LEARNING DEVELOPMENT IN STATISTICS EDUCATION

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Educators and employers value statistical and data analytics skills and the ability to infer meaningful conclusions from a wide variety of data, with these skills in demand in many companies and industries globally. Employability is complex and does not only reflect a person's ability to obtain employment, but it also encompasses their professional capacity within a particular field. Final-year statistics students were asked to complete a graduate employability survey to assess subject-specific skills, networking skills, the target job market, and extracurricular activities. When asked what useful skills they developed through their programme all students identified programming skills and statistical analyses. When asked what characteristics they believe would help them in employment, students responded with a combination of communication skills, writing skills, insights into the industry, willingness to learn new things, organisation, and computing skills. By offering more authentic developmental learning opportunities, we may better support students in future employability.

INTRODUCTION

When educators are asked if a statistics degree is 'worth it', they could refer to the breadth of transferrable skills applicable in many sectors and industries. Consequently, statistics degrees can be described as professional degrees with opportunities in academia or industry. When a group of non-academic statisticians were asked to comment on key skills in graduate statisticians' employment, the most reported 'non-statistical' responsibilities lay with writing, presenting and teamwork (Ritter et al, 2001). When contributors were asked to rank the importance of each, communication was ranked the highest. The contributors further advised educators that statistics should be multidisciplinary, taught in conjunction with another subject, and it's a growing discipline requiring continuous professional development and it's a 'team sport' (Ritter et al, 2001).

In 2023, a quick search of the 'data analyst' Glasgow job market, key qualifications listed are strong communication, interpersonal skills, teamwork, data management, interpretation, and rationalization of data in addition to industries asking applicants for awareness and knowledge of the field, for example, governance, policies, or the current market (LinkedIn, 2023).

The definition of graduate employability may depend on the context. For example, the concept of graduate employability may be different depending on whether you ask an employed individual, an unemployed individual, an employer, or an educator. In any case, graduate employability is complex and accounts for personal circumstances, and individual and external factors (McQuaid and Lindsay, 2005). More recently, graduate employability has received more attention across higher education institutions (HEIs), with the need to ensure educational quality and a return on investment for graduates (Jackson and Bridgstock, 2021). For the transition from education to employment to succeed, HEIs should ensure that their programmes prepare students for a dynamic market (Tomlinson, 2012). Perhaps the recent impact of artificial intelligence in higher education only indicates the need to better align education, in particular assessment, with the dynamic job market in higher education (Farrokhnia et al, 2023, Crawford et al, 2023).

To conceptualize graduate employability, Tomlinson developed a 'Graduate Capital Model' (Tomlinson, 2017). Tomlinson highlights the need to broaden the concept of graduate employability to include knowledge and skills, relationships, cultural identity, and psycho-social dispositions. This model captures the following key capitals.

- The human capital that captures subject specialism,
- the social capital that captures awareness of the job market and builds networks,
- the cultural capital that captures cultural awareness and confidence,
- the identity capital that captures personal development, and
- the psychological capital that captures resilience and adaptability.

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In this study, we adopted the 'Graduate Capital Scale' (Tomlinson et al, 2022), derived from the Graduate Capital Model, to assess the preparedness and confidence of final-year undergraduate statistics students in their transition to graduate employment. In addition, we were interested in assessing if students could be clustered depending on their employability preparedness, which may provide insights into groups of students that may benefit from further developmental opportunities.

METHODS

After receiving ethical approval from the College of Science and Engineering, University of Glasgow, we used the Graduate Capital Scale to survey final-year undergraduate students enrolled in a statistics degree programme between the 10th of November 2022 and the 30th of November 2022. This student cohort represents students due to graduate with an undergraduate honours degree in statistics during the summer of 2023 from the University of Glasgow.

A total of 44 students responded to the survey, corresponding to a 67% response rate. Of the 44 respondents, 32 students completed more than three questions, corresponding to a 45% response rate, that were later included in all analyses.

Our adaptation of the Graduate Capital Scale consisted of 27 Likert scale questions. Participants were asked to rate their perception of each question on a 5-point scale ranging from strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, and strongly disagree. Participants were also asked the following three open questions.

1. What are your future career aspirations?
2. What skills or characteristics do you think will help you get employed?
3. What skills did you develop during your programme of study that you think will help you in your future employment?

K-medoid clustering (Izenman, 2013) was used as an unsupervised approach to cluster students based on their responses to 27 questions from the Graduate Capital. This algorithm aims to partition observations around medoids which are representative observations. Each observation is assigned to the closest medoid depending on a pre-defined distance or dissimilarity measure. We opted to measure dissimilarity through Gower distance, given the nominal nature of the questions. Gower's distance between two students is the number of times the two students' responses match relative to the number total number of questions. If the two students' responses match on all items, then the Gower distance is 1 and if the two students' responses differ on all items, then their Gower distance is 0. To choose the number of clusters, the average silhouette method was used.

For each of the three open questions asked, Thematic analysis was used to identify key themes. Categories were identified based on descriptive coding and then collated into meaningful themes (Saldana, 2021).

RESULTS

Figure 1 provides the results from the 27 Likert scale questions that formed the Graduate Capital Scale.

Human capital

While students agree that their learning and skills developed from their programme be used in and help future employment, only around half of the students agree that they can produce an effective CV, keep up to date with the job market and perform well in an interview.

Social capital

It appears that students conveyed more disagreement in questions relating to social capital. Particularly, around 30% of students were confident in transferring their skills to the job market, knew key employers or networked with career contacts. Lastly, 50% of students agreed they were confident in their future career performance.

Cultural capital

While 2/3rd of students agreed they participated in extra-curricular activities, and nearly 90% agreed they learned work-related skills during these activities, around 55%-60% of students knew the job role they were interested in and felt confident in different cultural contexts.

Identity capital

Nearly a quarter of students disagreed that they were clear about their future career plans, and 31% disagreed that they could list their strengths. Lastly, just less than 50% of students agreed that they have recorded their developments through work experiences.

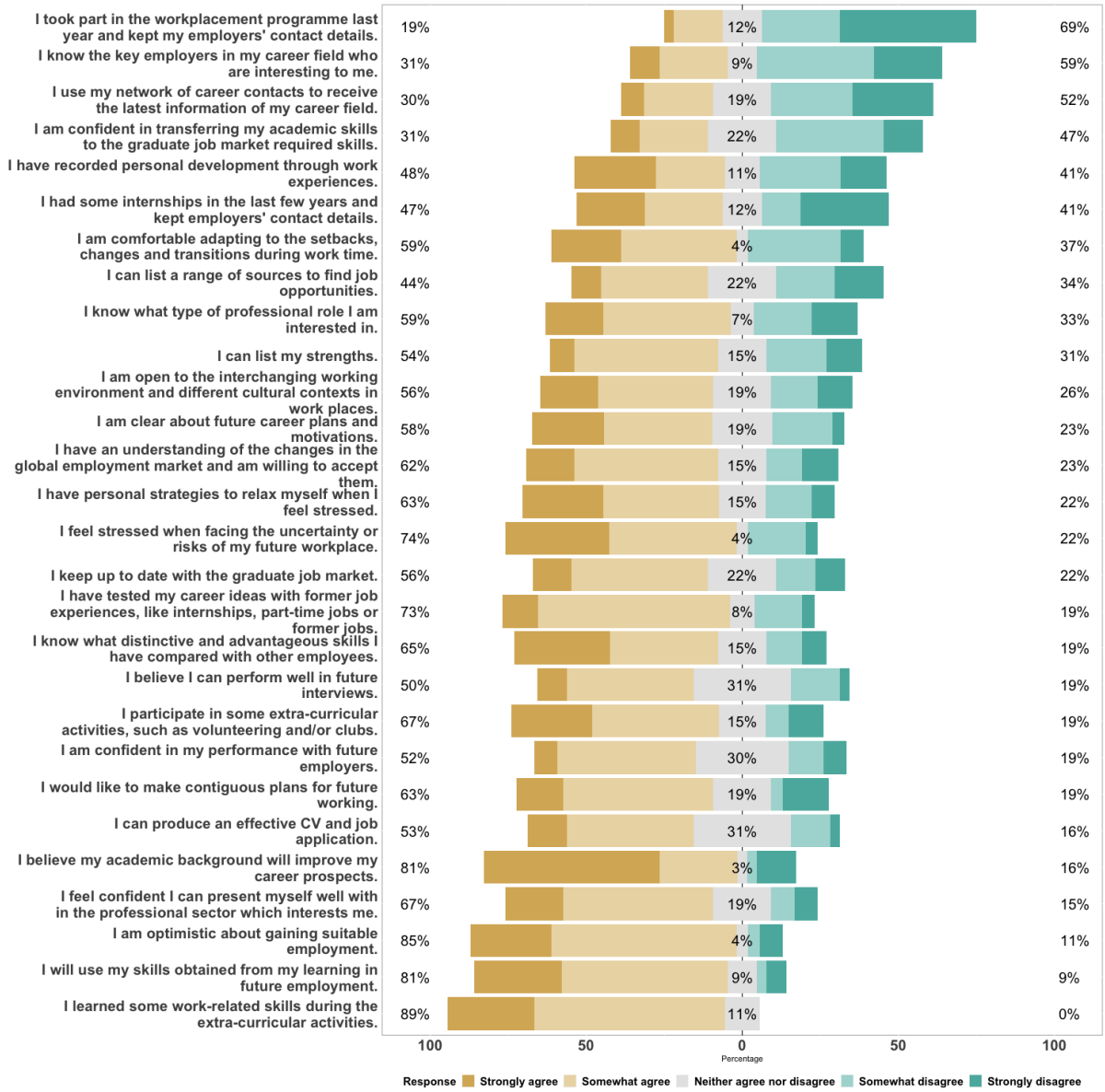

Figure 1. Results from the Likert Scale questions that formed the Graduate Capital Scale

Psychological capital

While 85% of students were optimistic about their future employment, 74% of students agreed that they felt stressed when facing uncertainty in future employment, even with 73% agreeing that they have tested career ideas with former experiences. Nearly 40% of students disagreed that they are comfortable adapting to setbacks.

Cluster analysis

Through clustering analysis, three clusters were chosen, and figure 2 provides boxplots for each capital separated by cluster. For the illustration in figure 2, strongly agree was coded as 2, somewhat agree was coded as -1, neither agree nor disagree was coded as 0, somewhat disagree was coded as -1 and strongly disagree was coded as -2. For each student, we computed capital scores, which were the sum of responses to questions belonging to the relevant capital.

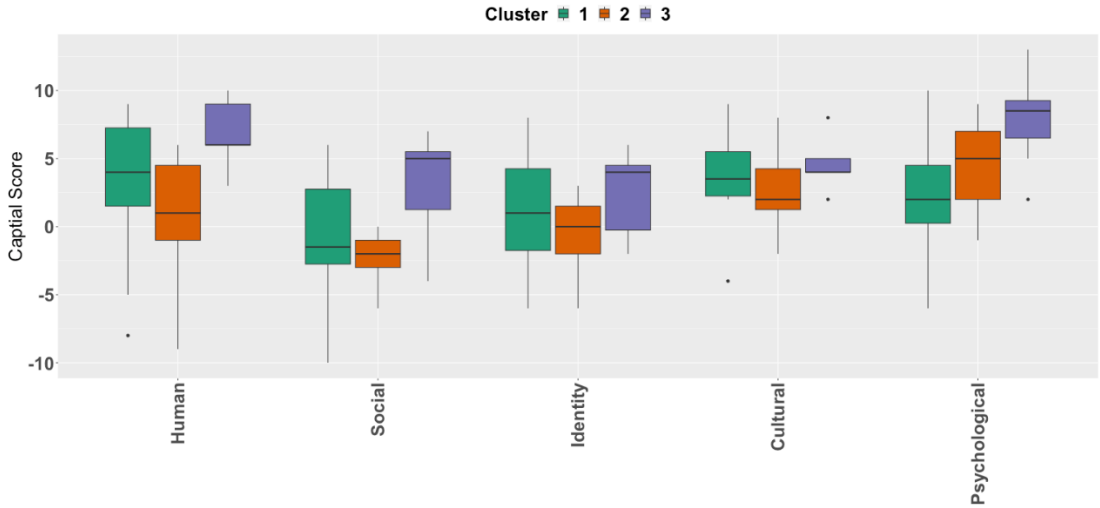

Figure 2. Boxplots of responses to the 27 Likert scale questions separated by cluster, cluster 1 in red, cluster 2 in green and cluster 3 in blue. Questions given on the x-axis are colored depending on capital (see Figure 1).

Similarities between clusters

Before discussing the distinguishing features between each cluster, we will first highlight the similarities. Most strikingly, all clusters show a median response of strongly agree when asked if their academic background will improve their future career prospects (as part of the human capital). For the most part, clusters showed similarities around the cultural capital in particular questions relating to extra-curricular activities, developing work-related skills, job markets of interest, and what skills separate these students from other employees.

Cluster 1 (Figure 2 red, 38% of student respondents)

Cluster 1 was the largest cluster and seemed to differ from clusters 2 and 3 in questions relating to the Psychological, Human and Social capital. Specifically, students in the cluster on average were likely to strongly disagree that they are confident in transferring their academic skills to the job market and more likely to disagree that can use their networks to keep up to date with the job market. Students within this cluster also appeared less likely to agree that they were comfortable adapting to setbacks and understanding changes in the global job market. On the other hand, students in this cluster were less likely to feel stressed when facing uncertainty and have personal development through work experiences. Lastly, these students were more likely to agree that they have recorded personal development and have learned work-related skills during their work experiences. To summarize, this group contains students who are confident in their academic ability and personal development but appear less confident in transferring their skills to the job market and networking with potential employers.

Cluster 2 (Figure 2 green, 34% of student respondents)

Students in cluster 2 appeared less confident in questions relating to Psychological and Human capital, with students neither agreeing nor disagreeing that they can produce an effective CV, can find resources for job opportunities, can perform well in future interviews, or keep up to date with the job market. Likewise, students in this cluster appear less confident in future job performances, and less likely to have developed personal skills through work experience. To summarize, this group contains students who are less clear on their future job goals and show less confidence in writing a CV

and performing well in interviews. Students here are less likely to know the current job market and perhaps are unaware of resources to find job opportunities.

Cluster 3 (Figure 2 purple, 28% of student respondents)

Cluster 3 was the smallest cluster and appear to sit around a value of 1, or the option 'agree', for most questions. While students in clusters 1 and 2 generally disagree with questions relating the social capital, students in the group indicate more confidence in this capital relating to networking skills and awareness in the current job market. Likewise, students in the group appear more likely to agree that they can use their academic skills in their future employment, as shown by questions relating to human capital. To summarize, this group contains students who believe their academic background will help their future careers, are confident in using these skills in future employment, and are more likely to know which field they are interested in. This group were more likely to strongly agree that they feel stressed about the uncertainty in their future workplace.

Career aspirations

When students were asked what their future career aspirations are, the most common answer was to work in the banking and financial field. Some students indicated data analytics or data science without providing a specific field, whereas other students were able to name specifically the bank or company they would like to work for.

Employment skills and characteristics

When students were asked to list the relevant skills or characteristics that they would need to help them in future employment, all students listed some variation of interpersonal skills, with communication skills being the most frequent response. Students also indicated insights into their field. Students indicated mathematics and programming skills; however, technical skills were provided more often in the next question.

Skills developed through their programme of study

The most listed skills were mathematics, statistical analysis, and programming skills. Some students also listed teamwork and working to deadlines.

DISCUSSION

Graduate competencies encompass hard and soft skills with both sets of skills deemed at least equally important to employers and in some cases soft skills deemed more important to employers (Pang et al, 2019, Baird and Parayitam, 2019). Over the past decade, studies have shown that employers, consisting of large, international companies covering a variety of disciplines, are increasingly placing more importance on soft skills (Succi and Canovi, 2020). Graduate employability should be at the core of graduate outcomes, and HEIs should work towards developing skilled graduates. With continuous advancements in the industry, skilled graduates should be able to transfer their skills and continuously develop and learn to meet the demands of a dynamic market.
This study aimed to provide insights into the student perception of graduate employability through the lens of final-year undergraduate statistics students from a Scottish university to identify key areas that may be improved or added to their programme. Clustering analysis was used to highlight any groups of students that may particularly benefit from such initiatives.

Students in this cohort were optimistic about their future career prospects and believe that their academic skills will help them in future employment. All students identified mathematical, statistics and programming as important skills that would help them in future employment. Most students indicated that they had work experiences that provided them with opportunities to develop professional and personal skills. However, this cohort of students was less confident in questions relating to their future employer, particularly about knowing key employers and being able to network, transferring their academic skills to the workplace, adapting to setbacks, and performing well in interviews. All students within this programme are exposed to key employers, through organized career events and invited speakers, however, these results indicate that these initiatives may not be enough to provide students with the confidence to network with potential future employers. Although all students were able to identify communication and interpersonal skills as key characteristics in

future employment, they indicated that they are not confident in using these skills. Most notably, when students were asked which skills developed through their programme they believed would be most helpful in future employment, the most frequently quoted skill was programming, whereas when students were asked which skill they believe would be most helpful in future employment, the most frequently quoted skill was communication. These results indicated that these are key areas that could be developed to further enhance student preparedness for future employability. In particular a focus on learning development, as opposed to subject specialism.

Programming and statistical analyses are at the core of employability for statistics graduates, as reflected in the level of confidence in these students. Transferability of skills and soft skills such as communication, writing, and self-directed learning are essential. This paper proposed that by offering more authentic developmental learning opportunities, potentially through direct collaboration with a range of student services and peer learning opportunities out with the classroom, we may better support students in future employability.

REFERENCES

Baird, A.M. & Parayitam, S. (2019). Employers' rating of importance of skills and competencies college graduates need to get hired. *Education + Training*, 61(5), 622-634.

Crawford, J., Cowling, M. & Allen, K. (2023). Leadership is needed for ethical ChatGPT: Character, assessment, and learning using artificial intelligence (AI). *Journal of University Teaching & Learning Practice*, 20(3), 1-19.

Farrokhnia, M., Banihashem, S.K., Noroozi, O. & Wals, A. (2023) A SWOT analysis of ChatGPT: Implications for educational practice and research, *Innovations in Education and Teaching International*, 0, 1-15.

Izenman, A. (2013). Recursive Partitioning and Tree-Based Methods. *In Modern Multivariate Statistical Techniques. Springer Texts in Statistics*, Springer.

Jackson, D. & Bridgstock, R. (2021). What actually works to enhance graduate employability? The relative value of curricular, co-curricular and extra-curricular learning and paid work. *Higher Education*, 81, 723-739.

LinkedIn. (2023). Data Analyst jobs in Glasgow, https://uk.linkedin.com/jobs/data-analyst-jobs-glasgow?position=1&pageNum=0, accessed 4th April 2023.

McQuaid, R. W. & Lindsay, C. (2005). The Concept of Employability. *Urban Studies*, 42(2), 197-219.

Pang, E., Wong, M., Leung, C.H. & Coombes, J. (2019). Competencies for fresh graduates' success at work: Perspectives of employers. *Industry and Higher Education*, 33(1), 55-65.

Ritter, M.R., Starbuck, R.R. & Hogg, R.V. (2001). Advice From Prospective Employers on Training BS Statisticians. *The American Statistician*, 55(1), 14-18.

Saldana, J (2021). The Coding Manual for Qualitative Researchers. 4th Edition, Sage Publishing.

Succi, C. & Canovi, M. (2020). Soft skills to enhance graduate employability: comparing students and employers' perception. *Studies in Higher Education*, 45(9), 1834-1847.

Tomlinson, M., McCafferty, H., Port, A., Maguire, N., Zabelski, A.E., Butnaru, A., Charles, M. & Kirby, S. (2022), Developing graduate employability for a challenging labour market: the validation of the graduate capital scale, *Journal of Applied Research in Higher Education*, 14(3), 1193-1209.

Tomlinson, M. (2017), Forms of graduate capital and their relationship to graduate employability, *Education + Training*, 59(4), 338-352.

Tomlinson, M. (2012). Graduate Employability: A Review of Conceptual and Empirical Themes. *Higher Education Policy*, 25, 407-431.