The who, how and why of choosing post-16 computing curricula: a case study of English further education colleges

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ABSTRACT

Given the evolving and diverse nature of post-16 computing curricula within England, this papers' primary objective was to identify the factors which influence the decision-making processes for education providers when choosing computing curricula. As a main provider of the vast array of post-16 qualifications, and due to their neglect both politically and in research, further education colleges were chosen as the subject of inquiry. Due to the focus on understanding employee perspectives, a qualitative research method was employed where semi-structured interviews were conducted with thirty-two employees from across thirteen colleges within England. These employees included computing lecturers, heads of departments, and members of senior leadership. Findings indicate the extent of the range of post-16 computing qualifications offered by colleges, in addition to identifying who the key players are for computing curricula decisions. Additionally, ten factors were identified as pivotal to influencing curricula choice, and from these factors, a model has been created classifying four central areas that should be considered regarding curriculum choice: labour market information, qualification relevance to industry needs, qualification attractiveness, and current college resources. This model should help inform education providers in making more informed computing curricula decisions.

KEYWORDS

Computing Education, Curriculum, Computer Science, College, Further Education

1. Introduction

1.1. The Importance of Computing Education

Education should support students in developing the necessary skills required by employers now and in the future, and therefore education should support students in engaging in curricula that are most effective at meeting this goal (Aničić *et al.*, 2017; Passey, 2017). Computing related courses, and the general skills surrounding computer literacy, have been highlighted as a key area where demand for these skills is growing, but also that there is a general lack of employees with these skills currently (Sinclair *et al.*, 2021). For instance, as identified by existing academic literature (Van-Laar *et al.*, 2020), research reports (The Royal Society, 2017), and the UK Government's Employers Skills Survey (Winterbotham *et al.*, 2018), a key area required by the workforce now and in the future is that of 'digital skills'.

'Digital skills', however, is a contested term, with other terms such as literacy, competency, and fluency sometimes used interchangeably. Therefore, any discussion of digital skills or computing skills should ensure that care is taken to be precise in what is meant by the terminology employed (British Computer Society, 2022). Some authors have attempted to address this concern such as Van-Laar *et al.* (2017) in their systematic literature review of 21st-century digital skills, or Janssen *et al.* (2013) in their Delphi study of ninety-five experts to define digital competence. Both studies resulted in frameworks consisting of twelve distinct areas. However, studies which indicate a proficiency level are perhaps more relevant when focusing on computing education and curricula. For example, Ferrari *et al.* (2013) details their DIGCOMP framework of twenty-one digital competences where each has a proficiency level of foundation, intermediate, and advanced. Meanwhile, the Digital Skills for the UK Economy report (2016) also provides three proficiency levels. These include basic digital literacy skills which are required by every citizen, digital skills for the general workforce, and digital skills that are specifically for ICT professions (ECORYS UK, 2016). It is this latter proficiency level which is the focus when discussing computing education and curricula in this paper.

For the latter proficiency level of digital skills as highlighted by ECORYS UK

(2016), it has been identified how there are particular skills gaps in the areas of computer science and engineering where employers' needs are not being met effectively (Augar *et al.*, 2019). In fact, computer science graduates have been described as lacking the technical and softer skills required for employment (Department for Business Innovation and Skills, 2016; Scepanović, 2019), which has resulted in poor graduate outcomes (Aničić, Divjak, and Arbanas, 2017). Of course, some of these reports have the potential for political bias as they are government sources, where the UK Government may be using these reports as justification for new initiatives in these areas, but it is difficult to argue against the pace of technology that is currently taking place. For example, there are the ongoing developments in areas such as artificial intelligence, cyber security and blockchain technology (Elliott, 2017; Vogel, 2016) that are changing how the world works. These advances in technology require curricula to be as up-to-date as possible to meet these future societal needs (Passey, 2017; Scepanović, 2019), and it is the responsibility of education providers to deliver these curricula.

1.2. The Context of England

Although there are issues that appear to exist regarding graduate outcomes of computer science, it has been argued that the issues of graduate employability originate earlier than in higher education (Shadbolt, 2016; Voogt *et al.*, 2013), with schools and colleges tending to be less responsive to changes in industry and employer needs. Therefore, with concerns being raised about the demise of computer science in some countries, there are calls for students to develop the key understanding, thinking approaches, and skills, which emerge from computer science before graduating from secondary school and proceeding to higher education (Webb *et al.*, 2017). Within England, the qualifications available that are immediately prior to university study are characterised as level three qualifications under the Regulated Qualifications Framework (RQF). The RQF provides a singular simple system for logging all qualifications regulated by the Office of Qualifications and Examinations Regulation (Ofqual), and characterises qualifications for England, Wales and Northern Ireland based on their size, challenge, and difficulty. RQF level three is equivalent to level four study of the European Qualifications Framework (EQF) and are for students that are aged 16 or above. The problem that exists at this level of qualification is the vast array of how many different courses are available. It has been reported in the landscape review of computing qualifications by the British Computer Society that even after reforms to computing qualifications in the UK, there are still fifty-one level three vocational and technical qualifications in computing that are currently operational which are registered by Ofqual (British Computer Society, 2022).

Some level three qualifications have been described by employers as poor quality (Department for Education, 2018), with the 2018 Secretary of State for Education stating that the Department for Education had let down those young people wishing to pursue a technical education route as opposed to an academic route (Department for Education, 2018). They further explained that many technical qualifications were failing to equip students with the knowledge and skills required for their chosen sector, but emphasised that even with newly developed qualifications, they are only as good as the quality of its teaching, and so both the content and teaching impact the overall quality of any qualification. Therefore, with such an array of qualifications on offer, this can lead to qualifications' having different values in the labour market (Norris and Adam, 2017). Furthermore, with so many qualifications on offer, and the amount of qualification reforms that have taken place in England (Burnell, 2017), Davenport *et al.* (2020) contend that there is a lack of coherency in addressing what has been coined the 'digital skills crisis'. Advances in technology demands updates in curricula (Webb *et al.*, 2017), with some areas drastically falling behind. For example, in areas such as IT security, most secondary curricula lacks the study of topics such as internet-of-things security, human factors, and newer technologies (Riel and Romeike, 2020). However, due to the very nature of how it takes time for a new qualification to be designed and then approved by Ofqual before being offered to students by providers, it can be argued that computing curriculum will inevitably somewhat lag industry needs.

The issues regarding computing related courses being out of sync with industry brings to question whether there is much support for computing education. However, there are several organisations committed to the development and success of computing education. For instance, the Joint Task Force on Computing Curricula: Association for

Computing Machinery (ACM) and IEEE Computer Society (2013) devised the Curriculum Guidelines for Undergraduate Degree Programs in Computer Science, while the British Computing Society (BCS), The Chartered Institute for IT, has set up a School Curriculum and Assessment Committee, while providing certifications for computing teachers (Sentance and Csizmadia, 2017), and providing degree accreditation (Crick *et al.*, 2020). Furthermore, the UK Government committed over £40 million to the development of the Institute of Coding (IoC) which was created in response to the digital skills shortages across sectors in the UK (Davenport, Crick, and Hourizi, 2020). That said, this is not an exhaustive list, with other organisations such as the National Centre for Computing Education (NCCE), the Raspberry Pi Foundation, and Computing at School (Sentance *et al.*, 2014), all playing a part to advance computing education. However, with so many organisations, committees, and level three computing qualifications that exist, a key question arises; how do education providers decide on their computing curricula. To explore this in more detail, it is important to first outline what the level 3 computing qualifications are within England.

1.3. Level Three Qualifications

1.3.1. A-Levels

Advanced level qualifications, or simply A-Levels, are subject based academic qualifications that can lead to further study, university, work or training and students can normally study three or more A-Levels over a period of two years. They do not contain any work experience elements and there currently exists an A-Level in Computer Science offered by a variety of awarding bodies, albeit with slightly different requirements.

1.3.2. BTECs

BTECs (Business and Technology Education Council) are specialist work-related qualifications that combine subject and theory content with practical learning. However, BTECs do not typically include any formal work experience. They are a form of an applied general qualification (AGQ), and there are three main BTECs regarding computing: BTEC Computing, BTEC IT and BTEC Games Development. Each can be studied as a certificate (0.5 A-Level equivalent), extended certificate (1 A-Level equivalent), foundation diploma (1.5 A-Level equivalent), diploma (2 A-Level equivalent) or extended diploma (3 A-Level equivalent). The extent of the BTEC chosen by a student will determine how many units of study they are required to take. For instance, the BTEC Computing contains 32 different units of study (see Pearson Education Limited (2015)).

1.3.3. Cambridge Technicals

Cambridge Technicals are another AGQ and are vocational level three qualifications designed in consultation with higher education providers and employers, so that learners can develop the knowledge and skills required for the workplace. The Cambridge Technical in Information Technology has 4 main pathways of study (OCR, 2016); IT Infrastructure Technician, Emerging Digital Technology Practitioner, Application Developer, and Data Analyst. Similar to the BTEC courses, there are different study modes available for students such as a foundation diploma and extended diploma, and they also offer a variety of units that are either mandatory or optional.

1.3.4. T-Levels

T-Levels are a two-year level three qualification that are equivalent to three A-Levels (Department for Education, 2019). T-Levels are an alternate route of education for students after their 14-16 schooling, and have been described as the 'gold standard' of technical education (Straw and Sims, 2019). They include a 45 day workplace component which occupies approximately 20% of the overall qualification (Department for Education, 2018), and are intended for students who want to progress into a career within the digital sector, but with a particular focus on software design and development (Pearson Education Limited, 2020). Ofqual is responsible for regulating the technical qualification that sits within T-Levels, but they are doing this collaboratively with the Institute for Apprenticeships (Department for Education, 2019).

T-Levels were designed to provide a direct route into skilled employment and not to provide access to a wide range of HE courses (Department for Education, 2019), but T-Level students do have other progression options. It has been suggested that a high proportion of digital T-Level students are likely to want to progress to university (Straw and Sims, 2019), but as a new qualification, T-Levels are not tried and tested, and there have been concerns as to whether higher education institutions would accept T-Levels (Straw and Sims, 2019). To combat this, the Department for Education has worked with the Universities and Colleges Admissions Service (UCAS), to ensure that T-Levels had UCAS Points associated with them (Department for Education, 2019), as this forms a key part of the admissions process for many higher education institutions.

1.3.5. Access Courses

The Access to Higher Education Diploma is a level three qualification which prepares people for study at university who do not have other traditional qualifications. Usually for those aged 19+, they are sometimes a second chance for those who failed to meet the required standards for university from other level three qualifications. They are delivered by colleges in England and Wales.

1.3.6. Apprenticeship Courses

Apprenticeship courses are on-the-job training qualifications and can range from RQF levels 2-7. They include practical training which should contribute at least 20% of the time spent in work hours (Snelson and Deyes, 2016). Apprentices earn a wage and are an alternate route to the aforementioned level three study options discussed. Some apprenticeships related to computing involve Infrastructure Technician, Software Development Technician, and Cyber Security Technician.

1.3.7. Qualification Summary

This section has outlined six main types of level three qualification, where each one has their own variations. According to an employer perspectives survey, this variation and uncertainty regarding qualifications has encouraged employers to focus on work experience above formal qualifications (Shury *et al.*, 2017). The report further indicates how employers' are critical of the work preparedness of education leavers they recruit, and that the development of work experience that respond to employers' needs is important for any study programme, a notion also reiterated by academic scholars (Passey, 2017; Aničić, Divjak, and Arbanas, 2017; Van-Laar *et al.*, 2017). While T-Levels and apprenticeships include this workplace component, other qualifications fail to incorporate such opportunities. However, A-Levels are seen as the traditional academic route, and so the Department for Education is planning on stopping funding qualifications' that do not provide the high-quality education which the reformed A-Levels, T-Levels, and apprenticeships provide. They further state how they want to align the majority of post-16 education and training to employer-led standards by 2030 (Department for Education, 2021b). Nevertheless, even though workplace components or certain topic areas may be present on a qualification specification, this is just a small component that contributes to what is taught to students, as there are a wider set of factors which can influence the teaching and learning environment (Wolf, 2011).

1.4. Colleges and Research Questions

Colleges within England, which should not be confused with their American counterparts, form part of the further education (FE) sector, and they primarily, although not exclusively focus on compulsory education for students aged 16-18 (Snelson and Deyes, 2016). They are one of the largest providers of level three qualifications within England, and offer some of the largest variation in curricula. The UK Government has frequently identified colleges as pivotal in addressing skills gaps in the UK workforce, including in regards to computing skills (Augar *et al.*, 2019; HM Treasury, 2020; House of Lords, 2015). However, they have suffered from continuous change both politically and through the extensive qualification reforms that have taken place (Norris and Adam, 2017; Orr, 2020). Hence, given their stature as providers of level three computing related qualifications, developing a good understanding of why they are offering the curricula they offer is important if the skills gaps are to be addressed effectively.

While some qualifications such as A-Levels are more academic and have recently been reformed, some are more vocational and in the process of transition such as apprenticeships, while there are new qualifications such as the digital T-Level where there is currently very little research concerning their effectiveness to date. Therefore, gaining an understanding of how colleges choose their computing (or related) curricula can provide an insight into what the priorities are when making these crucial curriculum decisions. Therefore, this paper aims to answer the following research questions:

(1) What is the extent of the different level three computing qualifications offered by colleges?
(2) Within colleges, who makes the decision of what computing curricula to offer?
(3) What are the factors that influence the decision making process for what computing curricula are delivered in colleges?

Additionally, after answering these research questions, a conceptual model will be provided to outline the key influencing factors for curriculum choice. Furthermore, by answering these research questions, a greater understanding of context can be drawn upon when considering other aspects of computing education, whether that is the challenges faced in teaching different computing curricula, or identifying good practice.

2. Materials and Methods

In order to gain an understanding of how colleges make computing curriculum decisions, three factors were considered important for answering these research questions effectively. First, given that curriculum decisions are likely to have both strategic and pedagogical considerations, multiple stakeholders within a college hierarchy should be considered including computing lecturers, heads of computing departments, and senior leadership teams (SLT). Second, colleges vary in size, structure, type, history and proximity to employers and/or major cities. Hence, these contextual factors are assumed to influence curriculum decisions and so multiple colleges should be considered for a more holistic analysis. Finally, due to the nature of the research question considering how decisions are made, this requires a research methodology that considers perspectives and subjectivity to consider the decision making process in depth.

Based on these three considerations, a qualitative research methodology was employed where semi-structured interviews were conducted virtually via Microsoft Teams with 32 college stakeholders [1] consisting of computing lecturers (n=14), head of computing departments (n=10), and members of senior leadership (n=8), from 13 of the 23 different colleges in South-West England (three sixth-form colleges (SFC), and ten general further education (FE) colleges). All colleges in this region were initially contacted via email using publicly available email addresses but not all were able to accommodate or replied. However, this still meant that the sample of colleges represented was 56.5% of colleges in the South-West of England, and 5.3% of colleges in England overall. For those that were involved, the initial contacts served as gatekeepers for identifying other relevant contacts through a snowball sampling approach.

Colleges were chosen from the South-West of England for multiple reasons. In comparison to areas with major cities such as London or Birmingham, the South-West of England has areas of 'not spots', where there are no providers for certain courses (Snelson and Deyes, 2016). As the largest region in the UK, and with the lowest amount of people per square km according to labour market statistics (Office for National Statistics, 2022), the rural nature of the region can emphasise issues relating to students being able to travel to appropriate providers that offer computing related courses. This issue is likely to continue with the South-West being reported as having the highest official vacancy rate in England for teachers (Migration Advisory Committee, 2017), while also being the region with the highest staff turnover in colleges at 19.9% (Association of Colleges, 2018). Furthermore, from an employment and skills perspective, the South-West has a limited number of appropriate employment opportunities for graduates of computer science (Department for Business Innovation and Skills, 2016). The South-West also has a higher demand for those with skills in computers and networking and machinery tech in comparison to the UK average (Nania *et al.*, 2019), while also having the highest proportion of unfilled vacancies within the UK that are caused from a lack of skills at 30% (Winterbotham *et al.*, 2018). Thus, this combination of factors make the South-West an interesting area for investigation regarding computing curriculum decisions.

Semi-structured interviews were the chosen data collection method because they have been used successfully in similar contexts before (Broad, 2015; Lahiff, 2015; O'Leary and Brooks, 2014), while they also help emphasise meaning and experiences through allowing the opportunity to further investigate interviewee responses during the interview. All participants were provided with an informed consent form and participation information sheet prior to the interview. Most participants signed and returned the forms prior to the interview, while for the remaining participants, verbal informed consent was obtained before the interviews commenced. Once consent was obtained, interviewees were explicitly asked three main questions regarding curriculum. First, how much influence they have on what qualifications and units of study are taught within their college. Second, to explain the process of how curriculum decisions are made, and whether that is by themselves, their team or other college stakeholders, and finally, why they offer the courses that they currently offer. Interviews were recorded using the Microsoft Teams functionality, transcribed, and then imported into NVivo 12 to assist in the organisation of interview data and coded using an iterative five-phase process of thematic analysis. This began with reading through each transcript before coding began as a process of familiarisation, before conducting some complete coding across the data-set of anything that may be relevant. Thereafter, codes were grouped into categories, and then themes, and then all codes, categories and themes were revisited to check they were suitable for what data they were representing.

While there were a variety of themes created through the thematic analysis process of interview data, it should be noted that the interviews were conducted as part of a larger analysis of UK college education that included the investigation of aspects such as the challenges faced in teaching computing curricula, and good practices for teaching computing, not just for the identification of factors related to curriculum choice. However, those aspects of the coding process which led to the identification of who makes curricula decisions and the key factors which influence curriculum choice will be presented in the subsequent section.

3. Results

The results of the primary research will be outlined as follows. First, a cross case analysis of results will be presented, and this will be followed by the extent of different qualifications offered by the sample of colleges. Next, this section will focus on who decides on what curricula to offer within colleges, and following this, the influencing factors of curricula choice will be presented. It is these factors that will then be grouped into a conceptual model depicting what is important when deciding on what curricula to offer.

3.1. Cross-Case Analysis

Due to investigating three related but different research questions, to help provide context for each college investigated as part of the study, a cross case analysis was conducted where the different findings could be combined into a tabular form as shown in Table 1. This table includes college contextual information such as the approximate number of 16-18 learners, and the college type. The table also includes what level three computing qualifications each college offered in the 2020-2021 academic year to help answer research question one. This information was sourced from each college's website, and then confirmed during the interview process. The next two sections of this table relate to the findings of research question 2, of who makes the overall curriculum decision, and who decides on the individual units of study within each organisation as this was found to be different in some cases. This included senior leadership teams (SLT), Heads of Departments (HoD), and the computer science (CS) department in a variety of ways. This information was sourced through the analysis of interview data.

The final section of the table collates some of the findings regarding research question three, and it is here when ten categories/themes are outlined which were created during the thematic analysis process. For these categories/themes, an 'x' is provided for each college should one of the interviewees from that college indicate that it was a factor which influenced curriculum choice in their organisation. By providing this table first, before going into more details about the results, it allows for both an overall initial summary of the study, but also allows the opportunity to compare colleges to each other more effectively and see how different factors relate to each other internally for each college.

Table 1. Cross-Case Analysis and Overview of College Curriculum Choice (2020-2021)

College ID	1	2	3	4	5	6	7	8	9	10	11	12	13	
College Statistics														
College Type	FE	SFC	FE	FE	FE	FE	SFC	FE	SFC	FE	FE	FE	FE	
Ofsted Rating [a]	2	2	2	3	3	2	1	2	2	1	1	2	2	
Student Destinations (%) [b] [c]	79	88	75	74	79	80	87	81	89	81	73	78	79	
Approx 16-18 Learners (000's)[c]	3	2	3	3	5	2.5	1.5	3.5	1.5	4.5	3.5	3	1	
Learners per Computer [c]	7	4	3	4	8	3	2	4	2	3	7	3	8	
Dependency on 16-19 Income (%)[c]	37	81	43	35	48	44	71	52	94	61	29	49	44	
Dependency on HE Income (%)[c]	8	4	12	13	16	9	0	8	0	10	10	5	7	
Level 3 Courses Offered														
Cambridge Technical IT									x					1
BTEC IT		x		x		x	x	x		x		x	x	8
BTEC Computing	x		x		x					x	x		x	6
BTEC Games Development	x													1
A-Level Computer Science	x	x			x	x	x	x	x	x	x	x	x	11
T-Level (Digital)	x	x								x	x			4
Access to HE Computing			x			x				x			x	4
Access to HE Games Development			x							x				2
Data Technician [d]	x												x	2
Cyber Security Technician [d]	x													1
Infrastructure Technician [d]	x		x		x	x		x		x	x	x		8
Digital Support Technician [d]		x		x									x	3
IT Solutions Technician [d]		x				x								2
Software Development Technician [d]		x			x						x		x	4
Overall Curriculum Decision														
SLT		x							x	x				3
SLT (HoD can make suggestions)					x	x								2
SLT and HoD	x										x			2
CS Department			x				x	x					x	4
CS Department (SLT confirms)				x								x		2
Units of Study Decision														
SLT (HoD can make suggestions)						x								1
SLT and HoD	x										x			2
CS Department		x	x	x	x		x	x	x	x		x	x	10
Key Influencing Factors[e]														
Labour Market Information	x		x	x		x				x	x			6
Industry Relevance	x	x	x	x		x		x	x	x	x	x	x	11
Skillset of Teaching Staff	x	x	x		x		x	x		x	x	x	x	10
Familiarity		x			x		x		x				x	5
Variation/Suitable for Students	x	x						x					x	4
Performance (Student Outputs)					x							x		2
Curriculum Funding Available	x	x									x			3
Student Recruitment (Demand)				x			x			x		x		4
Aligned to College Strategy						x		x						2
Available Resources			x			x		x	x					4

[a]Where Ofsted Ratings are: 1-Outstanding, 2-Good, 3-Requires Improvement, 4-Inadequate. Source: Department for Education, 2021a.
[b]Student destinations are defined as students that left 16 to 18 study at this college in 2017, who either stayed in education or went into employment from October to March the following year, or stayed in an apprenticeship for at least 6 months.
[c]Source: Education and Skills Funding Agency, 2021.
[d]Apprenticeship Course.
[e]The key influencing factors are those factors which were identified as influencing and effecting curriculum choice. They were derived from the codes and categories created as part of the thematic analysis process of interviewee data.

3.2. Extent of Qualifications Offered

This section will outline the findings directly relating to research question 1: What is the extent of the different level three computing qualifications offered by colleges? This will be provided through outlining the results by each qualification type.

3.2.1. Applied General Qualifications

Each of the 13 colleges offered an applied general qualification related to computing, where all but one offered at least one of the BTEC qualifications. The one college that did not offer a BTEC did however offer the Cambridge Technical in IT. Unique to this college was that they were the college with the highest dependency on 16-19 income, and the college with the best student destination statistics. That said, there were conflicting views of the qualification by interviewees. The head of the computing department at this college (College ID: 9) stated:

'So I think I think our choice of the C tech is a, I'm not saying it's a bad one, but it's a little bit old fashioned still.'

However, one of the lecturers stated the most opposing view:

'So with the Cambridge Technicals is also the most modern, I think of, the sort of vocational courses in what it covers.'

Regardless of the difference in views, this college was also just one of two in the sample who have zero reliance on higher education income. Both are sixth-form colleges, and each offered a focused curricula of just two computing courses. Furthermore, they also had the best ratio of learners per computer at two.

3.2.2. A-Levels

Only two colleges did not offer an A-Level in Computer Science. Interestingly, these colleges' had the second and third worst learner destination statistics of all colleges in the sample. There is not necessarily a causal link between these factors, but it could be an avenue of future research. Furthermore, for both colleges who did not offer Computer Science A-Level, this decision stems from the computing department with senior leaders seldom involved.

3.2.3. T-Levels

Four colleges in the sample offered the inaugural T-Level in Digital Production, Design and Development which focuses on software development. No discernible characteristics are initially drawn from the similarities between these colleges. They vary in size, type, and income dependencies. That said, for each of them, the overall curriculum decision involved senior leaders in a major way. Furthermore, it was only interviewees from colleges' who offered the digital T-Level where one of the key influencing factors identified was that funding is available. This is unsurprising given that government funding was offered to providers of the T-Level. For instance, as stated by a head of department at a general FE college (College ID: 11):

'as part of early adoption to the T levels, our first year through that also allowed us to sort of investing, specific capital.'

3.2.4. Access Courses

Only four colleges in the sample offered an Access to HE course in Computing, and two of these also offered an Access to HE course in Games Development. Other than all four being general FE colleges, there appeared no distinct similarities between these colleges.

3.2.5. Apprenticeships

All but two colleges offered some form of apprenticeship, and unsurprisingly, both were sixth-form colleges who typically do not focus on this type of provision. Overall, from the 11 colleges in the sample who did offer level three apprenticeships, there were six different types of apprenticeship on offer. The most common was the infrastructure technician apprenticeship offered by eight colleges, and although it is such a key issue nationally and internationally, only one college offered the cyber security technician apprenticeship.

Overall, this review of qualifications has outlined the extent of level three computing qualifications on offer by colleges, through a sample of 13 colleges in South-West England. While the findings are not generalisable to the whole of England, the findings do draw out some areas for discussion and future research.

3.3. Who Decides?

This section will briefly describe the findings directly relating to research question 2: Within colleges, who makes the decision of what computing curricula to offer? This was divided into two main areas, who is involved in the overall curricula decision, and who decides on individual units of study.

Interviews with college employees showed how the choice of curricula for computing, and the individual units of study within the different courses are decided by different individuals for each college. For some colleges, curricula decisions were made by only senior leadership (n=3), including for two of the three sixth-form colleges in the sample. For other colleges, senior leadership made the decision, but heads of computing departments could be slightly involved through making suggestions (n=2), and in two cases, both senior leaders and heads of computing departments made the curricula decisions together. In other cases, the heads of the computing department for a college would make the overall curricula decision, but this could include a consultation with their lecturing team (n=6). For instance, one head of department from a general FE college (College ID: 8) declared that:

'[the] courses that we run was a departmental choice. So it wasn't solely made by one person, we all sat in a room as a team.'

However, in two of the cases where the decision was made by the department, any curricula decisions would still need to be signed off and approved by senior leadership. For example, one senior leader of a general FE college (College ID: 4) stated:

'It's built from the bottom up. So when you ask me who's dictating the curriculum, it's, it's the reviews from our learners. It's the study program managers that teach it themselves. And they have direct access to the labour market data and the employers to inform their curriculum at that level. But it then goes through a process of being moderated by their manager, and then the leadership team.'

There was much more similarity between colleges regarding the individual units of study as this tended to be decided by the lecturing team (n=10) but often in consultation with their head of department. This process was stated very explicitly by some interviewees, as was the case for a lecturer at one FE college (College ID: 13):

'we sort of sat down together and knocked out what units would be best.'

It is important to note that for some colleges, particularly the sixth-form colleges, a computing department can be very small in terms of staff numbers, with the smallest case having just two members of staff. In these cases, the head of department was very closely linked to the teaching team, often having many hours of teaching themselves. However, for some colleges' with larger computing departments, the head of department could also be the head of department for other subject areas such as Business Studies. Therefore, in these instances, they tended to be less involved with the decisions around individual units of study.

3.4. Influencing Factors of Curricula Choice

This section will describe the findings directly relating to research question 3: What are the factors that influence the decision making process for what computing curricula are delivered in colleges? It is this section that outlines in greater detail the categories and themes created as part of the thematic analysis process of interview data.

One of the key influencing factors for many providers was using labour market information (LMI), which was a key factor for six colleges. LMI referred to sourcing and using data such as local, national, and international trends in technology, and identifying what technologies and skills employees or industry more widely required (e.g. through web scraping job adverts). Colleges would use this information to inform what computing curricula they should offer. For instance, a head of department at a general FE college (College ID: 11) explained:

'they [industry advisory board] think that about 18 months out, there will be quite an explosion for cyber in the area, for example. So that gets us thinking hold on, and what do we need to precede that explosion? So we started looking at our level three and level four provision.'

Equally a senior leader from another general FE college (College ID: 6), explained that for any qualification, they ask themselves a series of questions which all relate to LMI:

'Is there a market for this? What do potential customers say? Do employers want this qualification? What's the labour market look like?'

While LMI is clearly important, another key factor was that of delivering qualifications which are relevant to industry needs. This factor was important for 11 colleges, including all of those who emphasise the importance of LMI. For those using LMI, often it was to provide them with contextual information to map qualifications against for their relevance, so the two are intrinsically linked, albeit different. The key point of industry relevance however, was that it included factors such as how appropriate a qualification was regarding offering industry experience, having suitable assessments, or having an up-to-date specification. For example, the following comments emphasise how interviewees' placed an importance on industry relevance. A senior leader at a general FE college (College ID: 8) explained that:

'the curriculum team decide, and they obviously, try very hard to, to remain in line with, you know, the requirements of industry.'

Meanwhile, a lecturer at a different FE college (College ID: 13), showed how they considered local industry demand in addition to how they want their curricula to build on a students previous study:

'I just thought that the [BTEC] IT was a better fit with with the level two that we were teaching at the time and the kind of students that we get, and also what's needed locally, really.'

Due to the focus on industry relevance, some colleges are placing a higher emphasis on qualifications such as apprenticeships or the digital T-Level, as they are more aligned to industry needs than AGQs or A-Levels due to the workplace elements as part of the course. In fact, for some providers of the T-Level, some interviewees' described how as more T-Levels are introduced, they will discontinue other existing level three qualifications. For example, a senior leader of a sixth-form college (College ID: 2) stated:

'As each new T-level comes out, we are switching off the equivalent BTEC.'

As well as industry relevance and LMI, there are other factors which influence curriculum choice, with a significant factor being the skill set of college teaching staff, an important factor for 10 colleges. Some interviewees' identified how if the college does not have staff with the skills, they will simply not offer certain courses or units of study. Other colleges' have staff with perhaps a more proactive approach with lecturers' who want to learn new subjects if it has been identified as being relevant to industry. For example, one FE college lecturer (College ID: 3) specified:

'if market demand is for web dev, and we have no one that can deliver the web dev, right? So hey there we can teach ourselves, okay, if we have a time and then we say "Yes, okay, we can do the units".'

A related factor was the availability of resources, where resources can refer to a combination of funding, equipment available for teaching, and network infrastructure, since these are important resources that are required for offering resource intensive curricula such as computing. This is particularly the case for areas such as cyber security or the digital T-Level. If resources are not available, then this can be a driving force in influencing what curricula can be offered. For instance, a senior leader at a general FE college (College ID: 1) explained that the decision around curriculum is a:

'balancing act between the skills that we have, [and] the needs of industry.'

Other factors included offering a broad or varied curriculum to cater for the variety of learners that study at colleges. For instance, both A-Levels and T-Levels were perceived by some interviewees to be qualifications that are more difficult than other qualifications such as BTECs, and therefore not offering a BTEC course was seen as not catering to the variation in learner needs, as was the perspective of one lecturer from a general FE college (College ID:1):

'we still run BTECs here at college... So we still offer those out. Because not everyone, not everyone's suitable to do the T level... the BTEC students obviously, like, are a slightly lower level academically.'

There were also factors related to teaching courses or content that are familiar to the lecturing team, and where the department know they can achieve positive pupil outcomes. For instance, one lecturer of a sixth-form college (College ID: 7) stated:

'because I'm familiar with the A-level computer science, I like to stick with what I'm familiar with.'

Another example is that of a lecturer at a general FE college (College ID: 5):

'If you've been teaching a unit that may be outdated or may not have a great deal of relevance to industry, you carry on teaching it because you're comfortable with it, and you know that you can get the outputs for it.'

This highlights the issue of performance and student outputs, which in some instances was another key influence on curriculum choice. One head of department from a general FE college (College ID: 12) outlined the following:

'it's all about facts and figures now and meeting benchmarks and standardization. And it's less about what happens in the classroom.'

Overall, this section has outlined some key factors that influence the decision-making process regarding computing curricula being offered by colleges, with many supporting quotes to emphasise the different factors which exist. The following section will discuss these findings in greater detail, collate the influencing factors into a conceptual model of curriculum choice, consider these factors in relation to each other and existing literature, but also consider the implications stemming from these findings.

4. Discussion

4.1. Creation of the Four Pillars Model

There are a variety of factors that were identified which influence how colleges' decide what computing curricula to offer, and these initial factors outlined in Table 1 have been grouped based on their similar characteristics into four main areas as a conceptual model. Two of the ten factors remain largely the same: labour market information, and industry relevance. However, the remaining eight factors were grouped into two separate areas, as they were either related to college resources from a general point of view (staff, equipment, finance etc), or that the qualification has certain favourable qualities. This model is depicted in Figure 1, which shows how these four areas have been represented as the four pillars of curriculum choice. They are represented in this way as each factor is considered equally important in supporting curriculum choice, and that no individual pillar should be neglected.

The results of the interviews show how the decision surrounding curricula differs from college to college, where each college would choose from a variety of level three courses to offer. The model indicates how the 'decision makers' should ideally consider the different qualifications against each other, and then against each of the four pillars. Some pillars are related and as previously mentioned, LMI can inform how relevant a qualification is to industry needs. Furthermore, this relevance to industry needs may

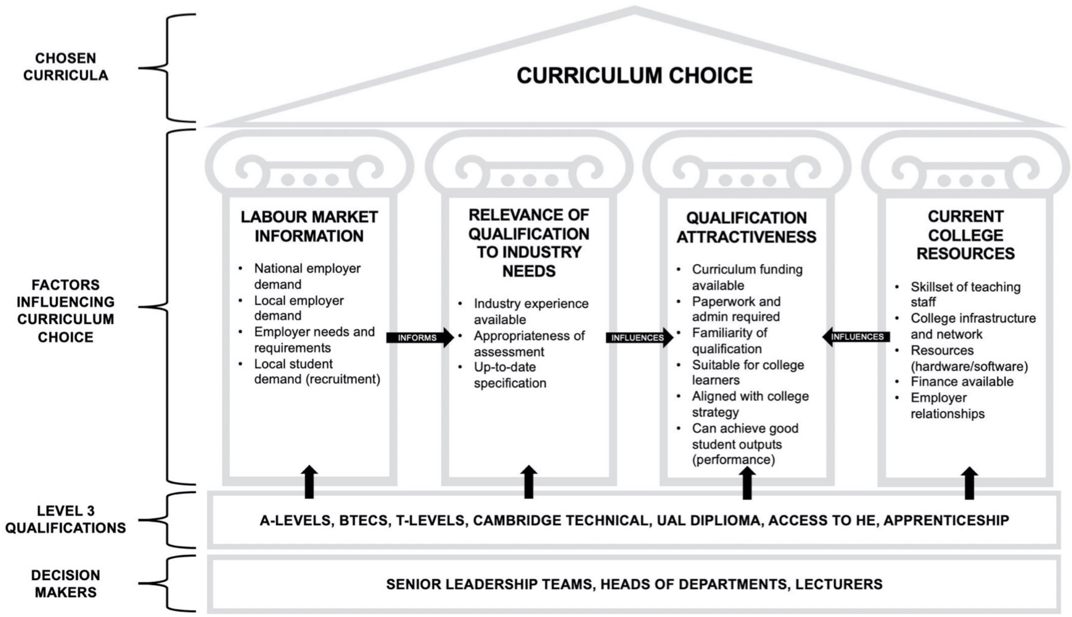

Figure 1. Four Pillars of Curriculum Choice

be something that influences a qualification's attractiveness, as this could be a key strategic priority for a college. Equally, a colleges' current resources may also influence how attractive certain qualifications appear to be, as some qualification's content and resource needs may be more aligned to the college's particular situation in this regard.

As seen from figure 1, the left two pillars are focused on external factors to a college, while the right two pillars are aligned towards factors internal to a college, whether that be perceptions regarding a qualifications' attractiveness or more explicitly, the college itself. A factor not included in this model is routes to higher education. It was surprising that this factor did not appear to be a driver of curriculum choice for this sample of colleges, with a greater focus being placed on industry relevance and employability generally, as opposed to preparing students explicitly for HE. That said, this may be a key influencing factor for colleges elsewhere, but this conceptual model has been created based on the findings of the study. Nevertheless, as indicated from the analysis of interview data from the sample of 13 colleges, it appears that all curriculum decisions regarding computing are influenced in some way by these four pillars, but some colleges' place a higher emphasis on some pillars more than others, and this is to be expected based on each college having their own individual circumstances and priorities.

For instance, one college placed a very high emphasis on LMI, and used this information to successfully identify which qualifications were most relevant to industry needs. Consequently, one decision they made was to offer the digital T-Level and while this college did not initially have the resources to offer this qualification, they used the T-Level funding that was available from the UK Government to help them overcome this. For this college, the T-Level was very attractive from a strategic point of view, and the benefits they could obtain (i.e. funding). However, the priority pillar was LMI, since this was needed to identify what would be most suitable, or not.

Overall, the type, size, location (rural vs urban - particularly for qualifications with a workplace component such as T-Levels or apprenticeships), and history (e.g. their traditional curriculum diet) of a college may influence the emphasis placed on each of the four pillars. While Figure 1 could be argued as being a simplistic model of representing what are complex organisational decisions, it does provide a model of understanding which identifies and separates some of the key influencing factors of curriculum choice. Hence, consideration of each of these four pillars could help inform colleges on which curricula to offer.

4.2. The Economic Argument

There is limited research available regarding how a college would choose their computing curricula but there is research which refers to computing curricula generally in the education sector, and what it should strive to achieve. While some of these aspects are idiosyncratic, some can be mapped to Figure 1. For instance, Passey (2017) outlines six main arguments for a computer science curriculum in schools, but some such as the 'economic argument' can be applicable in a college context. The 'economic argument' is that education should support learners in engaging in curricula which support the future economy, and so they can meet future needs and skills requirements (Passey, 2017). This argument is closely linked to that of the second pillar of choosing curricula based on its relevance to industry needs. This was the most common influencing factor in choosing curricula across the sample, and corresponds to existing literature that cites the importance of work experience from an employer's perspective (Shury *et al.*, 2017), which includes both technical and non-technical skills (Aničić, Divjak, and Arbanas, 2017).

Therefore, having up-to-date curricula, with varied assessments which replicate the 'real-world', together with work experience were seen by interviewees as more valuable qualifications. Hence, it was no surprise that interviewees' discussed the digital T-Levels, and how this qualification seems to meet these requirements. However, even with an industry placement, the T-Level still contains some written exams (Pearson Education Limited, 2020), that are not necessarily relevant to industry needs. Still, curricula is evolving over time, and while the T-Level may not be 100% relevant to industry needs, it may be closer to achieving this when compared to some of the other level three computing qualifications, and for some colleges, this relevance to industry needs may be the most important pillar of curriculum choice.

Passey (2017) further explains in regard to the 'economic argument' that to understand whether a qualification is relevant to industry needs, this implies that teachers' must require an understanding of what is required in industry. It is addressing this issue, where LMI can play an important role. A key point though is whether to consider LMI from a local or national perspective. A college could view the national perspective which considers wider technological trends, but each college will be operating is a specific local area, that will have its own unique characteristics and LMI. For example, one head of department at a FE college (College ID: 6) explained how there is a national demand for software engineers, but locally, there are limited employment options in this area, resulting in few workplace opportunities for students both during and after college:

'it's quite tough to sort of bootstrap the whole concept [of using labour market information] when when there's no industry demand [locally].'

Hence, LMI should be considered carefully from multiple perspectives. However, without considering LMI, this could lead to curricula lagging behind industry, as identified by some interviewees, academic literature (Mertala, 2021) and existing government reports (House of Lords, 2015). Technology and industry needs will continue to evolve, and this highlights the importance of education.

4.3. The Educational Argument

The educational argument is based on the premise that computing and technology will continue to develop, where it is not possible to see any endpoint in these developments. Consequently, education should include computer science and digital curricula that are aware, understand and support these future societal needs (Passey, 2017). Implicitly, there are future needs which do not exist yet and so the educational argument is also concerned with lifelong learning and building the capacity to do so within students. This has also been highlighted in existing reports (Shadbolt, 2016), and brings forward a key question. If the success of computing education is predicated on an ability of students to be able to engage in lifelong learning and being able to adapt to change, then surely, individual specifications and particular aspects of content are merely tools to learn, and not the goal themselves. Hence, the most important factors for choosing curricula would be based on what leads to the most effective pedagogy and the most prosperous teaching and learning environment, irrespective of the curricula itself. There is a difference between what is an intended curriculum, which can be defined by a given scheme or relevant standards, and the actual enacted or implemented curriculum that is experienced by students (Falkner *et al.*, 2019). Therefore, curricula can be argued as being simply guides to education, but education is not the curriculum. Hence, LMI and a qualifications' relevance to industry needs, should not be the only influencing factors regarding curriculum choice, and explains why some colleges' place a much heavier importance on the third and fourth pillars, since these relate to factors internal to the college, the place where students learn.

When considering existing literature regarding teaching computing within colleges, it is even clearer why curriculum choice may be dictated by these factors. Not only have colleges' been subject to continuous change (Norris and Adam, 2017), and a lack of investment (Department for Education, 2021b), but there is a lack of appropriately skilled staff for teaching computing which hinders any sort of curriculum innovation (Brown *et al.*, 2014; Webb *et al.*, 2017). These external factors influence how colleges operate, and despite LMI and a qualifications' relevance to industry, for some qualifications, a college may find it impossible to deliver them successfully, so curriculum decisions are made with a greater emphasis on pillars three and four. Regardless of any curriculum decisions that are made, it is the students who should be at the focus with their best interests in consideration. Students are the ones most impacted by curriculum changes (Sentance and Waite, 2018), as it is their education that is impacted, and arguably their future too. Hence, making the right curriculum decisions are extremely important, even though any curriculum is not the sole factor that influences a student's education.

4.4. Implications

While Figure 1 may not address every factor that influences curriculum choice, it provides some structure and contextualisation in answering 'What are the factors that influence the decision making process for what computing curricula are delivered in colleges?' As with any qualitative research, there are some limitations in what has been presented, the analysis and interpretation of interview data is subjective, including the creation of Figure 1. However, it was created through the analysis of a sample of 32 employees across 13 colleges and this variation should provide some confidence in the model created.

Advances in technology necessitate changes to curricula (Webb *et al.*, 2017), so LMI should be considered. However, changes in curricula often require changes in teaching and delivery methods (Aničić, Divjak, and Arbanas, 2017), and making effective changes can take many years (Falkner *et al.*, 2019; Sentance and Waite, 2018). Hence, colleges' should consider their own characteristics and find a balance between offering curricula based on LMI and relevance to industry needs, and how feasible it is given their current situation and what they find attractive. Therefore, to guide the decision-making process, colleges could use the Four Pillars model to ensure that sufficient appreciation is given to the different factors. If a college only focused on a singular pillar, this could lead to a less prosperous teaching and learning environment for computing education. However, through contemplating all four pillars, curriculum decisions would consider internal and external factors to a college, while considering future societal needs.

It is possible that the model could be applied to other subject areas, but it should be noted how the model was created under the context of computing curricula specifically, so may not be applicable to other subject areas. Further research could investigate this. Equally, future research should be undertaken to evaluate the model and whether it is applicable more widely than the just the sample of colleges investigated in this study, and to identify whether any other factors are missing. Finally, research into this area should not stop here, since in the area of computing and technology, change is omnipresent, and therefore so is the need for new curricula. Therefore, research that identifies how to simplify these complex organisational decisions surrounding curriculum choice, and what is considered good practice should be encouraged.

Word Count = 7973

Notes

[1]This project did not require formal approval by the University's Research Ethics Committee (UREC) due to the project adequately adhering to the ethical consequences of researching with human subjects, and by following the home institutions guidelines on 'Research Ethics: A Handbook of Principles and Procedures'. Nevertheless, the project was signed off and approved by the head of faculty, in addition to the faculty postgraduate research lead on 04/05/2020.

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