Financial and Digital Literacy (Murdoch University, 2023). Various institutional attempts at developing a bespoke skills framework, Jackson (2014) argues, have influenced different higher education approaches to employability skill development from stand-alone bolt-on learning programmes to incorporating work experience and work-integrated learning programmes as either complementary to study or alternative development options.

Curriculum

The Higher Education Standards Framework (2015) requires employability skills to be included as part of the learning outcomes for degree courses (Scarinci et al., 2023). A growing body of higher education literature from Engineering to Tourism shows various intra-disciplinary attempts to define an employability skills framework from which curriculum and pedagogy can be derived (Scarinci et al., 2023; Khan et al., 2022; McHenry & Krishnan, 2022; Aliu et al., 2021; Scott & Willison, 2021; Adeyinka-Ojo, 2018; Cake et al., 2018; Ruge & McCormack, 2017). Several studies have emerged to fill the research gap of understanding the 'how' of teaching employability and the need to ensure student engagement and ongoing reflection of their own skill set, where there might be room for improvement, and what skills they can continue to bolster (Ruge & McCormack, 2017). Alongside providing students with the opportunity to develop these skills, learning environments are now being integrated with technologies that underpin contemporary pedagogies and teaching practices (Le et al., 2022).

In their study of graduate employability for the building and construction industry, Ruge and McCormack (2017) suggest that the development of employability skills is best facilitated through discipline-based curriculum design linking university and industry expectations. Through the process of interweaving learning contexts and assessments, this embedding of employability skills development within disciplines allows students to develop metacognition for academic and professional purposes. Constructive alignment of assessment and scaffolded learning, as well as a "constructive, explicit, reflective teaching approach", encourages students to reflect on their skill development (p. 365). Interestingly, there is a scarcity of literature documenting the existence and success of centrally delivered tertiary units undertaken by multidisciplinary cohorts. The extent to which this focused learning environment made up of a largely homogenous cohort in terms of disciplinary expertise hinders or supports a student's ability to develop their graduate employability has not yet been explored in great depth within the academic literature.

Concurrent with understanding which employability skills are being privileged within a given educational context and how they should be embedded in the curriculum is the caveat that even when students can successfully develop the relevant employability skills, there exist numerous social, cultural, and political variables that may present as barriers to employment success or career advancement relevant to their study area. The curricular process may facilitate the development of prerequisites but does not guarantee it (Yorke, 2017). These other factors may include characteristics pertaining to the graduates themselves, the availability of jobs in any given market, and/or the changing world of work in the era of generative AI.

Digital literacy

Digital literacy skills are relevant to employability insofar as attempts to improve one's proficiency aim to improve employability (Khan et al., 2022). While digital literacy is generally considered an employability skill, there are few useful frameworks or guidelines for higher education to prepare graduates for the future workforce. Khan et al. (2022) describe important differences between *digital skills* and *digital literacy*, which are not interchangeable. Digital skills are defined as:

> "[A] collection of abilities that allow people to use digital devices, networks and communication applications to create and exchange information, connect and collaborate, and solve problems to improve their lives, learning, work and social activities" (p. 49).

Digital literacy builds on that functional foundation (the what and the how of digital skills) to include the why, when, who, and for whom. Thus, digital literacy is considered a set of competencies guiding the use of digital devices, including accessing, evaluating, applying, and synthesising data and creating new knowledge (Khan et al., 2022).

Potential employers increasingly expect new graduates to arrive on the job digitally literate and with the ability to review and analyse data, manipulate spreadsheets, and communicate findings and key recommendations for purpose (Khan et al., 2022; Kroes et al., 2013). However, Khan et al. (2022) point out that an exclusively workplace-focused view of the usefulness of this skill set is far too narrow and that being digitally literate is also about developing a set of fundamental skills that will apply more broadly to modern life.

Data analytics

To be digitally literate and develop the skills that would bolster one's ability to conduct analyses of a variety of data, students need to be active participants and purposeful in selecting and using information, generating new knowledge, and sharing that knowledge (Khan et al., 2022). Student learning of digital literacy and any resulting impact on academic performance and employability is still in its relative infancy. While some studies suggest a mostly positive impact on academic performance, there is little to no research focused on the relationship between digital literacy and employability (Khan et al., 2022). This is surprising given the substantial impact that the collection, aggregation, and analysis of data is having on virtually all industries in the contemporary world of work. Despite the high demand for digital and data literacy in higher education content, there is still a limited focus on data analytics, learning outcomes and employability in academic research.

In their study exploring predictors of academic success in a blended learning environment, Musabirov et al. (2019) point out that while high market demand for data science competency attracts students from different disciplines, including non-STEM, it tends to create a student cohort with diverse skill capacities depending on their major disciplinary exposure to data and data skills. Considering several factors related to initial mathematical knowledge, the traits of education programmes, blended learning engagement (whether the engagement was online or offline) and peer connections, they found that social sciences and humanities programmes' students had lower achievement in data analytics learning activities than students from economics, management, and other STEM programmes (Musabirov et al., 2019, p. 71).

The notion that non-STEM students are less equipped to engage with data analytics is not new. Vittengl and Vittengl (2022) suggest that despite having statistical analysis embedded in the psychology curriculum, psychology students find that "acquisition and generalisation of data analysis skills are perennial challenges". Sports science on the other hand, is an industry leading the way in data analytics (Kaluzny, 2021). As the analysis of data becomes normalised in both professional and personal realms, one might expect that a disciplinary equalisation of sorts will take shape in the tertiary sector, with commensurate emphasis across degree structures on developing data analysis skills alongside subject-specific knowledge acquisition.

Student self-perception

Broadly, the ability of graduates who are ready to enter the labour market is dependent on their *perceived employability* within a specific market (Nghia et al., 2022). Perceived employability relates to both internal and external factors: internal is the perception of one's knowledge, skills, abilities, and job search capability; while external is related to factors such as demand for expertise, institutional prestige, and overall labour market conditions (Nghia et al., 2022).

Based on the work of Vanhercke et al. (2015), who found that if employees perceive themselves as employable, they were more focused on accessing knowledge and resources to become more employable, Nghia et al. (2022) locate perceived employability as critical to the graduate transition to work and translating employment outcomes. Le et al. (2022) highlight a similarly delicate balance between a student's perceived level of digital literacy, motivation for engaging in the learning environment, and academic performance. However, in contrast, they found that students with a self-perception of high digital literacy (HDL) did not necessarily translate into the realms of high academic achievement in this space, in comparison to those who perceived themselves as having low digital literacy (LDL). There are few studies exploring the relationship between a student's ability to demonstrate employability and their employment outcomes (Nghia et al., 2022).

Methodology

The analysis central to this study is exploratory in nature. Through addressing the nationwide need to develop STEM capability in tertiary Australian students, regardless of their discipline of choice, MSP202 *The search for everything: Data analytics and storytelling in the twenty-first century*, offered students the chance to clean raw data sets, create pivot tables using *Microsoft Excel*, uncover insights through analysis of data, and pair those insights with story, discourse, and narrative in presentations to key internal and external stakeholders. To assess both proficiency in conducting data analysis and student attitudes towards data surveillance, ethics, the way data is collected, organised, and operationalised in their personal and professional spheres, and the importance of Big Data in the twenty-first-century world of work, a two-stage survey was developed and administered (see Appendix B).

Structured around twelve weekly topics, MSP202 students were invited in Weeks 1 and 12 to complete a survey containing a mix of multiple-choice questions, short answer questions, and questions that required a numerical response. As mentioned above, these questions sought to understand and uncover insights relating to skill development and the world of data analytics more broadly, and the mixed nature of the question structure yielded valuable qualitative and quantitative data for analysis.

In both stages of the survey, the Moodle 'Quiz' tool was used to source responses from students. As participants engaged with the survey in Week 1, they were presented with a Consent and Plain Language Statement (see Appendix A) regarding the nature of the research being undertaken and its purpose. This approach received prior approval from Murdoch University's Human Research and Ethics Committee. Recruitment took place through the unit itself, which the students enrolled in as part of their degree. As such, the study avoided traditional recruitment methods such as snowball sampling, flyers, and emails, with participation promoted as entirely voluntary and not connected to grade-related outcomes in the unit itself.

Data was collected across three semester deliveries: Semester 2, 2022 and Semesters 1 and 2, 2023. Each survey took between 10 and 20 minutes to complete, with the Week 1 iteration focused on student self-appraisals of their data analysis skills, their understanding of issues pertaining to data surveillance, the impact of data analytics on both their professional and personal spheres, and the potential real-world benefits of data analytics in the twenty-first century. The purpose of the Week 12 survey was to assess how/if the responses provided in Week 1 had transformed over the course of the student's time in the unit.

The surveys yielded both qualitative and quantitative data, and multiple methods of analysis were employed to understand these results. For qualitative responses, a mix of thematic and content analysis methods was used to assess the presence of consistent themes across the cohort of students. It was anticipated that students might share similar concerns, for instance, about Uber's tracking of GPS data or the use of personal information to influence political

outcomes, and so the purpose of qualitative analysis was to assess, summarise, and tease out the presence and nature of these concerns. With regards to quantitative responses provided by our cohort of students, we utilised basic methods of quantitative analysis, namely, assessing mean responses across the cohort, outliers, and changes over time.

Participants

The voluntary nature of the data collection process yielded a high percentage of students completing the Week 1 survey but not the Week 12 follow-up. This complexity necessitates a detailed summary of the participants who ultimately took part in this study.

A summary of the participants engaging in this study is divided into two parts: (1) the broader sample of the MSP202 student cohort who completed the Week 1 survey and (2) a smaller group of students who completed both Week 1 and Week 12 across the three semesters.

The broad sample of participants that took part in this study were 157 undergraduate students enrolled on the second-year unit titled MSP202 *The search for everything: Data analytics and storytelling in the twenty-first century*. Of these 157 students, 101 were female and 56 were male. A total of 73 students enrolled in the online version of the unit, while 84 studied on campus, predominantly face-to-face. Roughly 76% of the sample, or 120 of the 157 participants, were from non-STEM degrees, a figure that is commensurate with the expectations of the learning designers. Thirty-five separate degrees were represented in the sample, with Business (*n*= 31), Criminology (*n*= 21), Science (*n*= 15), and Psychology (*n*= 10) offering the largest enrolment numbers. Participation was consistent across each of the three semesters through which data was collected, as summarised in Figure 1 below.

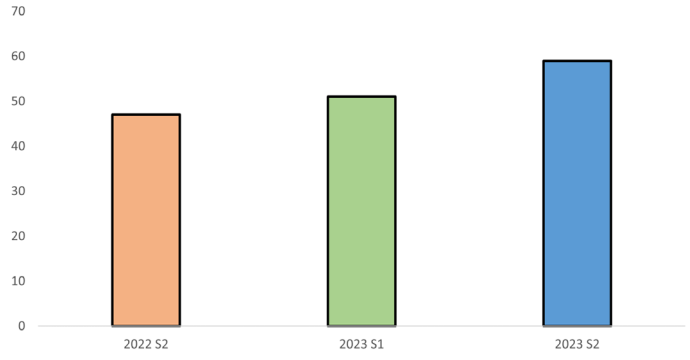

Figure 1. Participants by offering.

Of the overall sample of 157 who engaged with either the Week 1 or Week 12 surveys, 151 completed Week 1 in full, 30 completed just Week 12, and 24 completed both. The small percentage of respondents who completed both pre- and post-surveys presents a limitation of the study, addressed later in this paper.

The smaller sub-sample of 24 participants who completed both Week 1 and Week 12 surveys in MSP202 form the second set of data. This group forms the focus of analysis in the remainder of this paper. Of this sample of 24, a total of 19 were female, and five were male; 10 studied online while 14 took part face-to-face; 19 students came from non-STEM degrees, while a total of five students were STEM undergraduates. A breakdown of the degrees from which this smaller sample was drawn can be seen in Figure 2 below.

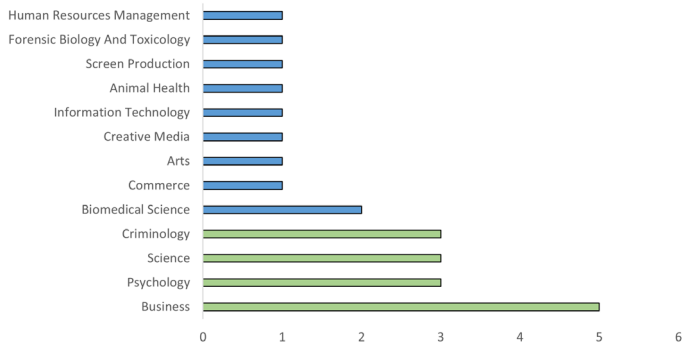

Figure 2. Participants by degree.

Some of the dichotomies identified above, including gender, study period, study mode, and degree type (STEM vs. non-STEM, for instance), provide a rich grounding for comparative analysis. While the 19 non-STEM versus five (5) STEM participants is not evenly balanced, as a preliminary and largely exploratory study, it remains useful to ask how non-STEM students might fare in developing data literacy skills (in particular, a capacity to analyse data using *Microsoft Excel*) and assessing at the same time, how the STEM group responded to the same learning materials, of which they are presumably more familiar.

The 24 students, drawn from the broader sample of 157, are presented in the findings as case studies (using pseudonyms) through which the transformation of students' perceptions, knowledge and ability pertaining to data analytics is explored.

Findings

Overwhelmingly, for the case study group, self-appraisal of data analytics capability and proficiency in using Microsoft Excel for conducting data analysis showed improvement over the duration of the unit for both STEM and non-STEM students. On a scale of 1-10, with 10 meaning 'very high proficiency' and 1 meaning 'very low proficiency', participants were asked to self-rate, (1) their data analysis skills and (2) their proficiency in using Microsoft Excel. Figure 3 provides a summary of self-appraisal scores for data analysis proficiency, measured in both Week 1 and Week 12.

Figure 3 illustrates consistent self-rated improvement for this group of participants. The group's aggregated mean for self-rating data analysis skills was 5.08 in Week 1, improving to 7.62 by the conclusion of the semester. In just one instance, for Participant Dana, the self-rating declined, though this might be owing to an over-appraisal of their proficiency at the time of completing the Week 1 survey. These figures suggest that the principal purpose of the learning experience – to offer students a chance to develop STEM skill capability – is being fulfilled. Figure 4 examines the same results but for the non-STEM cohort.

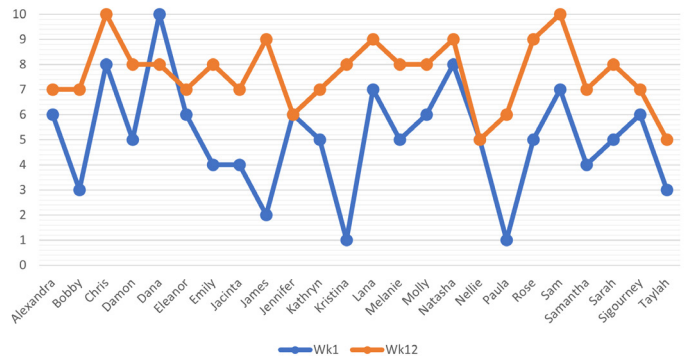

Figure 3. Data analytics proficiency, Week 1 and Week 12.

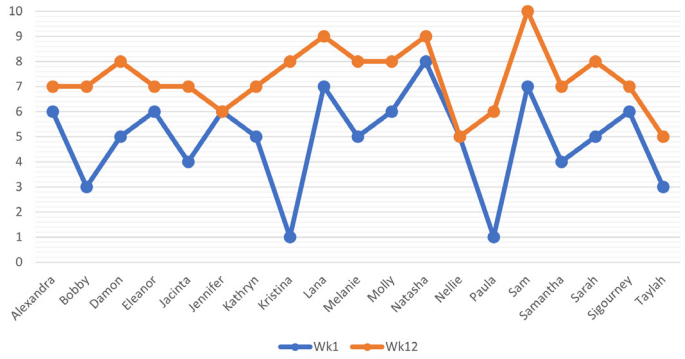

Figure 4. Data analytics proficiency, Week 1 and Week 12, non-STEM participants.

While the purpose of this study was not to evaluate the 'impact' or 'success' of a tertiary-level unit aimed at building data analysis skills, the findings presented in Figures 3 and 4 are significant when considered in the context of the research pertaining to non-STEM students and their perceived inability to be able to work with and acquire STEM-based knowledge and skills (Vittengl & Vittengl, 2022). In addition, Figure 3 indicates that the learning experience was useful for both STEM and non-STEM cohorts, suggesting that the disparate needs of diverse groups of students can be met within a singular learning experience. The findings pertaining exclusively to non-STEM students, documented in Figure 4, provide a visual summary of an aggregated mean improvement from 4.89 to 7.31 across the duration of the semester, and no individual cases where the two-stage – Week 1 and Week 12 – self-appraisal of data analytics skills declined. For some participants, namely, Kristina, Paula, and Bobby, the improvement is substantial.

Participants were also asked to self-rate their proficiency in using *Microsoft Excel* both in Weeks 1 and 12 of the semester, and the results were similar to the findings detailed in Figures 3 and 4 above. Over the duration of the semester, participants reported increased confidence in using *Microsoft Excel* for data analysis. The uniformity of this increase is evident with roughly 74% of participants in the sample of 24 reporting an increase in confidence/self-rating. There were four cases where participants (all of whom were from STEM degree programmes) reported a decrease in self-rated proficiency using *Microsoft Excel*. Possible reasons for this are discussed in the following section of this paper. Overall, the aggregated mean for the sample of 24 students improved from 5.41 to 7.29, and these findings are depicted in Figure 5, below. Figure 6 depicts the same evaluation of *Microsoft Excel* proficiency, but for the non-STEM cohort, with these numbers showing a mean aggregated improvement from 4.89 in Week 1 to 7.31 in Week 12.

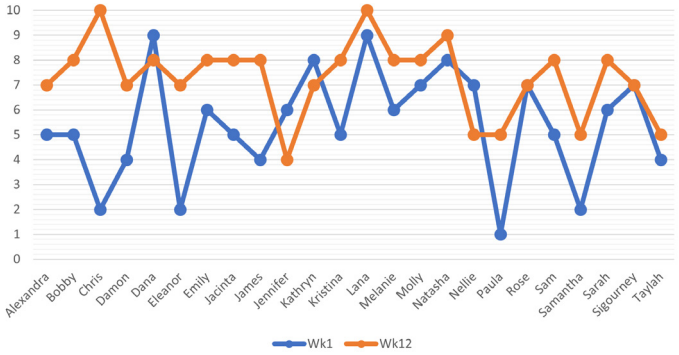

Figure 5. Microsoft Excel proficiency, Week 1 and Week 12.

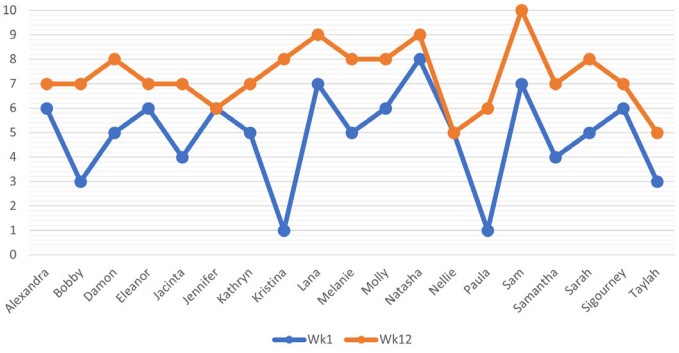

Figure 6. Microsoft Excel proficiency, Week 1 and Week 12, non-STEM participants.

For the non-STEM cohort exclusively, all participants reported a positive or neutral increase in *Microsoft Excel* proficiency, as indicated in Figure 6.

Figure 7 examines gender and data analytics proficiency (again, defined as a broader appraisal of student proficiency and comfort in multiple aspects of the data analytics process), while Figure 8 does the same, but exclusively for student proficiency in using *Microsoft Excel*.

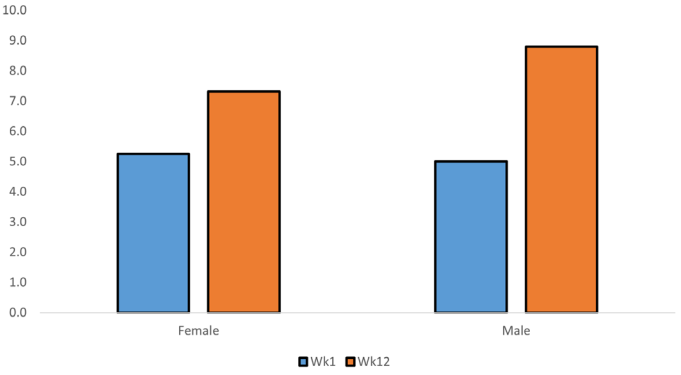

Figure 7. Gender and analytics proficiency, Week 1 and Week 12.

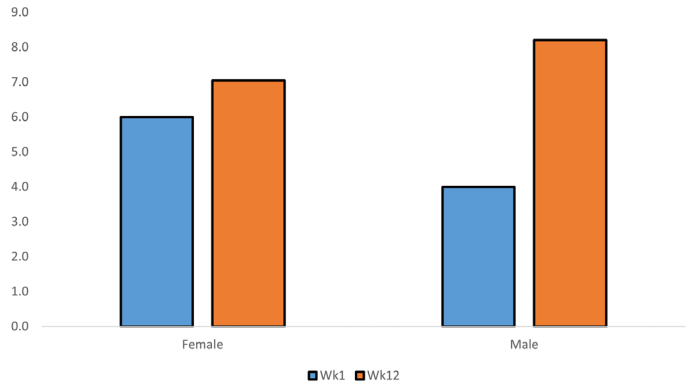

Figure 8. Gender and Microsoft Excel proficiency, Week 1 and Week 12.

At the start of the semester, female participants reported a marginally higher level of self-rated proficiency in Data Analytics (which can be seen in Figure 7). More considerable was the disparity in self-rating across males and females for *Microsoft Excel* proficiency, as depicted in Figure 8. However, by Week 12, males reported higher proficiency ratings for both Data Analytics and *Microsoft Excel* skill sets. The significance of these findings and hypotheses that could explain the trends depicted above would make a suitable potential study for future scholars interested in examining the intersection between data analysis skills and gender.

In totality, the findings depicted above suggest that students are placing emphasis on developing skills that are more closely aligned with what is becoming increasingly desirable in the world of work, notably digital literacy skills. They also suggest that despite the measure being a self-rating of proficiency, students are developing these skills successfully. These findings were supported by an examination of the sample's views on their own employability skills, notably, which ones were their strongest and which needed the most development.

The larger sample of 157 students was asked to rate their three strongest employability skills and the three employability skills that they believed contained the most significant room for growth and improvement. The list provided to participants consisted of the nine employability skills identified by Murdoch University as those to be used across career learning units, and these were: *Critical, Creative Thinking and Problem Solving; Planning and Organisation; Teamwork and Leadership; Digital Literacy; Initiative and Entrepreneurship; Verbal, Written and Interpersonal Communication; Learning and Applying Knowledge; Self-Management; and Financial Literacy*. In both instances where students reported on their strengths and areas where there was room for growth, the perceived importance of developing data literacy amongst the student population was apparent. These results are represented in Figure 9 and Figure 10 below.

The sample of 157 students responded to a question pertaining to the current state of their employability skills and, with regards to Figure 9, were asked to list their top three most proficient skills. A total of 24% of responses from students nominated Critical Thinking, Creative Thinking and

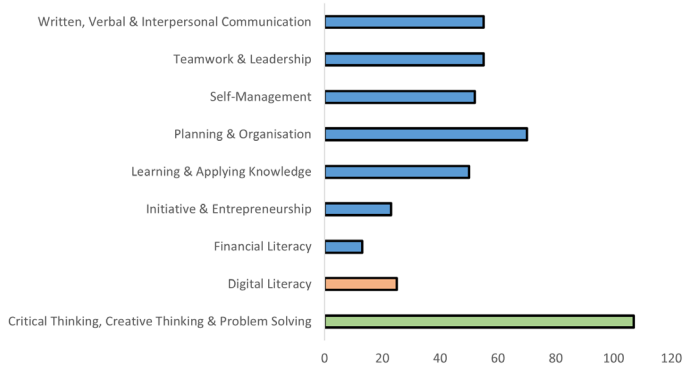

Figure 9. Employability skills (strengths).

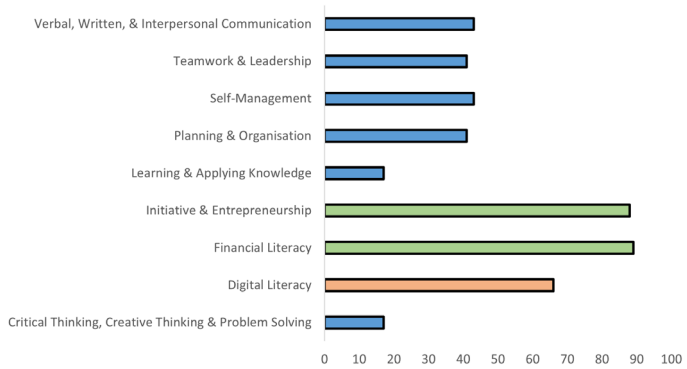

Figure 10. Employability skills (growth areas).

Problem Solving as their most proficient skills, while 16% of responses saw Planning and Organisation as the second most frequently cited skill. In the context of the present study, Digital Literacy and Financial Literacy were the least frequently identified employability skills, with 5% and 3% of responses respectively.

The findings depicted in Figure 10 offer support for those presented in Figure 9; students perceived *Digital Literacy* as one of the most pressing employability skills in need of development, alongside *Financial Literacy and Initiative and Entrepreneurship*. When we pair these results with the self-ratings from the sub-sample of 24 participants who completed the pre- and post-surveys in Weeks 1 and 12, we are presented with a picture of a group of students who understand the need to develop their digital literacy skills, and then a commensurate emphasis on improving in that domain, aligned with the identified need. While the results in Figures 9 and 10 are the inverse of each other, they reflect a cohort that saw digital literacy in great need of growth and, not surprisingly, not prominent in their list of strongest employability skills.

The significance of the findings depicted above becomes more pronounced when considering the qualitative responses documenting the sample's lack of experience in working with data and conducting data analysis. One participant commented that their only foray into understanding data prior to engaging with the unit had been on 'census night', while another simply responded 'I have little background in data analytics'. These comments were reflective of a commonality across the larger sample's (*n*= 157) response to this question:

> 'I have basically no prior knowledge of data analytics. I believe I did a little bit in maths in year 12'.
>
> 'This unit is the first time I have engaged with data analytics'.
>
> 'I haven't had much experience with data until I started this degree. Being involved in data is interesting and also challenging at times'.

At the close of each teaching period, participants were asked 'What has been the most transformational idea, concept, reading, lecture … you have engaged with throughout your time in this unit, and why?' A mix of responses highlighted the value of data manipulation, presentation skills and professional and personal development. Importantly, there was no significant difference in thematic underpinnings across gender, study mode, offering, or the STEM / non-STEM divide.

Three participants reported that the *Microsoft Excel* skills they developed were of greatest benefit to their career trajectory and efficacy in a particular line of work. One participant pointed to the transferability of the skill acquisition in other units.

> 'I think Topic 6 – manipulating data has been the most significant, as I have now started using those techniques I've learned in data handling for other units'.

Other participants focused on 'storytelling' and the presenting of data-driven insights as the aspect of the learning experience of greatest benefit. Below are extracts from two students who spoke extensively about the skills of greatest value that the learning experience had provided them with the opportunity to develop:

> 'I would have to say Topic 10 relevant to presenting data and this is because I found it to be the topic of which I am most interested in learning and applying within my career. I think that the bonus content especially offered some valuable insight into where I need to improve. The main readings and workshop were valuable for the development of my presenting skills. I am most grateful for Robert Dolan's works and the content relevant to his paper on effective presentation skills.
>
> 'Becoming a data story-teller' … was pretty significant and impactful in learning how to tell the story of everything I've learned or any initiative I want to take professional or informally in educating those around me inside and outside of my academic field. It … gave me a good … basis for how I should approach conversations, presentations and education in bringing up topics of mental health. Learning how to make the presentation of information flow, with the right language to suit your audience, relevant statistics and the strong emphasis of a story is a framework that can be used in any context … Learning how to do that is a skill I will keep developing and is very vital to what I want to achieve in my field, education on the psychology of humans.'

These two extracts reflect the broader sentiment within the sample of 24 participants around the development of data analysis skills is more than just the cleaning of and manipulation of raw data and, importantly, its impact on the likelihood of career success for the learner in question. This speaks to a broad and deep level of investment in the learning experience, and we suggest that this investment has been – at least in part – informed by an awareness of the 'weight' of data in the personal and professional lives of human beings. The majority of qualitative responses from participants spoke directly to this dual impact.

> This [data] affects everything from the world's economy to how we save money online, there is no doubt that the emergence of new data has a positive impact on our lives. It allows us to track our personal health, dietary habits and bank statements through a smart phone. Collecting and analysing personal data allows us take better control of our life by understanding it better. It can improve our work, habits, relationships and health, and help us focus on what's important to us, to achieve our goals.
>
> Addressing mental health. Tech companies' health and related health focus has increased in the last few years due to the identification process. We produce so much data about ourselves now, with this ontological taking place tech companies are able to capitalise on this which also gives us more mental health-focused programmes, and apps, and eased work constraints.

This suggests a transformative learning experience in which participants understand the impact across both professional and personal spheres in a way that is "useful, not just in the professional world but in everyday life." In the penultimate section of this study, the significance of these findings and recommendations for future scholars are presented.

Significance of findings

The purpose of this study was two-fold. First, we sought to examine non-STEM students' capacity to develop data analysis skills, and second, we measured growth and transformation in the cohort's understanding of the growing importance of data analytics in both professional and personal contexts. As outlined in the introduction to this paper, this two-fold purpose was tested within a second-year undergraduate data analytics unit and a broad socio-cultural backdrop that has privileged the development of digital literacy in a rapidly changing work context. In 2003, four countries significantly outperformed Australia in mathematics-based skill proficiency at the tertiary level, and by 2018, this number had reached 23 (Australian Government Department of Education, 2023). Australian universities continue to develop learning material that seeks to address this deficit.

The study's central finding can be summarised as a 'triad of employability awareness' as illustrated in Figure 11. Students understand the need to develop their digital literacy skills; they perceive it as a gap in their own skill set and importantly, they connect this need with a real-world socio-cultural evolution towards managing data across both professional and personal domains. Finally, they take this awareness into the learning experience itself and, in the main, improve both their data analytics proficiency and their use of *Microsoft Excel*. In this sense, learning was transformative as students present as highly self-aware and able to cognitively manage their position within the world of work through the development of data analytics skills, alongside an appreciation for the use of information technology, and generative AI. In short, they were aware of the human aspects of work, of the activities humans do well and need to continue doing well, namely, storytelling.

The first aspect of the triad, depicted in Figures 9 and 10, is the sample's appraisal of their strongest employability skills and those in greatest need of growth. Just 5% of the sample of 157 participants identified Digital Literacy as one of their strongest employability skills. This awareness of a need to develop digital literacy skills fuels the second part of the triad, which comes from the qualitative responses summarised in the previous section. The common thread within this set of responses was a comprehensive awareness of the need to develop data analytics skills to meet demands within their personal and professional domains. When this awareness of digital literacy as an area for personal growth is paired with an understanding of the demand for this set of skills in the workplace, what results is the third and final part of our triad: improved data analysis and *Microsoft Excel* skills.

The study found that self-appraisal of data analytics capability and proficiency in using *Microsoft Excel* to conduct data analysis showed improvement over the duration of the unit for both STEM and non-STEM cohorts. Curriculum focused on student awareness and development of digital literacy had a positive impact on students' perceived self-efficacy. This supports Le et al.'s (2022) recommendation that a greater emphasis placed on supporting student awareness and development of digital literacy often enhances academic success. This includes an emphasis on non-academic skill development such as "self-regulated learning, motivational beliefs, cognitive engagement, and resource management" (p, 318). Importantly, these transferable skills lead to academic success and greater employability.

The second major finding was, to some degree, unexpected. The study indicates that the disparate needs of diverse cohorts can be met within a singular learning experience. For both STEM and non-STEM cohorts, the study found improvements in the self-appraisals of data analytics skills as well as *Microsoft Excel* skills. While the improvements were more uniform for the non-STEM cohort, the results show that a unit designed to support and facilitate data analysis skill development in a predominantly non-STEM cohort had provided a learning opportunity and set of resources that achieved this objective.

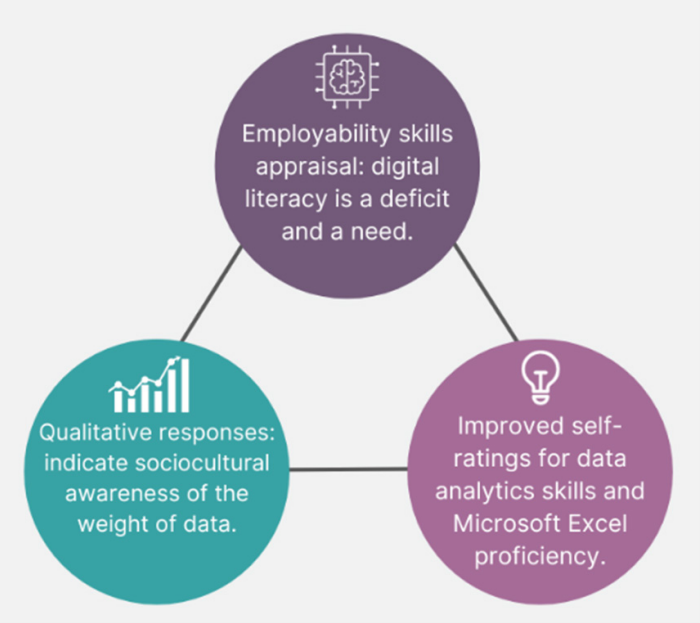

Figure 11. The triad of employability awareness.

Interestingly, this objective was also achieved for the small STEM cohort enrolled in MSP202. These results demystify the perceived inability of non-STEM students to shift their attention towards developing skills and acquiring knowledge in the STEM space. They offer a learning and teaching model as well as a plan for curriculum development that can be replicated in other learning environments to reinforce ongoing student success, both academically and in terms of their employability as graduates.

The findings support that "constructively aligned assessment designed to activate student-led learning is able to facilitate generic and early professional skill development" (Ruge & McCormack, 2017, p. 380). It further suggests that a constructively aligned curriculum developed for data analytical skills may have a broader learning impact on self-perception and engagement. However, it challenges the notion that employability skill development is best embedded through discipline-based curriculum design (Ruge & McCormack, 2017) and posits the need for further research into employability and employability skill development in multi-disciplinary learning environments.

Recommendations

The findings presented in this study have both learning and research-focused implications. From a curriculum development standpoint at tertiary institutions in Australia, the findings support a movement towards embracing and believing in the capacity for non-STEM students to engage with (and master) content and skills that would traditionally fall outside the domain of their degree of choice. The prevailing cultural view that a non-STEM student is less capable with numbers has not been supported by the data presented in this study; rather, non-STEM students show both an awareness of the need to develop STEM skills and a capacity to do so at a professional level. While the overall sample size is small (an outcome that will be examined in the section that follows), the results are uniform and consistent enough across three semesters in 2022 and 2023 to indicate

that non-STEM students have the capacity to develop STEM-based skills literacy, particularly when their awareness of the need for data literacy in both professional and personal spheres is apparent. This has potential implications for the inverse relationship of the one examined in this study, specifically, STEM students who are studying subjects in the Arts arena: history, philosophy, sociology, and creative media.

In light of this recommendation, future scholars should seek to expand on the findings presented in this study, replicating the survey for both STEM and non-STEM cohorts. Larger sample sizes would be preferable, and findings that suggest students can learn effectively outside their degree of choice could herald a new era for the development of a more holistic and employable student. Our broad cohort for the present study was 157 undergraduate students in total, with 24 from this larger group having completed both stages of our survey across Weeks 1 and 12. A study that delves more deeply into the nuances and tapestry of non-STEM student engagement with STEM content would benefit from a larger sample size, with the obvious implication being a greater capacity to generalise cohort change over time in digital literacy, *Microsoft Excel* skills, and a range of other employability skills. As discussed above, the same approach could be applied to a STEM-based cohort and their engagement with 'Social Science' content. An adjustment to the methodological approach utilised in this study might be beneficial in procuring this larger sample, with one potential area for change being the pre- and post-survey design. While a dual survey focus allows the research to assess change over time, when the nature of the survey is voluntary, asking busy students to complete one at the beginning of the semester and one during exam time will always be challenging. An exploration of ways to develop a singular survey yet still maintain an assessment of skills development over time would be a worthy pursuit.

Limitations

As an exploratory study, there were a few limitations. The most significant was in relation to the voluntary nature of the pre-and post-course surveys, which impacted the depth and breadth of data collected between 2022 and 2023. The Consent and Plain Language Statement reinforced for students enrolled in MSP202 that the information they provided in Weeks 1 and 12 was (a) not tied in any way to their overall grade within the unit and (b) was not compulsory. As such, enthusiastic students in Week 1 of the semester frequently completed the pre-survey embedded in the LMS for students, and this informed our broader sample of 157 students. However, far fewer students completed the Week 12 post-survey, which was designed to assess change over the course of the student's time in the unit. As such, our broader sample of 157 narrowed to 24, comprised of 19 non-STEM students and five (5) from the STEM cohort, which impacted the certainty with which the results can be presented.

Concluding comment

This study is the first of its kind in the academic literature to consider student perceptions of data analytics skill development from a multidisciplinary standpoint, incorporating both STEM and non-STEM perspectives, and to consider more broadly the impact of this learning within a social context. An ongoing evaluation of data analytics skill development and digital literacy, more broadly, should take into account the rapidly changing world of work, particularly the changes that are informed by the proliferation of artificial intelligence language models such as OpenAI's ChatGPT, which was introduced in November 2022. Scholars assessing the depth of organisational resilience at tertiary learning institutions following the major disruption of COVID-19 (Shafi & Middleton, 2024), have surely been met with a disruption of commensurate significance. While at the time of writing, the vast majority of contemporary students access the non-subscriber version of ChatGPT as their primary language processing model, models that can work with Microsoft Excel, clean and manipulate data, and visualise data for a variety of purposes, may have a significant impact on the validity and relevance of curriculum central to the unit examined in this study. These technological developments call into question the necessity for non-STEM students to develop digital literacy skills, and this study found that student perception of their own employability skill needs is aligned with what matters socio-culturally and in the world of work. This has a profound impact on student willingness to engage with data analytics content and their success in developing these skills. This space is certainly worthy of ongoing scrutiny and awareness.

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Appendices

Appendix A

CONSENT AND PLAIN LANGUAGE STATEMENT

Project Title

An Appraisal of Data Analytics Skill Development in Tertiary Students at One West-Coast Australian University

Principal Investigator/s

Dr Samuel Teague (Lecturer, Career Learning) – Samuel.Teague@murdoch.edu.au
Dr Alasdair Dempsey (Senior Lecturer, Exercise Science) – Alasdair.Dempsey@murdoch.edu.au
Dr Ellen Greenham (Lecturer, Career Learning) – E.Greenham@murdoch.edu.au
Dr Sarah Courtis (Associate Lecturer, Career Learning) – S.Courtis@murdoch.edu.au
Dr Robert Payne (Associate Lecturer, Career Learning) – Robert.Payne@murdoch.edu.au
Dr Kim Hudson (Associate Lecturer, Career Learning) – K.Hudson@murdoch.edu.au

Invitation

According to the Australian Government Department of Education, Skills and Employment (2021), the world of work continues to change rapidly, defined by advancing technology and increased automation of tasks and roles. To keep up, students studying at Australian higher education institutions must become better versed in STEM areas. Australia is losing ground in competing with other nations in the areas of Science, Technology, Engineering, and Mathematics. In 2003, four countries significantly outperformed Australia in mathematics. In 2018, a total of 23 did.

To address this issue, a Data Analytics unit has been created that will sit in the Career Learning Spine as its fourth unit offered to students to boost employability skills for career readiness. Its specific purpose will be to offer students the opportunity to develop data analysis skills, knowledge, and awareness.

The current research is being conducted to investigate the extent to which this unit supports data analysis skill development, and also explores concerns students may or may not have about data surveillance and the way data analytics is transforming both our professional and personal lives.

What are the requirements for participating?

You are eligible to participate in this study if you are over 18 years of age and a current Australian resident/citizen. Further, participants must be enrolled in *MSP202 - The Search for Everything: Data Analytics and Storytelling in the Twenty-First Century*.

What does taking part mean for me?

If you choose to partake in this research, you will be asked a series of questions both at the beginning of your time in this unit, and at its conclusion, pertaining to your data analysis skills, how they have developed over time, and any concerns you may or may not have about data surveillance and the way data analytics is transforming both our professional and personal lives.

Do I have to take part in the study?

Participation in this study is voluntary. However, your participation will assist us in understanding more fully how data analysis skills are developed in this unit, and areas of concern that students may or may not have about how data analytics is transforming our professional and personal lives.
Written consent in the form of a signature from participants is not required in this study as engagement with this document and completion of the questionnaires implies your consent to participate in this research. Should you wish to withdraw your consent for engaging with this project at any point, data/information provided in the questionnaires will be deleted immediately.

Your responses to the questionnaires embedded in the unit will be de-identified. Participants can withdraw consent from participating in this study up until the de-identification process has been complete. Should you wish to withdraw from the study before this point, please notify Dr Kim Hudson – K.Hudson@murdoch.edu.au – and your responses will be removed.

Risks and Potential Benefits

There are no foreseeable risks for participating in this research. However, should any negatives effects be experience, please contact the Dr Kim Hudson, who can guide you to the appropriate services. She can be contacted at K.Hudson@murdoch.edu.au

There are no direct benefits to participants in this study, and no payment is made to those completing questionnaires. However, findings will contribute to our understanding of the way students develop data analysis skills in a Higher Education unit, therefore, indirect benefits may occur for you if you have a specific interest in data analysis skill development and understanding more fully how data analytics is transforming both our professional and personal spheres.

What will happen to the information collected during the study?

All data provided to the Principal Investigators will be deidentified, with all demographic information being removed. This data is de-identified by the Principal Investigator – Dr Samuel Teague. In addition, all information we receive from you will remain confidential. All information provided by participants will be coded, filed, and retained on password-protected computers accessible only by the researchers. At the conclusion of the study, data will be retained for five years in accordance with X University's Human Research and Ethics Committee requirements, and potentially re-used and re-engaged with for the purposes of comparing how multiple cohorts of students engage with the unit over time.

What will happen to the results of the study?

The results of the study will inform continual unit improvement and curriculum development for the Data Analytics unit you are currently undertaking. It is anticipated that at least one peer-reviewed article will be published in a journal. Participants will be notified once the study has been completed and provided with an executive summary of the data provided by participants as well as access to any peer-reviewed publications that have been approved in relevant journals.

What if I have a complaint or concerns?

If you wish to discuss concerns or complaints pertaining to any aspect of this project, or you have questions about being a research participant in general, please contact:

Human Research Ethics Committee (HREC)
X University
90 South Street – Murdoch WA 6150
Phone: 9360 6000
Email: ethics@murdoch.edu.au

Thank you for choosing to participate in this study. Clicking next indicates your consent to participate, please close this browser if you do not wish to participate.

Appendix B

QUESTIONNAIRE

Project Title

An Appraisal of Data Analytics Skill Development in Tertiary Students at One West-Coast Australian University

Principal Investigator/s

Dr Samuel Teague (Lecturer, Career Learning)
Dr Alasdair Dempsey (Senior Lecturer, Exercise Science)
Dr Ellen Greenham (Lecturer, Career Learning)
Dr Sarah Courtis (Associate Lecturer, Career Learning)
Dr Kim Hudson (Associate Lecturer, Career Learning)
Dr Robert Payne (Associate Lecturer, Career Learning)

STAGE ONE

1. Describe your history of engaging with and learning about data analytics.
2. On a scale of 1-10, with 10 meaning 'very high proficiency' and 1 meaning 'very low proficiency', how would you rate your data analysis skills?
3. When did you first become aware that data is influencing nearly all aspects of our professional and personal lives? Was there a specific moment in time or event that lead to this realisation?
4. On a scale of 1-10, with 10 meaning 'very high impact' and 1 meaning 'very low impact', how significant do you believe data analytics has been (and will continue to be) in transforming the industry you hope to work in after completing your degree?
5. On a scale of 1-10, with 10 meaning 'very high proficiency' and 1 meaning 'very low proficiency', how would you rate your Microsoft Excel skills?
6. Units in X University's Career Learning Spine offer students the chance to develop a range of skills. From the list of nine employability skills provided below, which would you identify as your THREE strongest skills?
7. Units in X University's Career Learning Spine offer students the chance to develop a range of skills. From the list of nine employability skills provided below, which would you identify as your THREE weakest skills?
8. Data surveillance refers broadly to the tracking of individual behaviour, decision-making, GPS movements, and biological characteristics at any given time. These processes might occur when you're logging into Facebook and liking photos posted by friends, when you're ordering food using your UberEats app, or even when you're exercising and your smartwatch is providing feedback on your heart rate and blood pressure. On a scale of 1-10, with 10 meaning 'deeply concerned' and 1 meaning 'not concerned at all', how concerned are you about data surveillance in an increasingly virtual world?
9. Which of the following apps would you feel most hesitant in engaging with via your Smartphone or other portable device? (Multiple responses are permitted here. If you wish to avoid all ten of these apps, please tick all 10 options. Similarly, if you would continue to engage with all 10 apps, without hesitation, please tick no boxes).
10. What have you gained from this unit, in terms of the development of your skills, increasing depth of knowledge, and understanding of our social world?
11. On a scale of 1-10, with 10 meaning 'very curious' and 1 meaning 'not curious at all', how interested are you in learning more about data analytics and developing skills in this particular domain moving into the future?
12. Identify three words that come to mind when you see the phrase 'data analytics'.

STAGE TWO

1. On a scale of 1-10, with 10 meaning 'very high proficiency' and 1 meaning 'very low proficiency', how would you rate your data analysis skills?
2. On a scale of 1-10, with 10 meaning 'very high impact' and 1 meaning 'very low impact', how significant do you believe data analytics has been (and will continue to be) in transforming the industry you hope to work in after completing your degree?
3. Units in X University's Career Learning Spine offer students the chance to develop a range of skills. From the list of nine employability skills provided below, which would you identify as your THREE strongest skills?
4. Units in X University's Career Learning Spine offer students the chance to develop a range of skills. From the list of nine employability skills provided below, which would you identify as your THREE weakest skills?
5. Which of the following apps would you feel most hesitant in engaging with via your Smartphone or other portable device after learning about data surveillance in this unit? (Multiple responses are permitted here. If you wish to avoid all ten of these apps, please tick all 10 options. Similarly, if you would continue to engage with all 10 apps, without hesitation, please tick no boxes).
6. What have you gained from this unit, in terms of the development of your skills, increasing depth of knowledge, and understanding of our social world?
7. Data surveillance refers broadly to the tracking of individual behaviour, decision-making, GPS movements, and biological characteristics at any given time. These processes might occur when you're logging into Facebook and liking photos posted by friends, when you're ordering food using your UberEats app, or even when you're exercising and your smartwatch is providing feedback on your heart rate and blood pressure. On a scale of 1-10, with 10 meaning 'deeply concerned' and 1 meaning 'not concerned at all', how concerned are you about data surveillance in an increasingly virtual world?
8. On a scale of 1-10, with 10 meaning 'very curious' and 1 meaning 'not curious at all', how interested are you in learning more about data analytics and developing skills in this particular domain moving into the future?
9. On a scale of 1-10, with 10 meaning 'very high proficiency' and 1 meaning 'very low proficiency', how would you rate your Microsoft Excel skills?
10. Of the twelve topics covered this semester in The Search for Everything, which has been the most significant for you in terms of your learning experience and knowledge development, and why?
11. Throughout your time in this unit, you have engaged with readings, videos, lectures, quizzes, discussion forums, and live workshops with your peers. Within those forums and experiences, you've engaged with concepts, processes, data analysis methods, socio-political theories, Microsoft Excel, and much, much more. What has been the most transformational idea, concept, reading, lecture, video, etc. that you have engaged with throughout your time in this unit, and why?
12. What do you see as the most positive impact data analytics could have (or already has) on our professional and/or personal lives?
13. Identify three words that come to mind when you see the phrase 'data analytics'.