Evaluation of core competencies for food science graduates

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In September 2019 a roundtable organised by AIFST was assembled that included representatives from ten Australian universities, one TAFE, nine food companies, and one government body to discuss competencies for food science graduates in Australia. Questions discussed included the following: Are the threshold learning outcomes from our food science degrees being achieved? Are our students getting adequate scientific training and professional skills to develop into competent food scientists? What are the attributes that industry looks for in our graduates and are our degrees fulfilling these requirements? More information regarding the drivers for this initiative, including the continual need to attract and train highly qualified food scientists in Australia, and the need for a clear understanding of what food science programs should teach, can be found in a previous edition of *food australia*.[1]

An outcome of this discussion was the desire to survey food industry representatives, and other organisations that employ food scientists/technologists, on the value of various core competencies. The Institute for Food Technologists (IFT) provide a list of core competencies that are used to evaluate and approve undergraduate food science programs in the USA and internationally. These were adapted for incorporation into the AIFST survey. The competencies fall into five main areas: (1) food chemistry and analysis, (2) food safety and microbiology, (3) food processing and engineering, (4) applied food science, and (5) success skills. This list of core competencies was last updated by the IFT in 2001 (Note: recent revisions to these standards have been carried out by IFT[2]). The AIFST survey included several additional graduate attributes, in view of changes in the food industry over the past 20 years, and considering Australia has a food industry more dominated by small and medium enterprise businesses than the USA.

Despite good intentions in 2019, the pandemic delayed the finalisation and release of the survey, which occurred in July 2022. At least 62 responses were obtained for the questions evaluating the importance of the IFT competencies, and at least 58 responses for the additional questions regarding food science and technology graduate skills or knowledge. Most participants were from private industry (65%), followed by the government/public sector (18%). Participants were affiliated with organisations that frequently operated in Australia and internationally (49%), or in Australia only (47%). Many of the organisations host interns or placement students (42%), and most experience difficulties in recruiting scientists/technologists (58%). Just over half the survey participants indicated they would be interested in collaborating with academics at various universities in developing better educated and experienced graduates.

Response to the IFT core competencies

Participants were asked to rate the importance of most of the individual IFT core competencies as essential, desirable, or not important. Numerical scores were applied (essential, 2; desirable, 1; not essential, 0) to enable quantitative analysis and relative comparisons between competencies. The higher the number (between 0 and 2), the more important the competency was regarded. The results (mean 3 standard deviation) for each competency are shown in Table 1.

Of the 42 core competencies evaluated in this survey, only 2 were identified as being less than desirable (i.e., had an average score <1). This indicates that the survey participants saw the majority of the IFT core competencies as being desirable in food science graduates. The IFT use these core competencies and several other factors (e.g., staffing/expertise) to evaluate and certify food science programs at universities in the USA and several other countries, including Australia. The results of this survey suggest that these core competencies can continue to be used by universities in Australia to assist in the development of new programs in food science, or reviewing, or redesigning current offerings. This paper will briefly explore the competencies which had the lowest and highest scores.

The lowest ranked core competency was "*be able to use the mass and energy balances for a given food process*" (0.77 rating) which is perhaps a skill that is not expected of food scientists, but rather food engineers. In agreement with this, ratings of other food engineering principles including "*know the transport processes and unit operations in food processing as demonstrated both conceptually and in practical laboratory settings*" and "*know the unit operations required to produce a given food product*" were also not very high, with averages of 1.03 and 1.06, respectively. The second lowest scoring competency was "*utilise laboratory techniques to identify microorganisms in foods*" (0.94 rating). This may reflect the common outsourcing of microbiological testing to specialised testing service labs for various reasons (e.g., cost, speed, infrastructure limitations). Interestingly, the average score for the equivalent food chemistry technical skills competency "*use the laboratory techniques common to basic and applied food chemistry*" was high (1.31 rating). It is possible the low scoring microbiology competency was due in part due to referring to a higher-level skill set (i.e., identifying microorganisms), rather than general food microbiology laboratory skills.

The three highest scoring core competencies were "*commit to the highest standards of professional integrity and ethical values*" (1.92 rating), "*teamwork - work effectively with others" (1.90 rating) and "ability to work to a timeline*" (1.86 rating). These competencies were all from the success skills category, which had 9 out of 15 competencies that also scored very highly (≥1.73 rating). An area of increased focus at universities is work-integrated learning (WIL) and career development initiatives which contribute to the development of success skills. A Universities Australia report[3] identified 4 main categories of WIL present in universities which covered 1) placements – where students spend time in a workplace, such as an internship; 2) projects – an activity designed with and for employers, such as client-assigned projects; 3) fieldwork – learning activities that occur off campus and in person, such as factory site visits to determine manufacturing process flow diagrams; and 4) simulations – where a student experiences all the attributes of a placement or workplace task in a university setting, such as more recently development of Product Information Forms (PIFs) using the same platforms as industry.

Further examples of preparation for WIL include compulsory academic integrity modules for new students, group-based activities and assessments, and deadlines for assessments. In addition, some universities have food science student societies/clubs, which further assist in building many of these success skills. The results of this survey suggest there should be a strong focus on developing and assessing the attainment of success skills in food science/technology teaching programs.

Outside of the success skills category, the next three highest scoring competencies all relate to food safety ("*Know the principles that make a food product safe for consumption*" (1.84 rating), "*Know the basic principles and practices of cleaning and sanitation in food processing operations*" (1.78 rating), and "*Identify the conditions under which the important pathogens are commonly inactivated, killed or made harmless in foods*" (1.78). Having graduates well trained in food safety systems and understanding how pathogens are controlled is critically important to maintaining Australia's precious safe food reputation.

An interesting and similar study carried out in 2006 by researchers from Purdue University involved 28 respondents from industry that also evaluated the importance of the IFT core competencies for food science graduates.[4] There was a high level of correlation between their findings and the AIFST survey, with remarkable consistency in terms of which competencies received high and low ratings. Given that the roles of food scientists are relatively similar in different countries, having a qualification that meets these core competencies would prepare graduates for an exciting career that could take them anywhere in the world.

Evaluation of additional knowledge and skills

The respondents were also asked to rate 23 knowledge or skill attributes for graduates, in addition to the IFT core competencies. These additional attributes were more specific and/

Table 1. *Evaluation of the importance of IFT core competencies for food science graduates on a 3 point scale. At least 62 responses were provided for each competency.*

IFT core competencies in Food Science		Average score* (n=62+)	SD
Food chemistry and analysis	Know the chemistry underlying the properties and reactions of various food components	1.54	0.59
	Have sufficient knowledge of food chemistry to control reactions in foods	1.47	0.62
	Know the major chemical reactions that limit shelf life of foods	1.57	0.61
	Use the laboratory techniques common to basic and applied food chemistry	1.31	0.73
Food safety and microbiology	Identify the important pathogens and spoilage microorganisms in foods and the conditions under which they will grow	1.70	0.52
	Identify the conditions under which the important pathogens are commonly inactivated, killed or made harmless in foods	1.78	0.49
	Utilize laboratory techniques to identify microorganisms in foods	0.94	0.73
	Know the principles involving food preservation via fermentation processes	1.16	0.74
	Know the role and significance of microbial inactivation, adaptation and environmental factors (i.e., water activity, pH, temperature) on growth and response of microorganisms in various environments	1.63	0.55
	Identify the conditions, including sanitation practices, under which the important pathogens and spoilage microorganisms are commonly inactivated, killed or made harmless in foods	1.72	0.52
Food processing and engineering	Know the source and variability of raw food material and their impact on food processing operations	1.52	0.56
	Know the spoilage and deterioration mechanisms in foods and methods to control deterioration and spoilage.	1.63	0.58
	Know the principles that make a food product safe for consumption	1.84	0.41
	Know the transport processes and unit operations in food processing.	1.03	0.67
	Be able to use the mass and energy balances for a given food process.	0.77	0.66
	Know the unit operations required to produce a given food product.	1.06	0.69
	Know the principles and current practices of processing techniques and the effects of processing parameters on product quality.	1.41	0.59
	Know the properties and uses of various packaging materials.	1.20	0.57
	Know the basic principles and practices of cleaning and sanitation in food processing operations.	1.78	0.45
	Know the requirements for water utilization and waste management in food and food processing.	1.11	0.62
Applied food science	Be able to apply and incorporate the principles of food science in practical, real-world situations and problem.	1.76	0.47
	To solve food science problems and produce reports and presentations.	1.63	0.58
	Be able to apply statistical principles to food science applications.	1.17	0.68
	Be able to apply the principles of food science to assure the quality of food products.	1.64	0.60
	Know the basic principles of sensory analysis	1.41	0.68
	Be aware of current topics of importance to the food industry.	1.49	0.54
	Know government regulations required for the manufacture and sale of food products.	1.72	0.49
Success skills	Demonstrate the use and practice of different levels of oral and written communication skills. This includes such skills as writing technical reports, letters and memos; communicating technical information to a non-technical audience; and making formal and informal presentations.	1.83	0.42
	Be able to develop a process for solving and preventing re occurrences of ill-defined problems; know how to use library and internet resources to search for quality information, and solve a problem; and make thoughtful recommendations.	1.78	0.46
	Apply critical thinking skills to new situations.	1.83	0.42
	Commit to the highest standards of professional integrity and ethical values.	1.92	0.27
	Work and/or interact with individuals from diverse cultures.	1.83	0.38
	Demonstrate the need for and have a plan to continually educate oneself.	1.47	0.56
	Teamwork - work effectively with others	1.90	0.30
	Provide leadership in a variety of situations.	1.47	0.53
	Deal with individual and/or group conflict.	1.56	0.56
	Independently research scientific information.	1.60	0.58
	Competently use all forms of information resources.	1.44	0.53
	Ability to work to a timeline.	1.86	0.35
	Know how to facilitate group projects.	1.44	0.59
	Know how to be a good team member.	1.84	0.37
	Handle multiple tasks and pressures.	1.73	0.45

*Scale: 0=unnecessary; 1=desirable; 2=essential.

or have grown in importance since 2001. Participants were asked to rank the importance of the attributes on a 5-point Likert scale (0, not at all important to 5, essential) (Table 2).

Only 4 items had an average rating above 3 (very important). These were "*food safety and quality systems*" (3.17 rating), "*allergen management*" (3.11 rating), "*working in multi-function teams*" (3.08 rating) and "state, national and international regulations" (3.03). Apart from allergen management, the other items (food safety/quality, teamwork, and food regulation) had similarities to IFT core competencies that also scored highly, as mentioned above (Table 1). Allergen management has clearly grown in prominence in the past 20 years. It is now a major activity in the food industry and should be considered as a core competency for food science graduates in the future.

All but three items had an average score above 2 (moderately important). The three lowest scoring items were "*entrepreneurship*" (1.38 rating), "*marketing*" (1.49 rating), and "*finance*" (1.57 rating). Entrepreneurship would perhaps have a higher rating of importance in smaller start-up companies rather than established businesses, while finance and marketing are typically separate divisions in organisations.

Table 2. *Evaluation of the importance of specific knowledge or skills in various areas using a 5-point Likert scale. At least 58 responses were provided for each item.*

Importance of specific knowledge/skills in:	**Average score* (n=58+)**	**SD**
Industry experience (work experience)	2.56	1.10
Occupational health and safety	2.54	1.15
Desktop research	2.03	0.97
Entrepreneurship	1.38	0.99
Negotiation	2.07	0.95
Working in multi-function teams	3.08	1.04
New product development	2.26	1.18
Sustainability and environmental impact of food production	2.11	1.10
Waste reduction	2.07	1.14
Allergen management	3.11	1.03
Nutrition and health	2.41	1.12
Functional food	2.07	1.01
State, national and international regulations	3.03	1.00
Global food trends	2.15	0.96
Food traceability	2.86	1.21
Understanding food fraud (prevention, avoidance and impacts)	2.51	1.15
Finance	1.57	0.94
Marketing	1.49	0.98
Understanding of ingredients	2.93	1.12
Raw material procurement and supply	2.18	1.13
Analytical testing and analysis	2.41	1.05
Research and development	2.31	1.22
Food safety and quality systems	3.17	0.99

*Scale: 0= not at all important; 1 = slightly important; 2 = modestly important; 3 = very important; 4 = essential.

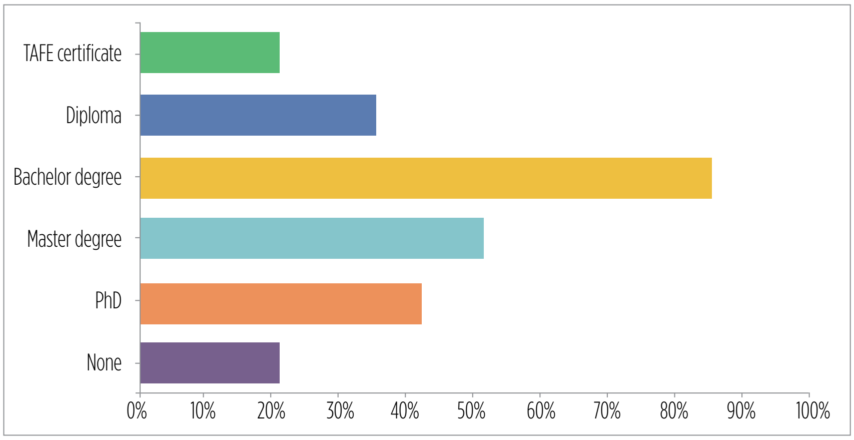

Figure 1: *Types of degree qualifications that employees have in the surveyed organisations.*

Open-ended questions

Types of graduates hired by food industry organisations

Food industry and associated business/entity employers have particular qualifications for their earliest career employees. Out of 76 respondents, >80% highlighted they employ graduates with a Bachelor's degree at their organisation. Around 35-50% of respondents hired graduates with Diploma, Masters or PhD qualifications, suggesting a broad mix of qualifications in employed graduates (Figure 1).

The reasoning for particular qualifications required for graduate employees for many of the organisations tied to specific minimum requirements for the positions being filled, however employer preference also influenced some responses, for example:

- "*These are the minimum essential requirements*" (referring to Diploma and Bachelor's degree qualifications)
- "*In some cases, the positions with the organisation require specific minimum requirements (e.g., eligible for appointment as an*

Authorised Officer under the Food Act 2001..."
- "*Diploma students are far more real world trained. As they have come from a competency-based education, they have the physical skills already learned. Often uni graduates are theory based with no real-world skills or knowledge and often their educators have not worked in the food industry itself...*"
- "*Company policy for minimum qualification in technical role*"
- "*Need to at least a degree for the level of work needed*"
- "*As required for specific positions in R&D and manufacturing*".

It was also acknowledged that higher qualifications are valuable for R&D based roles, but not necessarily needed to enter the industry, for example;

- "*Research and development based and tend to require some level of higher education and expertise*"
- "*We always look for someone degree qualified, preferably with some manufacturing experience. For our scientists, they generally have or are in the process of having a PHD(sic)*"

Collaboration between training institutions and industry

For graduates to be appropriately qualified and experienced upon entering the food industry, placements and graduate programs provide valuable learning experiences that can complement the knowledge gained through a formal qualification. Employers prefer their new employees to have some experience and exposure to the workplace, but despite this desire, when questioned about whether they take placement students, nearly 60% of survey respondents (n=65) do not take internship or placement students.

When delving into the reasoning for this type of response, those who did take internship students typically trained them for 3,6, or 12month placements. For some respondents who did not take internship or placement students, they mentioned it takes extra resourcing (budget and time) to be able to train placement students, which was not possible in their organisation. One respondent mentioned they "*Have tried to in the past but no suitable pathway mechanism to engage with university anymore*", however many universities do have work placement courses with a staff member as the main point of contact. One added complication is that students may also already be employed part-time, or full-time in another job while completing their studies.

A related question, >70% of respondents (n=63) indicated that they do not have a graduate program, with resourcing again being one of the main hurdles (budget and time) to accommodating such a program. This is a challenge that can affect experience levels for students if they cannot undertake placement prior to graduation.

For appropriately experienced graduates to enter the workforce it is beneficial for industry and university to work together and co-design internship programs that benefit both the workplace and the placement student. When this is done well, students may be permanently employed by the organisation hosting their internship or placement.

As a case study, one of the authors based at the University of Southern Queensland (UniSQ) has worked since 2018 with each industry contact that has hosted UniSQ students to develop tailored internship programs (if needed) that meet work placement course requirements, adhere to Fair Work Act and optimise staff time spent on training. Some mechanisms for industry to stay connected with university programs involve guest lectures, project mentorship, suggested assessment to solve a business problem etc. In this way industry members can interact with students while they are still studying and gauge their potential abilities before considering taking on a placement student.

Ideally placements are compensated, however due to limited resources and size of organisations, this may not always be possible. To develop a placement program for unpaid placements, at UniSQ, this involved students working for 2-3 days per week for 12 weeks and undertaking a semi-structured program which encompassed approximately 4 weeks as general rotation and understanding the business activities, 4 weeks in New Product Development and 4 weeks in Quality Assurance. The part-time nature of the placement ensured that host staff had less time spent monitoring internship students but also meant that the students have exposure to different work types within the business. In several instances, due to being a competent known entity, the student was then hired as a graduate employee upon completing their placement.

The AIFST are planning to build further on this work to assist the education and training of industry ready food science graduates in Australia. To register your interest to be involved, please contact education@aifst.com.au.

Limitations of this study

All questions had at least 58 responses, however this is unlikely to provide a broad enough representation of the Australian food industry. Food scientists undertake diverse roles and there may be bias from the participant completing the survey who is focussed on a specific role (e.g. food quality control).

Acknowledgements

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