Full Title

Curriculum Mapping Food Science Programs: An Approach to Quantification of Professional Competencies

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[END PAGE 1]

ABSTRACT:

It is fundamental that students are able to identity where they have developed specific professional competencies during their study. This ensures students can not only articulate their competencies well in job applications and assessments, but also draw on their experiences for use in the workplace. The aim of study was to ascertain if desirability of an *element* or competency as indicated by employers, was reflected in an equivalent level of program content, appropriately perceived by the student. A case study approach mapped *elements* of the previously developed Competencies for Food Graduate Careers (CFGC) framework against food sciences curricula at University of Nottingham (UoN). The mapping process facilitated evaluation of appropriate levels of inclusion of each *element* in degree programs, by recording types of content and experiences provided, in collaboration with teaching staff. Perspectives of the student experience were captured using an online survey. In addition, guidance from a prior industry survey provided context of the level of desirability for each *element* across the range of graduate roles in the UK. The results showed some areas of mismatch, where curricular content did not align with employer expectations or student perceptions. This has informed review of this curriculum, to best reflect 'competency development' to meet the needs of the food industry. Recommendations were made to address gaps through enhancement of: content, delivery, communication or assessment. Additionally, the exercise has suggested a more informed development of curricula categorization and coding for future similar mapping activities.

5 Keywords: curriculum, education, experiential learning, mapping, professional competencies.

Practical Application: *NOTE: Do not include a PA for JFS Concise Reviews, JFSE, and CRFSFS papers.* ***N/A***

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Introduction

Over the past decade, the employability of university graduates has been a focus for policy development and debate, including the question of whether university tuition fees provide value for money (Office for Students, 2019). The higher education sector has recognized the importance of ensuring graduates possess a range of professional competencies beyond traditional technical skills, so they can compete and succeed in an uncertain world.

Establishing credibility of program content to meet workplace requirements is embedded in structured vocations such as the veterinary profession (Vinten, Cobb, Freeman, & Mossop, 2016), but has been explored in a more limited capacity in other areas of degree study. The limited prior examples focussed on food science education are outlined later. In recent years, University of Nottingham (UoN) have endeavored to establish the desirable professional competencies for food science graduates entering their first roles in the UK industry. In collaboration with employers a language tool was constructed (Weston, Crilly, Mossop, & Foster, 2017) and a range of roles with corresponding desirable qualities (Weston, Foster, Crilly & Mossop, 2020) have been described. Competencies for Food Graduate Careers (CFGC), comprises a set of 48 *elements* across 8 *themes,* outlining which are desirable for each of 14 typical graduate roles (Weston, 2018).

To enhance the caliber of 'oven-ready' graduates entering the food industry, it is recommended CFGC be used for careers education and competency development in higher education. Whilst use of CFGC to support the former could commence, application of this framework to establish degree curricula alignment to industry needs was required.

Curriculum mapping

Understanding the 'curriculum model' informs an educator what to include in any curriculum mapping, review or development. Hale (2008) defines a curriculum map as a, "succinct summation of planned and operational learning" (p.39). A curriculum map can be simple or as intricate as necessary for the scale and complexity of the task in hand and can be utilized for many purposes (Hale, 2008; Harden, 2001; Joyner, 2016b) such as, exploring content, gaps or repetition, visualising student development or as evidence for accreditation purposes. Curriculum mapping – the process of categorizing parts of a degree curriculum model – is a varied process with multiple approaches described.

The criteria for mapping in higher education can include nationally agreed standards laid out for subject areas or detailed mandatory competency frameworks for vocations such as the medical profession. It is common for standards used to be translated by an institute into learning outcomes (LOs), and cascaded into operational plans and use, so the simplest form of mapping is to use LOs as the working reference point in mapping (Ramia, Salameh, Btaiche, & Saad, 2016). The division of material when mapping changes between researchers and studies as well as the nomenclature applied to categories generated, which can create confusion in comparison of data between studies. For example in the field of pharmacy education, some studies categorize LOs, alongside lectures and practicals as 'enacted' (Kelley, McAuley, Wallace, & Frank, 2008; Ramia et al., 2016), whilst others classify LOs as 'declared' (Harden, 2001; Vinten, Cobb, Freeman, & Mossop, 2016). The other area of frequent difference observed is the substance of the 'learned' curriculum, as student experience, activities and perception (Kelley et al., 2008; School of Biosciences, n.d.) or as assessment (Harden, 2001). Kelley et al. (2008) exemplify an approach where the primary emphasis was made to select a model and associated language appropriate for use, used consistently and having 'meaning' for staff involved. Utilizing a single auditor can be the simplest mapping approach to take, however the involvement of relevant staff is important to gather the fullest evidence (Joyner 2016a) as long as data gathered is challenged appropriately (Jerez et al., 2016; Tariq, Scott, Cochrane, Lee, & Ryles, 2004). It is suggested staff involvement could include supply of content inclusion evidence and involvement in a collaborative agreement or consolidation process (Hale, 2008, Lam & Tsui, 2016; Spencer, Riddle, & Knewstubb, 2012; Sumsion & Goodfellow, 2004; Tariq et al., 2004).

Variants in mapping processes published include the permitted evidence for inclusion (Arafeh, 2016; Jerez et al., 2016; Spencer et al., 2012), types of inclusion (Kelley et al., 2008; Tariq et al., 2004), stakeholders involved (Ramia et al., 2016) quantification of data (Perera, Babatunde, Zhou, Pearson, & Ekundayo, 2016), and whether to assess level of mastery (Arafeh, 2016; Joyner, 2016b). Approaches to recording and presenting data range from simple binary reports to illustrations or software generated colour-shaded heat maps (Spencer et al., 2012).

Within food science educational research, most contemporary studies investigate what the ideal competencies should be within a degree program as opposed to what is actually included. CFGC is aligned to a number of aspects of the USA-based Institute of Food Technology (IFT) degree standards (2019; Weston et al., 2020). Studies with food science employers in the USA (Morgan, Ismail, & Hayes, 2006) identified a high desirability for IFT 'success skills', concluding that these skills should be embedded throughout the curriculum. A few studies in the USA and by the Europe-wide ISEKI scheme have sought to establish what competencies students' perceive they have developed from studies against the IFT standard (2019) or previously constructed lists by means of surveys and reflective reports (Bohlscheid & Clark, 2012; Flynn, Ho, Vieira, Pittia, & Dalla Rosa, 2017; LeGrand, Yamashita, Trexler, Vu, & Young, 2017).

Hartel and Gardner (2003) reflect on the benefits of curriculum mapping and recommend use of the IFT degree framework as a standard, to change or

develop curricula, a process undertaken by Joyner (2016b) some years later, Broader learnings from Joyner's work have been embraced during this study, including the undertaking to establish some type of inclusion level for each competency.

Aims and Objectives

This study utilizes a long established UK food sciences university curriculum at UoN, as a case study. The aim was to establish, with some level of quantification, where opportunity for development of each of the 48 *element*s of CFGC (Weston et al., 2017) exists within this current food sciences curricula, by gathering perspectives from documentation, staff, students, graduates (2015-2017 alumni) and employers. The ideal would be to achieve 'congruence' (Waple, 2006) where for example, if the desirability according to employer feedback is 'high', then the program content and student perception of inclusion should also be 'high'. Using the outcomes of this study, recommendations were made for future refinement of teaching and learning activities at UoN. The outcome from this case study approach are intended to be utilized by other educators with similar curricula. The study also includes reflection on and refinement of the described methodology, to support future use by other institutions.

Methods

The study was conducted from the summer 2017 for 10 months and the approach undertaken is summarized in Figure 1. Embracing features from previous studies (Hale, 2008; Joyner, 2016b; Kelley et al., 2008; Spencer et al., 2012), staff in the form of individual module conveners and the mapping team created individual module maps, and a reviewing team provided a broader assessment of results and ratified outcomes. Beyond this, two indirect factors were added to the study by the use of online surveys. Perceptions of recent graduates were sought, aiming to provide some measure of effectiveness of delivery. In addition, drawing from previous industry survey data (Weston et al., 2020), employers' desirability for each *element* can provide a 'level of importance' to contextualize content evaluation. These indirect measures aimed to support a more comprehensive investigation of program effectiveness (Hartel & Gardner, 2003). As no single, prior approach was reproduced for this case study, an iterative process was employed with points of review and consolidation.

Curriculum Mapping (or teaching staff perspective)

The two, full time. three year undergraduate food science programs at Nottingham during the study period were "Food Science" and "Nutrition and Food Science". Nineteen core modules were shared between programs (of varying credit levels), alongside two and three additional core modules respectively. Modules chosen for any optional credits and the additional industrial placement year option were omitted from the case study. Each core module was mapped discreetly, for ease of application in both degree programs and future flexibility (Joyner, 2016b).

Creation of categories and code book

An adaptation of the School of Biosciences internal categorization 'TLA' system (taught, learned, assessed) was developed for the mapping exercise with inclusion of more detailed definitions (Table 1). Whilst not aliglned to the literature, where Harden (2001) is clear that what is learned is demonstrated by students via assessment, the decision was made to use this nomenclature which was already in place, anticipating engagement of module conveners would be greater when using familiar vocabulary supported by enhanced definitions (Kelley et al., 2008).

To differentiate between formal and informal inclusions in modules and indicate 'confidence' (Spencer et al., 2012) by discriminating between 'explicit' and 'implicit' inclusion (Arafeh, 2016) and levels of relationship to outcomes (Kelley et al., 2008), a system of numerically weighted codes were developed by the mapping team (Table 2). Scoring of codes was designed to reflect where activities may be not perceived as mandatory and thus not engaged with, such as formative assessments.

Theoretically when mapping an *element* in a single module using outlined scoring options (Table 2), a maximum of 3.7 could be achieved. However, it would not be common for such a comprehensive breadth of inclusion, so for the purposes of comparisons in later stages an 'ideal' inclusion score of 3.0 was considered appropriate by the mapping team for explicit inclusion in a module.

Mapping process

A member of the mapping team conducted one-to-one sessions with the appropriate module conveners (teaching staff). A spreadsheet matrix was prepared for logging results of mapping each of the 48 *elements* of CFGC against a single module. Mapping protocol including the CFGC language book (Weston et al., 2017) and the categories outlined in Table 1, was issued in advance to module conveners, to provide opportunity for initial review of their module, reflection of content against the criteria and possible evidence for 'formal' inclusions (Sumsion & Goodfellow, 2004).

In the session (typically one hour) module material was reviewed against each *element* of CFGC until consensus was reached and notes recorded on a printed blank matrix. The scope of material under consideration included formally issued items including: the module specification with LOs, documentation

provided to students personally or on the UoN internal e-learning platform and also assessment criteria. Any recent or forthcoming changes to the module content significant to the study were recorded.

Results were populated on the spreadsheet by the mapping team recording a total score (Table 2) for each *element* in the module and supporting evidence and rationale. The draft was returned to the convener for comment or approval and any required amendments were considered before finalization. The mapping team conducted regular reviews during the initial mapping stages (Joyner, 2016b) and after final data collation to reflect on the process and ensure consistency and reliability (Hale, 2008).

A 'program score' for the all core modules for each of the 48 *element*s was inspected. A mechanism was devised to differentiate between scores. Using the 'ideal' module inclusion of 3.0 (see earlier), the program 'ideal score' could be calculated by multiplying by the number of core modules in each program. As the two programs have a different number of core modules, Food Sciences had an 'ideal score' of 63 (3.0 x 21) and for Nutrition and Food Sciences, 66 (3.0 x 22). Each *element* program score was presented as a proportion of either 'ideal score' (63 or 66) and converted to a low, medium or high category using the matrix in Table 3. For example, a program score of 6.9 is equivalent to 11% of the 'ideal score' for a food science program and so would be categorized as 'medium'.

Employers' desirability

An indication of 'relative importance' it may have in the graduate workplace was estimated using the prior industry survey in 2017, by tallying how frequently a CFGC *element* was considered desirable in one of the 14 typical graduate roles (Weston et al., 2020). Each time an *element* was included in a final role profile it was given a score of 1.0. However six roles with low response rate in the survey were agreed by the industry-based project stakeholder group (Weston et al., 2017) to be less frequently recruited, with susequently less weighting on competency requirements for a graduate pool. Their numerical contribution was thus halved to 0.5. Categorization of the summated scores for each *element* was agreed as from 0 to 1.5 scoring 'low', 2.0 to 3.5 scoring 'medium' and 4.0 or greater scoring 'high'.

Graduate survey (student perception)

An online survey (Online Surveys™, Jisc, Bristol, UK) was utilized to gather graduates' (alumni 2015, 2016 and 2017) perception of 'inclusion levels' of CFGC *element*s in their studies. Format reflected suitability for completion on desk and hand-held devices (Brace, 2013) and an informal pilot was conducted. Figure 2 illustrates an example of a question for a single *element* with the expandable 'more info' feature.

Ordinal data obtained from graduates from both programs across the three years were collated due to the limited sample size. Resultant useable scoring in the graduate survey (Figure 2) was, '1 - excellent inclusion' to '4 - no inclusion'. If a response for any *element* was recorded as '5 - Don't Know' the item was removed from the data set (for separate inspection) and total responses for that *element* reduced accordingly (Manisera & Zuccolotto, 2014). Data analysis was conducted by counting the frequency of scoring "excellent inclusion" (No.1) and "good inclusion" (No.2). A score of "High" was applied where >50% of responses were No.1, a score of "Medium" to where >70% of responses were either No.1 or No.2 and the remaining results given the score "Low". Comments collected from open text points of the survey were also analyzed by simple thematic evaluation.

Data collation

Data from the three collection streams: employer desirability, program content and graduate perception were compiled on a spreadsheet with a row for each of the 48 *elements*. Data associated with each *element* were placed in columns and color coding applied to associated 'low', 'medium' and 'high' categories. *Elements* with congruence between employer desirability, content and student perception were deemed 'balanced' and no further action taken during this study. *Elements* were highlighted as 'imbalanced' if employer's desirability score was 'high' or 'medium' but program content or graduate scoring was below this. Areas of incongruence and proposed 'imbalanced' were reorganized at the top of the sheet and detailed notes gathered for each of these *elements* including open comments retrieved from the graduate surveys and quotations from employer stakeholder interviews (Weston et al., 2017).

Consolidation

The reviewing team conducted a series of meetings to further validate mapping outcomes from a broader perspective. Appreciating the mapping process captured a moment in time (Bath, Smith, Stein, & Swann, 2004; Harden, 2001), reflections on current status, past experience and future strategy were included during discussions. Two initial considerations were undertaken following reflection of the mapping activity. Firstly, whilst mapping the final year research project module commanded an unusual opportunity for a student to develop many *element*s of CFGC to a noteworthy level. The larger size (40 credits), nature and duration of focus over the final semester (effectively 3 days per week of independent endeavor) was appreciated, so consideration of how to captured this in mapping results was agreed worthwhile. In addition, suggestions were gathered from staff and students, where it was thought a particular *element* could be developed in activities outside of specific modules but within program experience. Suggestion was explored to establish validity for certain

*element*s in CFGC as being developed by the wider journey of studying a degree program (Barrie, 2007) and if so how this could be included into mapping results. Agreed adjustments by the reviewing team were made for these two factors.

A spreadsheet was used to populate results and color was added to illustrate outcomes by heat maps (Spencer et al., 2012). The final color coded report highlighted areas of imbalance using the criteria and color coding below:

- *Elements* where the employers' desirability were scored 'low' were placed at the bottom of the list (no action required and marked with a green box).
- All *elements* where the employers' desirability were scored 'medium' or 'high' and the content score and student perception were equally scored were placed at the bottom of the list (no action required and marked with a green box).
- *Elements* with 'imbalance', where the employers' desirability was not matched by program content and/or student perception were placed towards the top of the list (review required).

Of the 'imbalanced' *element*s:

- If the employers' desirability was 'high' or 'medium' and program content was scored 'low' then they were taken to the top of the list ahead of others and marked with a red box (priority).
- If the employers' desirability was 'high' or 'medium' and there was any other 'imbalance' of program content OR student perception against desirability, then they were placed below the red items and marked with an amber box (investigate)

Following examination of the final report by the reviewing team, suitably prioritized proposals for development of teaching content, approach and communications were made. Ideas posed, included workshops and guided activity sessions (Anthoney, Stead, & Turney, 2017).

Ethics

The graduate survey was approved by the School of Sociology and Social Policy as aligned to University of Nottingham Code of Research Conduct and Research Ethics. Informed consent was obtained from participants before survey completion. Related ethics approvals for the industry survey have been reported previously (Weston et al., 2020).

Results

Graduate survey

A total of 37 participants completed the survey, 15 from those graduating in 2015 or 2016 and the remaining 22 from the 2017 cohort. Reflecting limitations in ability to contact all alumni, this represents approximately 35% of the three cohorts. The omitted 24 instances of the 'don't know' response were predominantly from the 2017 graduates, representing 1.3% of the total data set. Sixteen of the responses were derived from six participants (five from the 2017 cohort) and the rest were singular instances. Two *elements* appearing to generate uncertainty of response were, *work experience* and *English proficiency,* perhaps reflecting not all students engage with the former, and most of the cohort do not need to consider the latter during degree study. Prevalence of 'don't know' responses from recent (2017) graduates could result from inability of students to notice their personal development in real time before 'practising' their competency in the world of work (Trought, 2012).

Overall collation and consolidation

The final results for each *element* after scoring each of content mapping, employers desirability and graduate feedback can be found in Supporting Information 1 where visual comparisons could be made for each *element* between employer desirability, levels of curricular content and graduate perception of inclusion (student view).

Due to the nature and level of independent work undertaken by the student, it was agreed to double the scoring of any formal inclusion of an *element* in the final year Research Project module. The reviewing team also established that wider development opportunities would be valid where an *element* could be justifiably developed in activities outside of individual modular teaching. An example was *planning and organising,* where it was noted by a number of staff members, students will develop this *element* by handling their study and personal activities whilst studying for a degree. Conversely, it could be argued there would not be an expectation for *global supply chain* to be developed outside of specific modular teaching. A prior independent assessment, followed by a collective review established a list of 22 *elements* considered justifiably developed during wider degree study (Table 4), and numerical coding applied was set at 1.0 for each program, so having equivalency to a single formal learning opportunity in a module (Table 2).

Findings

From module mapping, the program content was calculated as ‘low’ for 13 and 16 *elements* in the BSc Food Science & Nutrition and BSc Food Science programs, respectively. A total of seven *elements* were considered by graduates to be ‘low’ in program inclusion. A summary of the imbalanced *elements* from the full report is presented in Table 5.

Results indicate congruency for the majority of *element*s in CFGC with respect to desirability and program content. Nineteen of the 48 *element*s were in some form imbalanced, of which 15 *element*s had less program content than desirable to employers. Any specific areas of ‘imbalance’ were analyzed and where actions deemed necessary, appropriate plans agreed by the reviewing team.

Five of the imbalanced *element*s have been proposed as peripheral to core food sciences curricula (The Quality Assurance Agency for Higher Education, 2016), namely; entrepreneurship, leadership, negotiation and influencing, the mechanics of business and commercial awareness. Future appropriate inclusion opportunities will be considered, perhaps reflecting any changing employer needs. In the meantime, any students wishing to improve competency in these *elements* will be provided with clear signposting to where optional modules may develop these *element*s, or opportunities outside of study could be considered such as, self-directed learning material, taking an industry placement year, or undertaking wider experiences to assist their focused personal development.

Review of imbalances and action plan

A review of fully collated data by the reviewing team for *elements* of higher priority such as ‘red’ items allowed for agreement of decisions and future actions. For example, *working under pressure* (Supporting Information 2), has a ‘high’ desirability for employers, however for content the food sciences program is categorized as ‘medium’, and for the nutrition and food sciences program, ‘low’ (although only 0.4 from achieving medium score of 6.6), the difference arising from core module content (see methods). Student perception is ‘medium’. With this particular *element* the reviewing team believed there was appreciable opportunity to practice *working under pressure* during broader degree study and this is supported by comments in the graduate survey,

> *“Again working under pressure with many deadlines/exams at once [at] university is, by nature, a stressful environment and encourages you to thrive under pressure.”*

> *“Having short deadlines (restricted in the time you can spend on something) was uncomfortable and therefore helped develop this a lot.”*

Comments about inclusion in specific modules by graduates and conveners noted development of *working under pressure,* referenced, the ‘Research Project’ module but it was not formally stated in associated module information, so currently only implicit. Consideration of other priority elements used same approach.

Considering *element*s with ‘low’ student perception of inclusion of an *element* compared to program content scoring (Table 5), a contributory factor was impact of minor program development causing variation in the student experience for each cohort (survey undertaken with graduates of 2015, 2016 and 2017). However it should also be noted the process of explicitly highlighting to students exactly where they are developing employability competencies within study has been limited in the past.

An action plan was constructed with the following classifications:

- Communication to students where specific elements are not intrinsic to a food science program (as outlined earlier).
- Minor amendments to module material.
- Consideration of new program content.
- Opportunities to make existing competency development more explicit.
- Broader or longer-term activities.

Minor amendments to module material

Throughout the module mapping exercise, there were inclusions of ‘informal’ items debated in the one-to-one sessions (see Table 2). These included activities or sessions that were routinely incorporated into a module, but not made explicit to the student in documentation or timetables provided. An example would be *working under pressure* (Supporting Information 2), which is commonly experienced and thus challenged during undertaking the final year Research Project module. It would therefore be expected that this development opportunity is explicit. However, currently it is not included in a LO (a possible suggestion could be, ‘you will be more confident in handling work pressure’) or included in the more expansive module support information given to students. It was suggested in some circumstances, the module convener should modify module documentation to ‘formalize’ the inclusion of an *element*. It was agreed this minor amendment to be a reasonably effected in the coming academic year.

Consideration of new program content

In some cases it was thought more appropriate to increase program content of a particular *element* to match employer's desirability; the most appropriate modules or year of study were selected for attention. This could be achieved by inclusion of taught, learned or assessed components. As a result of the outcomes of the study, consideration has been made whether it was possible to traditionally 'teach' (Vinten et al., 2016) certain *element*s either generally or in the context of food science degree study. It is appreciated, there may be difficulty in adding formal developmental inclusions of *element*s such as *personable*, preventing improvements in mapping scores. However some elements, including *resilience,* may be formally included by alternative or active forms of teaching inclusions (Bhattachaya, 2013)().

Whilst *working under pressure* and *resilience* have been confirmed desirable professional competencies for a graduate to possess, the reviewing team suggested they would be equally as useful during undergraduate study. It was agreed there could be a relationship between the two *element*s when considering development strategies. Occasions for development may be most useful in the early stages of study. As such a short workshop centered on concept mapping (Anthoney et al., 2017) for newly arrived undergraduate 'Freshers' commenced in September 2018. With support from health promotion experts, it was created to discuss and foster personal resilience and an ability to handle pressure. To encourage a more open and relevant environment and to share experiences (Gallie, Felstead, Green, & Inanc, 2017), the session was led by current final year students given prior training. Feedback obtained was that first year students found the session useful especially during small table discussions, so will be repeated in 2019. Interestingly the final year students themselves commented they found the process of training and delivery affected them personally, reflecting on their own wellbeing and sharing experiences: "There are good days and bad days but there are many different ways of dealing with this" (final year student, personal communication, 2018).

Opportunities to make existing competency development more explicit

Echoing Morgan *et al.'s* (2006) assertion food science educators should emphasize development of 'success skills' (IFT) both throughout the curriculum and in extracurricular activities, this study provided and informed foundation to deliver a clear message to UoN students. A summary one page matrix or 'passport' for each degree program, confirming where *elements* are included in core module content, has been constructed, initially issued to those completing degree study in June 2018. Subsequently it has been presented to students at earlier stages of their studies (in particular at the start of each academic year) to encourage real-time understanding on their competency development instead of retrospective. Informal feedback to date has been positive and the passports are integrating well into program rhetoric.

Broader and longer-term activities have been integrated into teaching strategy. Endeavors already commenced for inclusion of CFGC into careers education and degree teaching at UoN and other HEIs, are intended to progress and reflections published in due course.

Discussion

The aim of the case study, to establish with some level of quantification the developmental opportunities of CFGC within UoN curricula was accomplished. Outcomes confirmed a significant proportion of *elements* were encompassed in program curricula at a commensurate level to industry desirability and registered, as included in their course by students after graduation. This generated confidence in the applicability of the programs in developing relevant professional competencies in food science students and provided a foundation for planning future curricular developments. Exploring the outcomes of four studies mapping against the current USA-based IFT standard, one is looking for desirable competencies by industry (Morgan et al., 2006), whilst three others search for gaps in program content (Bohlscheid & Clark, 2012; Johnston et al., 2014; Joyner, 2016b). All three studies are based at differing institutes and some data gathered from older alumni (Bohlscheid & Clark, 2012), so data cannot be accurately compared, only inferred. However, Morgan *et al.* (2006) suggest a high requirement for 'critical thinking' (and general problem solving skills), and 'professionalism', with some corresponding gaps found in development opportunities of these competencies in the three other IFT-based investigations. A relatively high desirability for 'handling multiple tasks and pressures' was also noted. Comparison with CFGC notes that for *critical thinking, decision making* and *professionalism,* (all having 'medium' employer desirability) they meet or exceed 'medium' scoring in program content and student perception. For *working under pressure*, this is considered 'high' in desirability and as highlighted earlier, does not yet have the equivalent level of program content at UoN, so action plans are in place to address this. Other possible gaps from the IFT studies were 'communication' and 'group dynamics', neither a current concern in UoN program provision, supported largely by the problem based learning and product development modules at UoN.

As part of the Europe-wide ISEKI projects, a survey conducted by (Flynn et al., 2017) suggested students were satisfied with their 'training' in 'working with others' and 'being responsible', and more so than training in 'solving problems', 'communication' and 'positive attitude'. Wording used in ISEKI 'soft skills' are not directly comparable to CFGC but similarity can appraised. It is estimated against CFGC using terms provided, that 17 of the *elements* are encompassed in the detail of ISEKI 'soft skills'. From these only one*, cultural sensitivity* was considered at UoN, low in program content and student perception (Table 5).

The rest are all categorized as ‘high’ or ‘medium’ in UoN programs (Supporting Information 1), Understanding the challenge in direct comparison, it appears ISEKI ‘soft skills’ are embraced in UoN program content and well regarded by students for inclusion levels.

The reflections are based on minimal literature, so there are limitations to any inferences made; however this further emphasizes the need for more work in the field and justification for development of the CFGC framework.

Strengths and limitations of the study

It is appreciated that discrete curriculum mapping has its limitations; this type of activity is a snapshot of events and thus, future developments are not captured (Bath et al., 2004). Module conveners were asked to inform the researcher of any future changes, to allow simple amendment to a module, for cascading into program results. Undertaking a repeat mapping activity in perhaps three years’ time may also be prudent to capture all changes cohesively.

With respect to the codebook used, whilst agreed the definition used for ‘learned’ was suitable, the term itself required examination reflecting on previous studies (Harden, 2001; Kelley et al., 2008).. The proposal was to replace ‘learned’ with the term ‘practiced’ in future, and therefore use categories ‘TPA,’, employing the same definitions.

Module mapping was evidenced using documentation and one-to-one interviews with staff and participation was notably supportive to the venture (Joyner 2016a). Observational audits (Arafeh, 2016; Hege, Siebeck, & Fischer, 2007) were not included, however effectiveness of inclusion was aimed to be captured by gathering student perception as an alternative.

As described earlier, the method of quantifying levels of inclusion of an *element* in a module was drawn from characteristics of a selection of past mapping activities. No universal scoring system for curricula quantification is available for reference, so past practitioners have also developed a ‘tailored’ method that is appropriate and sensible for their context. Such an approach was taken whilst gathering information on classification of student feedback and employers desirability of *element*s and is thus considered suitable. In consequence the approach used for the study may not be applicable for studies with other aims or circumstances. However credibility and contextual transferability of study could be evaluated by repeating the mapping exercise at another food science degree provider.

When mapping, data was discrete to each module and consideration of sequential growth of a competency was not made. This is contrary to some approaches where levels of competency are layered through a program from ‘introductory’ to ‘mastery’ (Joyner, 2016b; Morgan et al., 2006), or the learning trajectory tracked in some form (Wijngaards-de Meij & Merx, 2018). Discrete module mapping in this study allows flexibility for any future change, but prevented this opportunity. However, the mapping program content score could provide an indirect measure of the amount of opportunity to master competence in each *element.*

Graduate outcome surveys can be used to check delivery of learning outcomes or degree standards (Bohlscheid & Clark, 2012) and also indicate possible curricula drift. As alumni had graduated 6 or 18 months before the date of the first surveys in spring 2017, the a risk of recall bias (Ramia et al., 2016), was understood but unavoidable factor for this study. For graduates of 2017, survey participation was at the point of graduation (and will be in future years). Surveys sought participant’s perception and therefore not factual data (Bath et al., 2004), and each cohort will receive a slightly different experience in content and experience. It was reassuring to find limited use of ‘don’t know’ responses (though more in 2017 cohort) and otherwise, little difference between data from the three cohorts was found.

Capturing the viewpoints of students during the course of their study, rather than on graduation may be of interest to validate the effectiveness of inclusion, mindful of risk of collecting short-term recitation of any signposting provided by academics. Alternative types of validation methods to surveys could be considered, perhaps in-depth reviews or discussions. Finally, it is worthwhile considering whether the stated ‘inclusion’ of an *element* in a module is effective in creating a useful and recognizable development opportunity for the student.

The use of a well-designed software system for recording mapped data would be ideal, however the spreadsheet report served adequately in terms of accuracy and visual impact with color coding. Overall the team involved in the case study were generally satisfied with the process undertaken for curriculum mapping and opportunities for further debate in review consolidation sessions.

With regard to reviews how results are integrated into actions, where gaps are found within core content that cannot necessarily be ‘taught’ in as noted earlier, limitations in the effectiveness of ‘signposting’ to motivate students to undertaken any self-directed development are appreciated.

Finally as outlined in earlier work (Weston, 2020), future work is advisable to understand if employers’ requirements for graduates change and thus the alter the dynamics of the mapping criteria. Whilst it is informally understood students from both programs enter a full range of the future graduate roles outlined in CFGC, it may be prudent to examine destinations of each cohort and perhaps reflect this in desirable elements for each program.

Conclusion

The mapping of food sciences programs at UoN as a case study has been undertaken in a thorough and contextual way. Methodology developed served to provide satisfactory quantification for effective review of curricula against the standards used. Inclusion of a number of perspectives aside from documentary inspection and ensuring clarity of criteria used is recommended for those undertaking a similar venture. Approaching the question of curriculum suitability by combining structured mapping with relative industry desirability and graduate reflections has been worthwhile and to be recommended for future consideration. Results indicate that curricula provide the majority of employer's requirements with respect to CFGC. Immediate work focused on completion of the action plan to address specific areas of imbalance. Looking longer term, the influence of the hidden curriculum and optional year-long placement is hoped to be considered. It is also recommended that a similar mapping process be undertaken at another HEI for comparison purposes.

There are no previous studies undertaken to inspect or review food science degree curricula for inclusion of employability-based competencies in the UK. However mapping results from this case study appear to suggest both programs tend to provide an encouraging level of opportunities for students to develop professional competencies desirable in the workplace and thus fit for purpose. Initial endeavors to cultivate student understanding of in-program developmental opportunities such as the use of the passport are to be recommended for other institutes to consider.

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Author Contributions (required for *JFS* original research manuscripts)

Emma Weston and Maria Benlloch-Tinoco were responsible for the design, execution and presentation of results for the project and drafted the manuscript. Fiona McCullough and Liz Mossop contributed to terminology and categorization design, in addition to manuscript revision. Tim Foster has contributed to interpretation of results, execution of developments and manuscript revision.

Nomenclature or Appendix

N/A.

Supplemental Information – 2 of

Title

Supporting Information 1 - Extract of curriculum mapping outcome report 2018.

Supporting Information 2 - Example of data collated to review an imbalanced *element* in the curriculum mapping study (2018).

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LIST of CAPTIONS FOR TABLES AND FIGURES

Tables *All attached as excel files*

Table 1 - Initial categories or codebook used for mapping *elements* to modules in the study.

Table 2 - Scoring applied for quantifiying inclusion of an *element* in a module.

Table 3 - Method of differentiating scores for an element dependent on program content.

Table 4 - The 22 *elements* agreed being developed by wider food science program study by reviewing team.

Table 5 - Overview of imbalanced *elements* from the curriculum mapping exercise.

Figures *All attached as TIFF or pdf files*

Figure 1 - Approach taken for curriculum mapping in the study.

Figure 2 - Illustration of question utilized in survey issued to students graduating in spring 2017. The ‘more info’ icon is expanded in this screenshot to display scale label definitions.

END
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