# PREPARING GRADUATES FOR THE 21ST CENTURY JOB MARKET: COMPUTER SCIENCE SKILLS PROFILING


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EPD Feedback Loop

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# SUMMARY

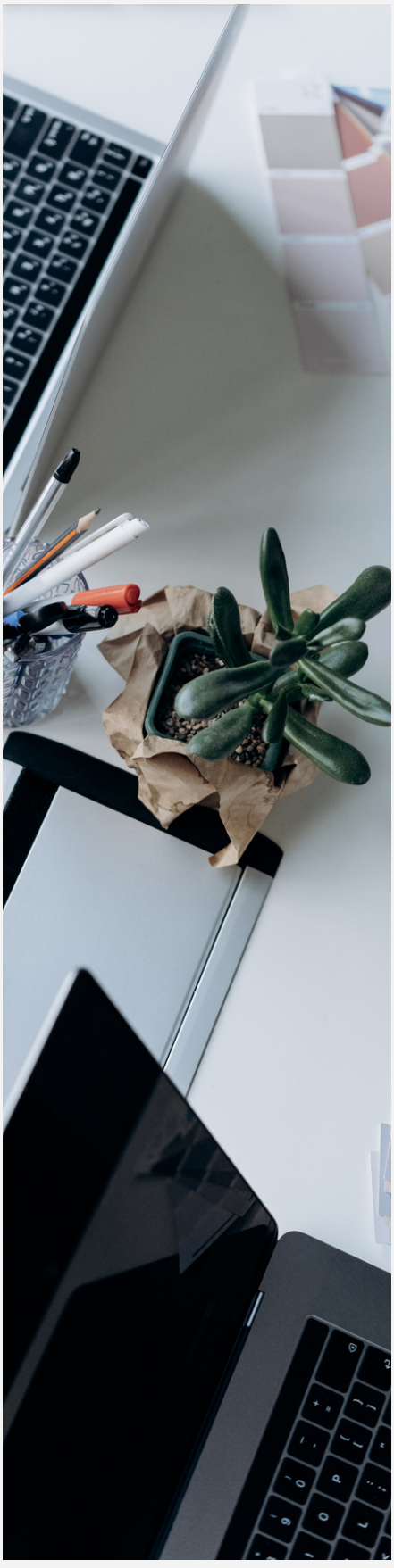
Using a novel skills profiling approach, a set of computer science department courses from six UK universities were translated into 21st Century Skills categories to enable educational delivery to be compared to job requirements. Lightcast labour market information was used to identify 21st Century Skills requirements within relevant jobs. Learning outcomes from our university courses were then translated into 21st Century Skills, and 'skills hours' were calculated using assessment components and their weightings.

The primary aim of this work was to connect the capabilities developed within higher education with the competencies sought by employers, so that learner-earners can better understand themselves and their alignment to a rapidly evolving job market. Our work also enables employers to better understand and differentiate learner-earners. In so doing, this project has demonstrated how stackable badging and micro-credentialing can be used to support more responsive and adaptive learning and reskilling both within higher education and within employment.

# CONTEXT

The primary aim of this project was to connect the capabilities students develop within higher education with the competencies sought by employers. To achieve this, the study considered how stackable badging and micro-credentialing can be incorporated into higher education. This process provides a mechanism by which learning can become more granular, bespoke, employer-aligned, personalised and, therefore, more efficient for initial skills acquisition and, increasingly, on-the-job reskilling.

Professor Sue Reece's UK micro-credential model was used to explore different applications of skills profiling to the micro-credentialing of UK higher education courses at both undergraduate and postgraduate level (QAA Quality Compass publication, April 2021). In this particular case study, computer science department courses across a range of UK institutions were chosen, with the aim of comparing and contrasting current approaches to course delivery (including the use of badging and micro-credentialing) and skills profiling.



Skills profiling involves the coding programmes of study into 21st Century skills categories by considering the learning hours, assessments and learning outcomes. The resulting translation provides two skills profiles - one for subject specific skills and a second for transferable skills. These profiles are expressed in terms of the number of skills hours that each 21st Century skill contributes to the programme of study. Whilst clearly an approximation, the approach is very useful in comparing skills within education, within employment and between education and employment. For the latter comparison between education and employment, percentage skills profiles are used.

By comparing a set of similar degree programmes from different institutions whose approaches to quality assurance, course content and alignment to personal and professional development varied significantly, the case study was able to confirm broad applicability whilst also highlighting specific considerations arising from institutional differences.

Another advantage of this approach was that it demonstrated how badging and micro-credentialing from outside of higher education can be incorporated into degree programmes. For example, two of the institutions involved in the study, University of Huddersfield and Northumbria University are global pioneers in terms of recognising LinkedIn Learning for credit within their Masters programmes. It also considered how the increasing prevalence of personal and professional development courses, alongside degree programmes, can be accommodated better within the structures of degree programmes. Indeed, it can be argued that the rise of such courses is symptomatic of the needs for a more adaptive and responsive approach to quality assurance and course content within higher education.

From the labour market perspective, Lightcast labour market information provides a rich dataset of current job roles and skills sought. By categorising these skills using the same 21st Century Skills classification scheme that is used for higher education programmes the skills developed and the skills sought can be compared. This approach clearly has significant benefits for learner-earners, educationalists and employers. Firstly, it enables a direct comparison between what is being sought and what is being taught. Secondly, it enables the educationalist to review academic course content against job roles and reflect (and

perhaps modify) standardised content to better meet employer needs. Thirdly, it enables employers to understand, compare and contrast learners' skills match against their various job roles. Fourthly, it provides a way to personalise learning within the same programme of study by evidencing the same skills to different extents and levels. Finally, through this personalisation, it enables learner-earners to better understand how their education prepares them for employment and highlights career and employment routes based on their current skills, or through reskilling, that would not otherwise be obvious.

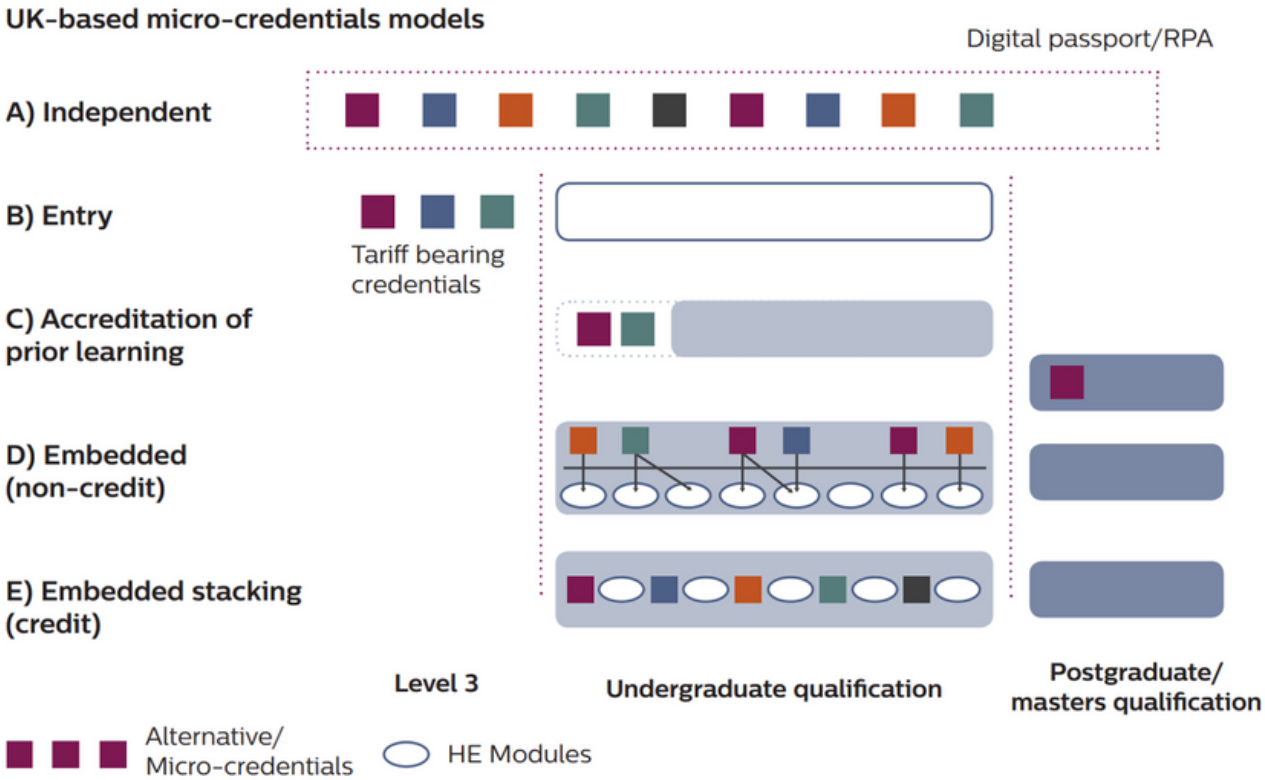



*Figure 1 – Professor Sue Reece's five potential models for UK micro-credentialing*

# METHODOLOGY & IMPLEMENTATION

To support the skills analysis of our existing courses and begin the skills profiling process, six skills themes were used: A) Understanding, B) Context, C) Solutions, D) Delivery, E) Behaviour and F) Reporting. In addition, 25 skills categories (S1A to S6F and T1A to T19F) were used. These categories are laid out in the figure below:

| | SKILLS | SHORT DESCRIPTIONS |
|---|---|---|
| | **Subject-based** | |
| **S1A** | A – Theory | Theoretical subject area knowledge |
| **S2B** | B - Business Requirements and Applications | Business needs and use |
| **S3C** | C – Innovation | New subject area approaches |
| **S4D** | D - Process and Production | Actions or steps taken to achieve a particular result |
| **S5E** | E - Self-Reflection | Contextual analysis within the environment in which the subject area is applied |
| **S6F** | F - Technical Writing | Subject-related writing that requires direction, instruction or explanation |
| | **Transferable** | |
| **T1A** | A - Information Literacy | Integrated abilities encompassing discovery, production and valuing of information |
| **T2B** | B - Business Alignment | Recognition of organisational purpose, aims and objectives |
| **T3B** | B - Entrepreneurship | Developing and managing business ventures |
| **T4B** | B - Numeracy | Use of numbers to solve real life problems. |
| **T5B** | B - Analysis | Gaining improved understanding through simplifying a complex topic |
| **T6C** | C - Creativity | Creating new things |
| **T7C** | C - Problem Solving | Finding new solutions to complex issues |
| **T8D** | D - Technical Proficiency | Apply technical knowledge and skills to specialist roles and responsibilities |
| **T9D** | D - Self-Regulation | Managing oneself in order to achieve goals |
| **T10D** | D - Leadership | Motivating others to perform |
| **T11D** | D - Management | Planning, organising, directing or controlling physical, financial, human and informational resources efficiently and effectively to achieve organisational goals |
| **T12E** | E - Professionalism | Professional status, methods, character or standards |
| **T13E** | E - Ethics | Concepts and principles determining behaviour that helps or harms |
| **T14E** | E - Evaluation | Assessing the amount, number or value of something |
| **T15E** | E - Risk Analysis | Identifying and analysing potential negative impacts on goals |
| **T16E** | E - Sustainability | Maintaining resources in ecological balance |
| **T17E** | E - Social Learning | Understanding and applying behaviours within social contexts |
| **T18E** | E - Collaboration | Processes where two or more people work together to complete tasks or goal |
| **T19F** | F - Communication | Conveying meaning to others |

*Figure 2 - 21st Century Skills categories (6 subject-specific & 19 transferable)*

These categories, drawn from a research study of existing literature regarding 21st Century skills, helped us to translate learning outcomes into the most appropriate subject-specific skills category, with skills hours calculated pro-rata from learning outcomes, assessment weightings and learning hours as shown in the figure below. For example, a 20 credit/200 learning hour module with two assessment components was calculated in the following way:

| Module Learning Hours | | 200 | | | |
|---|---|---|---|---|---|
| | | | | | |
| Asst | Weighting | Asst Learning Hrs | Learning Outcome | Learning Outcome Hrs | Subject-Specific Skills Categories |
| 1 | 60% | 120 | 1 | 30 | S1A |
| | | | 2 | 30 | S2B |
| | | | 4 | 30 | S4D |
| | | | 5 | 30 | S4D |
| 2 | 40% | 80 | 2 | 40 | S2B |
| | | | 3 | 40 | S6F |

| | Subject-specific Skills Hrs |
|---|---|
| S1A | 30 |
| S2B | 70 |
| S4D | 60 |
| S6F | 40 |

*Figure 3 - Subject-specific Skills Hours Calculation*

A similar approach was used for transferable skills, though here several categories can apply to an individual learning outcome, so transferable skills hours are captured as outlined in the figure below:

| Module Learning Hours | | 200 | | | |
|---|---|---|---|---|---|
| | | | | | |
| Asst | Weighting | Asst Learning Hrs | Learning Outcomes | Learning Outcome Hrs | Transferable Skills Categories |
| 1 | 60% | 120 | 1 | 30 | T1A |
| | | | 2 | 30 | T2B, T3B |
| | | | 4 | 30 | T9D, T10D, T11D |
| | | | 5 | 30 | T8D, T11D |
| 2 | 40% | 80 | 2 | 40 | T4B, T5B |
| | | | 3 | 40 | T19F |

| | Transferable Skills Hrs |
|---|---|
| T1A | 30 |
| T2B | 15 |
| T3B | 15 |
| T4B | 20 |
| T5B | 20 |
| T8D | 15 |
| T9D | 10 |
| T10D | 10 |
| T11D | 25 |
| T19F | 40 |

*Figure 4 - Transferable Skills Hours Calculation*

One of the most exciting uses of this approach is in providing increased flexibility in assessment. There are two key ways in which this can be done. The first is through reducing assessment burden by enabling some of the existing assessment requirements to be met in alternative ways. Using this approach, existing assessments are analysed and translated into skills hours as per the example below. Once this has been done, External Learning Resources (ELRs) can be identified which meet some of the skills hours requirements. This means that existing assessments can be reduced and replaced with more suitable ELRs, whilst providing increased flexibility, relevance and student engagement.

For example, if a Cyber Security (CS) module represents 200 learning hours, and has 2 assessments, each weighted at 50%, assessing 3 subject-specific skills, suitable ELRs could replace 120 learning hours, as shown below. Clearly a similar approach could be taken with transferable skills, but for simplicity the examples below consider just subject-specific skills:

| CIS2201 Cyber Security | | | Module Learning Hours | | | 200 |
|---|---|---|---|---|---|---|
| | | | | | | |
| Asst | 1A | 2B | 3C | 4D | 5E | 6F |
| 1 | 67 | | | | | 33 |
| 2 | | | | 67 | | 33 |
| **Total** | **67** | | | **67** | | **67** |

*Figure 5 - Example Cyber Security Module Assessments*

| ELR | 1A | 2B | 3C | 4D | 5E | 6F |
|---|---|---|---|---|---|---|
| 1 | 5 | | 10 | 5 | | |
| 2 | 10 | 5 | | 10 | | 10 |
| 3 | 5 | | | 10 | | 5 |
| 4 | 10 | | | 5 | | 5 |
| 5 | 5 | | | 10 | | 10 |
| **Total** | **35** | **5** | **10** | **40** | | **30** |
| **Remainder** | **32** | **-5** | **-10** | **27** | | **37** |

*Figure 6 - External Learning Resources (ELRs) that represent skills developed in the Cyber Security Module*

| CIS2201E Cyber Security (ELR) | | | Internal Learning Hours | | | 80 |
|---|---|---|---|---|---|---|
| | | | External Learning Hours | | | 120 |
| | | | | | | |
| Asst | 1A | 2B | 3C | 4D | 5E | 6F |
| 1 | 28 | | | 22 | | 30 |
| ELRs | | | | | | |
| 1 | 5 | | 10 | 5 | | |
| 2 | 10 | 5 | | 10 | | 10 |
| 3 | 5 | | | 10 | | 5 |
| 4 | 10 | | | 5 | | 5 |
| 5 | 5 | | | 10 | | 10 |
| **Total** | **63** | **5** | **10** | **62** | **0** | **60** |

*Figure 7 - Use of ELRs to reduce the number of module assessments*

The second, more exciting, application of this approach is in enabling personalised learning and assessment within module studies. This has clear benefits for the learner, who is able to specialise in areas best suited to their interests and aptitudes. It is also beneficial for the earner, who is better aligned to and competent to perform their job roles. Finally, it benefits employers, and indeed society, who benefit from clearly differentiated applicants enabling more effective selection processes, a more productive and happier workforce and more efficient approaches to reskilling and personal and professional development.

In the example below, the same module and ELRs are considered. In this case, the number of assessments remain the same, but the amount of time dedicated to them (the learning hours associated with them) are reduced. This reduction provides space and opportunities for ELRs to be incorporated. By providing choice in which combination of ELRs a learner undertakes, this also means that different skills profiles can be gained and therefore different learner skills profiles can be differentiated. The learner can, therefore, review which skills they wish to develop further and select based on this, or they can consider employment requirements through labour market information and choose ELRs that best meet the skills profiles required for job roles.

For the module under consideration in Figure 8 below, the internal learning hours (from the two assessments) are reduced from 200 hours to 140 hours, with a pro-rate reduction in the skills hours arising from these assessments:

| CIS2201P Cyber Security (PL) | | | Module Learning Hours | | | 140 |
|---|---|---|---|---|---|---|
| | | | | | | |
| Asst | 1A | 2B | 3C | 4D | 5E | 6F |
| 1 | 47 | | | | | 23 |
| 2 | | | | 47 | | 23 |
| Total | 47 | | | 47 | | 46 |

*Figure 8 - Skills Hours from Internal Learning, based on a pro-rata reduction in module assessments*

This then means that the external learning hours can be gained from a combination of the ELRs. Two examples are shown below:

| ELR | 1A | 2B | 3C | 4D | 5E | 6F | |
|---|---|---|---|---|---|---|---|
| 2 | 10 | 5 | | 10 | | 10 | 35 |
| 5 | 5 | | | 10 | | 10 | 25 |
| **Total** | **15** | **5** | | **20** | | **20** | **60** |
| | | | | | | | |
| ELR | 1A | 2B | 3C | 4D | 5E | 6F | |
| 1 | 5 | | 10 | 5 | | | 20 |
| 3 | 5 | | | 10 | | 5 | 20 |
| 4 | 10 | | | 5 | | 5 | 20 |
| **Total** | **20** | | **10** | **20** | | **10** | **60** |

*Figure 9 - Two combinations of ELRs to enable the requisite External Learning to be gained.*

These two combinations would then result in two different skills profiles for the module as shown below:

| CIS2201PL Cyber Security (PL) | | | Internal Learning Hours | | | 140 |
|---|---|---|---|---|---|---|
| | | | External Learning Hours | | | 60 |
| Asst | 1A | 2B | 3C | 4D | 5E | 6F |
| 1 | 47 | | | | | 23 |
| 2 | | | | 47 | | 23 |
| ELRs | | | | | | |
| 2 | 10 | 5 | | 10 | | 10 |
| 5 | 5 | | | 10 | | 10 |
| **Total** | **62** | **5** | **0** | **67** | **0** | **66** |

*Figure 10 - A personalised skills profile based on selection of ELRs 2 and 5*

| CIS2201PL Cyber Security (PL) | | | Internal Learning Hours | | | 140 |
|---|---|---|---|---|---|---|
| | | | External Learning Hours | | | 60 |
| Asst | 1A | 2B | 3C | 4D | 5E | 6F |
| 1 | 47 | | | | | 23 |
| 2 | | | | 47 | | 23 |
| ELRs | | | | | | |
| 1 | 5 | | 10 | 5 | | |
| 3 | 5 | | | 10 | | 5 |
| 4 | 10 | | | 5 | | 5 |
| **Total** | **67** | **0** | **10** | **67** | **0** | **56** |

*Figure 11 - A personalised skills profile based on selection of ELRs 1, 3 and 4*

# ANALYSIS AND EVALUATION

Across the range of institutions included in the study, it was found that institutional constraints on numbers of learning outcomes and highly bespoke approaches to defining learning outcomes lead to some variance in what skills were identified through the skills profiling process. There were also many similarities when skills profiling across institutions, and reasonable alignment with labour market information, for example when comparing two similar named degrees at two different institutions there was very good agreement on a skills profile and good alignment of both with future job roles. There was also variation by sub-discipline and differences between what course teams thought was being taught and what was defined as being taught through the learning outcomes.

However, the approach demonstrated that Lightcast labour market information can be mapped onto module and programme learning outcomes through a skills profiling approach. It also showed the broad applicability of such an approach. Indeed, the universality of learning outcomes, as a measure of capability within higher education globally, and the competency focus within job postings, mean that a skills profiling approach can be used anywhere. The issues identified were institutional variations that can be easily addressed locally as and when they present any difficulties.

Beyond this, the skills profiling approach provides opportunities to reduce the assessment burden and to open up programmes to a more skills-based approach, incorporating badges, micro-credentials and external learning resources. It also enables personalised learning to be introduced into higher education and workforce development, promising significant benefits in terms of better employee productivity and fit, more efficient and effective reskilling and workforce development. This approach is likely to also result in happier and more productive learner-earners, who have greater agency over their own lives and careers, and a better understanding of their capabilities and competencies. This should, in turn, enable them to make better life choices.

# REFLECTION AND NEXT STEPS

As an approach, the profiling of skills has shown broad applicability within UK computer science higher education sector. Further studies are already underway to expand the contexts in which this approach can be applied such that its global applicability can be tested and demonstrated. Whilst evidence suggests that the approach itself seems sound, it does require a shift in how course teams consider learning outcomes and how they align skills to these. This approach provides a valuable opportunity for course teams to review current provision and provide opportunities to further personalise learning within higher education (Ward, 2020a; Ward, 2020b).

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