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Integrating food literacy and food numeracy across the Australian secondary curriculum

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Abstract

Aim: The alarming rise of poor dietary behaviours among adolescents and the consequential health, economic and environmental concerns associated with these behaviours have been well established in the literature. Given that schools are recognised as primary centres for acquiring life skills and establishing healthful behaviours, the focus of this paper is on strengthening food literacy and food numeracy across the Australian secondary curriculum. Accordingly, this paper aims to:

a) provide an overview of the definition, application and contribution of food literacy to adolescents' healthful behaviours
b) introduce food numeracy and its anticipated contribution to adolescents' healthful behaviours
c) introduce the term 'integration capacity of curriculum'
d) identify the barriers and enablers to incorporating food literacy and food numeracy into Australian secondary schools, and categorise these into the three components of a Health Promoting School Framework
e) discuss the possibilities for integration of food literacy and food numeracy across the entire secondary-school curriculum.

Methods: Methodologically, all relevant primary and grey literature sourced from digital databases and based on selected key terms has been studied.

Results: The scope and potential contributions of food literacy and food numeracy to adolescents' dietary behaviours have been described; the integration capacity of a range of subjects in the Australian curriculum has been tabulated; and enablers and barriers to the integration of food literacy and food numeracy into the curriculum have been elaborated on.

Conclusions: If food literacy and food numeracy are to be an integral part of the secondary-school curriculum with a goal of improving both adolescent and planetary food-related health, then an effective model for food literacy and food numeracy that is supported by the education sector at all levels of decision-making is required.

Keywords: adolescents, food literacy, food numeracy, nutrition education, secondary schools

Introduction

Adolescent diet-related health

The alarming rates of overweight and obesity among adolescents have caused global concerns. The World Health Organization (2004) has made a call to action to address this epidemic, which has resulted in serious health complications such as high blood pressure and high cholesterol (two risk factors for coronary heart disease), type 2 diabetes, and psychological disorders (for example, disordered eating and emotional disturbances). Adolescents' obesity can be attributed to a combination of factors. However, poor dietary intakes, lifestyle choices and socio-economic status play major roles (Stanford Children's Health, 2020).

In Australia, the Australian Institute of Health and Welfare (AIHW, 2018) reported that in 2011–12, 29 per cent of children and adolescents aged 9–13 years and 30 per cent of adolescents aged 14–18 years were considered overweight or obese. These figures are congruent with the latest *Schools Physical Activity and Nutrition Survey* (Hardy et al., 2016), which reported the rate of obesity and overweight among adolescents from low socio-economic status and non-English speaking backgrounds at 32 per cent and 41 per cent, respectively. Tables 1, 2 and 3 show the poor dietary intakes among Australians aged 12–18 years.

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Table 1. Proportion of adolescents meeting daily recommended serves of food groups* by gender and age, 2011–2012

Food group	Aged 12–13 yrs		Aged 14–18 yrs	
	Girls	Boys	Girls	Boys
Fruits	34.1%	33.9%	28.2%	25.7%
Vegetables, legumes/beans	0.4%	0.4%	0.7%	0.5%
Milk, cheese, yoghurt and alternatives	1.8%	3.9%	0.5%	2.5%
Lean meats and alternatives	0.7%	4.2%	1.4%	14.9%
Grain (cereal) foods	26.7%	34.9%	4.6%	22.8%

* As recommended by the National Health and Medical Research Council (2013).
Source: Australian Bureau of Statistics (2017).

Table 2. Proportion of adolescents with inadequate nutrient intakes by gender and age

	Age 12–13 yrs		Age 14–18 yrs	
	Girls	Boys	Girls	Boys
Calcium	84.4%	67%	90.3%	71%
Iron	11%	3%	40%	8%

Source: Based on Australian Institute of Health and Welfare (2018) material.

Table 3. Source of total energy intake for adolescents by age

Source of energy	Age 12–13 yrs	Age 14–18 yrs
Discretionary foods	40%	41%
Added sugars Recommendation <10%*	12%	13%
Saturated and trans fats Recommendation of no more than 10%**	14%	13%

* World Health Organization (2020)
** National Health and Medical Research Council and New Zealand Ministry of Health (2006)
Source: Based on Australian Institute of Health and Welfare (2018) material.

> *Countries should consider increased investment in school health and nutrition programmes*

Research has also established a potential correlation between poor dietary intakes and the increasing rate of mental-health concerns among this age group. For instance, Kulkarni et al., (2015) showed an association between quality of diets and mental health among socially disadvantaged New Zealand adolescents (mental-health score was raised by five points in adolescents consuming healthy diets).

Consequently, the rise in both obesity and mental-health concerns, and their associated detrimental impacts on health, the economy and the environment, necessitate improving adolescents' dietary intakes through enhancing their knowledge and skills in food-related studies. Accordingly, this paper investigates the potential impact of strengthening 'food literacy' and 'food numeracy', as two umbrella terms for agriculture, food and nutrition education in secondary schools. This approach is in line with the World Health Organization's (2019) recent statement which states that 'schools are excellent environments in which to address the double burden of malnutrition and install good dietary habits, and to reach the growing market of young people with increasing economic power and influence them to avoid the consumption of foods and beverages high in sugars, fats and salt. Countries should consider increased investment in school health and nutrition programmes' (World Health Organization, 2019, p. 8).

Food literacy

Food literacy has been defined in the literature as 'scaffolding that empowers individuals, households, communities or nations to protect diet quality through change and strengthen dietary resilience over time. It is composed of a collection of interrelated knowledge, skills and behaviours required to plan, manage, select, prepare and eat food to meet needs and determine intake' (Vidgen & Gallegos, 2014, p. 54). Or, as Vidgen and Gallegos (2014) go on to say, this can simply be interpreted as the tools needed for a healthy lifelong relationship with food. Vidgen (2014) further identified four focus areas of food literacy, namely, food

> *Incorporating health-promoting pedagogical approaches into the school curriculum … must address the three components of the World Health Organization Health Promoting Schools Framework*

planning and management, food selection, food preparation, and eating. Subsequently, both Fordyce-Voorham (2017) and Ronto et al. (2016b) developed food-literacy assessment tools that can be used to measure students' food skills at basic, intermediate and advanced levels.

Food numeracy

This paper introduces, for the first time, 'food numeracy' as a new umbrella term to cover numerical concepts of agriculture, food and nutrition education. It is complementary to the term 'food literacy'. Food numeracy involves the use of numerical, spatial, graphical, statistical and algebraic concepts and skills and consists of critical evaluation, interpretation, application and communication of mathematical information related to a diversity of food practices. To be food numerate is to use mathematical knowledge and skills effectively to partake of daily food requirements and be fully conscious of its value from farm to fork, with the capacity to maximise benefits to health, economy and environment (Shakeri, 2020).

The introduction of food numeracy aims to facilitate the incorporation of food-numeracy concepts (for example, understanding portion sizes, the costs of diet-related health burdens, and food budgeting) into various subjects such as Mathematics and Commerce. Additional food-numeracy concepts could include the implications of industrial-food production, the globalisation of food systems, and the impact of multinational food corporations on local food vendors (Clapp & Purugganan, 2020). The first author is in the process of developing a series of food-numeracy competencies that can be integrated and achieved across several subjects.

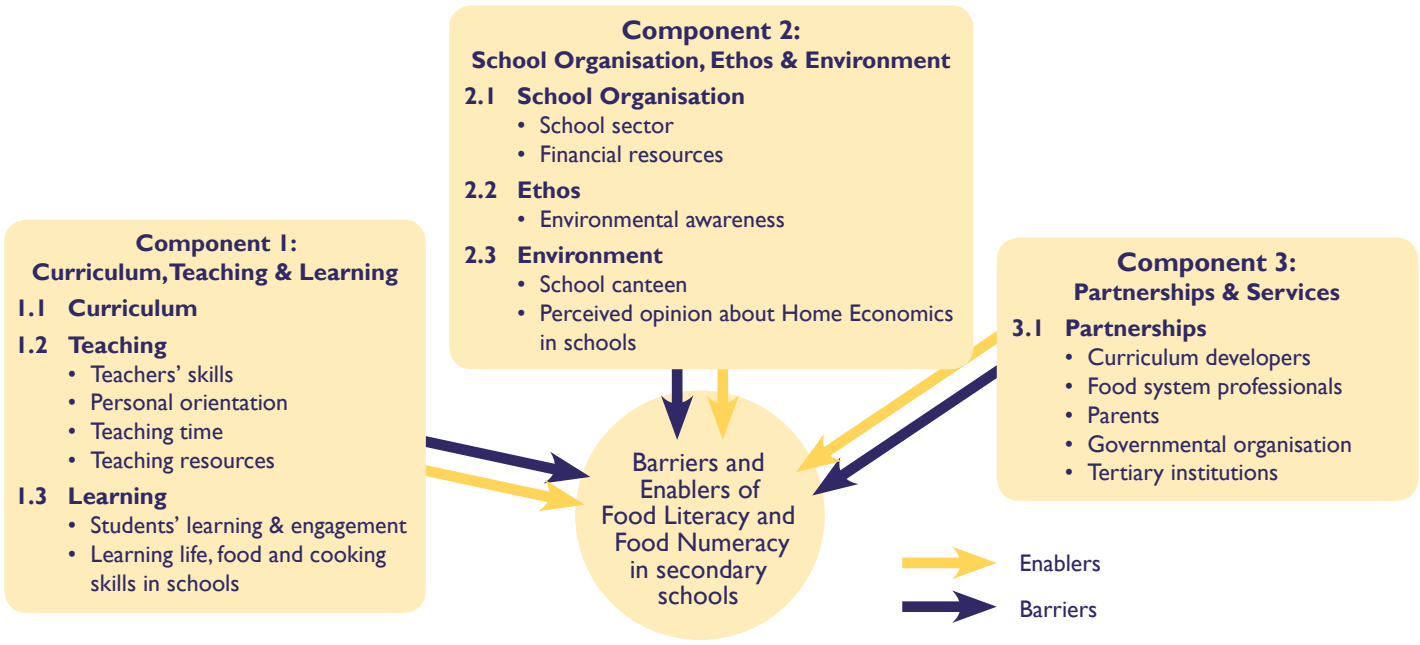
It is anticipated that, in light of current environmental, economic and health concerns, supporting students to enhance their food-numeracy competencies could facilitate further application of innovative enterprises that could enhance existing food systems in local communities. As a practical example, local school gardens could facilitate further enhancement of both food numeracy and food literacy while addressing local food-security concerns (Shakeri, 2020).

A framework for analysing the barriers and enablers to incorporating food literacy and food numeracy across the Australian secondary curriculum

Incorporating health-promoting pedagogical approaches into the school curriculum can be very complex. It is now broadly accepted that effective incorporation must address the three components of the World Health Organization Health Promoting Schools Framework (HPSF) (World Health Organization, 1996), which was introduced to provide a scaffold for the design, implementation and evaluation of pedagogical approaches for prevention of both communicable and non-communicable diseases. The three components of the HPSF are:

1) curriculum, teaching and learning
2) school organisation, ethos and environment
3) partnership and services.

Figure 1. The Health Promoting Schools Framework (World Health Organization, 1996) as a basis for identifying enablers and barriers to strengthening food literacy and food numeracy in schools



Accordingly, the identified enablers and barriers to incorporating food literacy and food numeracy into Australian secondary-school subjects have been categorised into these three components (Figure 1).

Methods

An electronic search of literature was conducted employing digital databases (EBSCO, ProQuest, Emerald Plus and Google Scholar) using the following key terms: 'food literacy', 'food numeracy', 'secondary schools', 'adolescents' and 'nutrition education'. An additional search was conducted by manually scanning the cited references and searching for authors' names that had more than one citation in relevant articles. Peer-reviewed papers with a focus on definition, application and evaluation of food literacy within secondary-school contexts were chosen; nutrition education was used as an additional key term to broaden the search.

The term food numeracy is first author's invention; a separate search was conducted for it using the above search engines, with zero results.

Concurrently, the Google search engine was used to retrieve the latest Australian health reports, Australian curriculum documents, and curriculum documents from the New South Wales Education Standards Authority website. All curriculum documents for Years 7–10, irrespective of being mandatory or elective subjects, were scanned and studied using two keywords, 'nutrition' and 'food', consecutively, and the frequencies of their appearance were recorded (see Table 4).

Additionally, in reference to their frequency, their place of appearance, and the aim of the statements in which they appeared, a 'Yes or No?' decision was made on the current capacity of each subject to integrate and enhance food literacy and food numeracy (Table 4). This resulted in the introduction of another new term, 'integration capacity', to refer to the current capacity of each subject to enhance food literacy and food numeracy.

Results

Figure 1 shows the three components of Health Promoting Schools Framework (World Health Organization, 1996) used to categorise enablers and barriers to strengthening food literacy and food numeracy. These enablers and barriers will now be elaborated on.

Component 1: Curriculum, teaching and learning

Curriculum

The *Australian Curriculum* (Australian Curriculum, Assessment and Reporting Authority, 2016) was developed to enhance educational quality and consistency across Australia whilst offering flexibility for teachers in all states and territories to tailor the recommended content to their diverse settings based on schools' demographics, students' needs, and the school sector (government, independent or Catholic). The *Australian Curriculum* consists of eight learning areas (English, Mathematics, Science, Humanities and Social Sciences, Arts, Technologies, Health and Physical Education, and Languages); seven general capabilities (Literacy, Numeracy, Information and Communication Technology, Critical and Creative Thinking, Personal and Social Capability, Ethical Understanding, and Intercultural Understanding); and three cross-curriculum priorities (Aboriginal and Torres Strait Islander Histories and Cultures, Asia and Australia's Engagement with Asia, and Sustainability), which take priority for integration across all learning areas. The learning areas most closely aligned with the study of food and nutrition are Technologies (*Food specialisations* and *Food and fibre* contexts) and Health and Physical Education (*Food and nutrition* focus area).

The *Australian Curriculum* and specifically the New South Wales (NSW) approach to the *Australian Curriculum* (NSW Education Standards Authority, 2019) was analysed to determine the enablers and barriers to enhancing food literacy and food numeracy. The literature was also interrogated to determine the potential for integrating food literacy and/or food numeracy across the curriculum.

Enablers

The integration of the knowledge component of food literacy into a range of subjects may allow adequate time for the development of food skills in those subjects that specialise in food and nutrition, such as Home Economics or Food Technology, while minimising competition and pressure from other core subjects in the curriculum (Markow et al., 2012). Similarly, food numeracy concepts could be incorporated into subjects such as Mathematics and Science. For instance, Follong et al. (2020a) examined the potential integration of nutrition education within Mathematics in Australian primary schools. They found that an integrative pedagogy could have considerable benefits for both

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> *Home economics teachers expressed their concern about the capacity of Health and Physical Education subjects to fully enhance the food-literacy competency of students*

nutritious eating and improved numeracy skills. Follong et al. (2020b) went on to investigate the impact of a teaching unit on portion-size estimation skills when nutrition is integrated within a mathematics unit involving volume and capacity. Similarly, Sörensen and Mouritsen (2019) showed the possibility of teaching science through food and cooking by examining the outcomes of two major programs, the *Science and Cooking* program at Harvard University and the Danish *Taste for Life* national program. This study concluded that these integrative programs could take place in all educational settings, inclusive of primary and secondary schools. Regardless, collaboration between all subjects which aim to enhance food literacy is considered beneficial (Ronto et al., 2016b).

Evidence suggests that a cross-curricular approach can prepare students for their future lives and career paths (Turner, 2016) and enrich their understanding of the interconnectedness of food systems in other disciplines. Integration can further facilitate several additional extracurricular activities organised by other disciplines, such as participation in food-market days and multicultural days (Ronto et al., 2016b).

In a recent study, food-system professionals displayed a consensus about the benefits of integrating nutrition and food studies topics across the entire curriculum (Sadegholvad et al., 2017b). They stated that due to time limitation, provision of a separate subject for food studies is not a priority. Based on their opinions, as a primary strategy an integrative approach would facilitate an appropriate level of food-related education, irrespective of the choice of school or subject. They also suggested implementing specific actions to improve the existing curriculum of food-related school subjects, specifically to improve the food-systems component. Their final recommendation was a call to action and collaboration between schools, educational authorities, tertiary institutions and experienced experts from different food-related disciplines. It is noteworthy that more schoolteachers than food-industry and food-system professionals highlighted the complications associated with an integrative approach (55 per cent compared to 28 per cent). Their scepticism about the feasibility of this cross-curricular approach is possibly due to the lack of familiarity of teaching personnel with this format (Sadegholvad et al., 2017b).

Based on the appearance of food and nutrition key words in the New South Wales approach to the Australian curriculum, Table 4 shows that:

- subjects closely aligned with the Technologies *Food specialisations* context (for example, *Food Technology*) have the highest integration capacity to enhance food literacy and food numeracy. This is compulsory in Years 7 and 8 and can be chosen as an elective in Years 9–12.
- subjects aligned with the Technologies *Food and fibre* context (for example, Agricultural Studies) and those aligned with the Health and Physical Education *Food and nutrition* focus area (for example, *Child Studies*, and *Personal Development, Health and Physical Education*) also have good integration capacity.

Barriers

In a 2016 study (Ronto et al., 2017), home economics teachers expressed their concern about the capacity of Health and Physical Education subjects to fully enhance the food-literacy competency of students. This is because nutrition only forms a section of this curriculum and the curriculum apparently lacks opportunities for practical food-skill development. According to the home economics teachers, practicum must accompany knowledge to accomplish a sustainable and effective change in the dietary behaviours of adolescents.

Additionally, in relation to the curriculum, a recurring theme in recent studies is the necessity to make food education/food literacy compulsory throughout secondary schooling to achieve continuous progression in food-literacy competency. This view has been echoed by members of the public (Pendergast et al., 2011), food professionals (Nanayakkara et al., 2018), home economics teachers (Ronto et al., 2017) and medically oriented researchers who have advocated for the inclusion of Home Economics as a core subject for sustainable and health-promoting curricula (Lichtenstein & Ludwig, 2010). However, curriculum overload is a major challenge for schools and teachers (Elsden-Clifton & Futter-Puati, 2015). Therefore, an area of exploration in this paper is the concept of integration of food literacy and food numeracy concepts across the entire curriculum.

As stated by some home economics teachers, caution must be practised when integrating food literacy and food numeracy across the curriculum because separation of the practicum and knowledge components of food literacy may inadvertently lead to dissemination of misguided healthy-eating messages as well as to diminishing the experiential benefit of combined knowledge and skill-based lessons (Boddy et al., 2019).

Table 4. Capacity of NSW Curriculum, Years 7–10* to integrate food literacy and food numeracy

NSW Syllabus Learning areas/subjects Years 7–10	Number of times *Nutrition* appears	Number of times *Food* appears	Integration capacity to enhance food literacy	Integration capacity to enhance food numeracy
English	0	0	No	No
Mathematics	1	3	No	Yes
Science	1	31	Yes	Yes
Technologies				
Technology Mandatory	7	80	Yes	Yes
Agricultural Technologies	4	35	Yes	Yes
Design and Technology	0	0	No	No
Food Technology	70	726	Yes	Yes
Graphics Technology	0	0	No	No
Industrial Technology	0	0	No	No
Marine and Aquaculture Technology	4	86	Yes	Yes
Textile Technology	0	0	No	No
Humanities and Social Studies (Human Society and its Environment)				
Aboriginal Studies	0	2	Yes	No
Commerce	0	5	No	Yes
Geography Elective	0	2	No	Yes
History Elective	0	0	No	No
Health and Physical Education				
Child Studies	45	33	Yes	Yes
Physical Activity and Sport Studies	33	11	Yes	Yes
Personal Development, Health and Physical Education	11	38	Yes	Yes
Creative Arts (2003 Syllabus, Course Description)				
Visual Arts, Drama, Music, Dance, Photographic and Digital Media	0	0	No	No

* NSW Education Standards Authority (2019).

Studies have indicated that the perceived opinion about food-related subjects can be a barrier to food literacy. These studies have referred to the limiting views of some school staff and executives, such as a generally dismissive attitude toward food literacy in some schools; occasional changes to administrative policies in favour of incorporating other knowledge and skills into a pressured curriculum (Markow et al., 2012); endorsing the use of some non-specialised teachers to teach Home Economics; and considering Home Economics to be non-academic (Pendergast et al., 2011; Ronto et al., 2016a).

Some studies have recommended that, while an integrative approach enables exploration of diverse aspects of food literacy through other disciplines, several factors such as students' expectations and outcomes, teacher's expertise and available resources need to be considered carefully before implementation of an integrative pedagogy (Cargill, 2015; Nanayakkara et al., 2018).

Teaching

Enablers

Time allocated to practical sessions is an often-mentioned enabler for achieving desirable outcomes in developing students' food literacy (Markow et al., 2012). Practical lessons may consist of cooking, visiting food-related establishments and inviting food-related professionals as guest speakers, all of which require sufficient time for implementation. These experiential activities complement the acquisition of food skills in schools by enriching students' cultural and social skills, which are two major components of food literacy (Fordyce-Voorham, 2011).

> "Time allocated to practical sessions is an often-mentioned enabler"

Barriers

Some teachers lack confidence in providing effective nutrition education (de Vlieger et al., 2018) and this could be a barrier to enhancing food literacy and food numeracy. This concern also exists among home economics teachers, regardless of the fact that the education authorities

> *Irrespectively, home economics teachers often express concern over the fact that some colleagues have inconsistent food-based training and goals*

in every state and territory in Australia have specific accreditation criteria for this subject. For example, in New South Wales the criterion states that the minimum discipline study for first-area teaching as Food Technology is a 'major in food areas such as dietetics, nutrition, food technology, food science inclusive of studies of the Australian food industry, food manufacture, food product development and nutrition' (NSW Education Standards Authority, 2018, p. 6). Irrespectively, home economics teachers often express concern over the fact that some colleagues have inconsistent food-based training and goals (Ronto et al., 2016a). This was believed to taint the authenticity and integrity of the intended healthy-eating message of Home Economics. This concern has been pronounced as a pivotal problem by some home economists, public health nutritionists and dietitians, who state the need for appropriately trained teachers as being a problem, along with adequate monitoring of teachers' knowledge of nutrition and food systems (Sadegholvad et al., 2017a). Further studies are required to investigate the potential for inclusion of food and nutrition education in all teaching qualifications to enhance the curriculum capacity in preparation for an all-encompassing integration and enhancement of food literacy and food numeracy.

In addition, teachers' personal orientations toward food and nutrition can influence the focus and content of their teaching, impacting food literacy and food numeracy outcomes. To illustrate, home economics teachers' personal orientation can be categorised into:

a) consumer environmentalists—who tend to focus on ethical farming practices, organic-food consumption, and shopping seasonally and locally
b) nutritionists—who tend to focus on the Australian Dietary Guidelines with an added inclination to include dietary-analysis software for dietary monitoring, food planning, budgeting and achieving nutritional value for money
c) aesthetes—who tend to focus on more traditional recipes while resisting recipe modifications and adaptations in favour of refining presentation of the final product.

Conversely, a common acknowledgement and articulation of these orientations may lead to a more complementary mode of program delivery, attracting future teachers with diverse personal orientations who are assured that their diverse needs are accommodated and their orientations are appreciated (Pendergast & Dewhurst, 2012).

Another barrier to integrating food literacy and food numeracy is the time available to cover the curriculum content for subjects such as science and languages, without also incorporating food literacy and food numeracy. Even in the Health and Physical Education learning area, time for the *Food and nutrition* focus area may be limited in preference to other components such as physical activity. In some studies, home economics teachers have stated that even in food-related subjects, sometimes time is limited as these subjects have to compete for time with subjects with more academic prestige such as mathematics and science (Ronto et al., 2017; Slater, 2013).

Online teaching resources can be both barriers and enablers. Some nutrition experts have indicated their concern over the exaggerated and misguided nutrition education broadcast by media (Sadegholvad et al., 2017a). However, the power of this resource cannot be underestimated, as it is a low-cost, direct and instant method of disseminating nutrition messages to the young with potentially positive outcomes. These digital sources have been identified to potentially increase both students' and teachers' food literacy and to enable them to distinguish between credible and non-credible messages broadcast by fast-food manufacturers (Tobey & Manore, 2014). An example is the *TEXTBITES* study project developed in 2019, which aims to improve weight and dietary behaviours in adolescents by texting research-based healthful messages (The University of Sydney, 2020). Hence, further development of research-based online teaching resources has the potential to enable integration and enhancement of food literacy and food numeracy.

Learning

Enablers

The wide range of student-centred, collaborative and consultative academic and practical learning experiences afforded by the study of food and nutrition can optimise students' learning and engagement and thus support enhancing food literacy and food numeracy. Furthermore, students' motivation toward healthy eating is optimised when they are involved in the early stages of lesson design and development, and students are able to extrapolate deep meaning from taught content (Henderson, 2018; Lee Baker, 2017). Student motivation and engagement can be further enhanced by allowing students to display their cooking abilities to their parents and peers, through taking prepared food home or participating in school food fairs (Ronto et al., 2016a).

The provision of essential life, food and cooking skills as an enabler of food literacy and food numeracy is highly regarded by all stakeholders (food experts, teachers, parents and students). Evidence shows that the acquisition of such skills in schools results in higher food-literacy competencies and is associated with longer, more healthful living (Boddy et al., 2019). This is in consideration of the growing concern about the loss of cooking skills due to modern changes in home environments, thereby making Home Economics cooking classes a necessity, particularly for young males and those from lower socio-economic demographics (Vidgen, 2014).

It is noteworthy that gender plays a pivotal role in subject selection, with females being more in favour of Home Economics compared to males. This is consistent with a recent qualitative demographic survey, which reflected that women achieved higher scores for nutrition knowledge (Sadegholvad et al., 2017a).

One study has related the acquisition of food skills to the enrichment of other life skills such as analytical, organisational and management capabilities in adolescents (Pendergast & Dewhurst, 2012). All these findings are in harmony with teachers' views that 'experiential food-skill sessions must accompany lessons based on declarative knowledge to ensure a joyful, engaging and accomplishing learning process' (Boddy et al., 2019, p.285). Various examples of the above skills include: recognition of seasonal fresh produce; developing consumer confidence in troubleshooting with anticipated cooking practices; following and interpreting basic recipe instructions; planning and preparing meals instead of relying on takeaway meals; recipe differentiation to achieve a product that meets the budgetary and nutritional requirements of consumers; proper food storage according to the best guidelines for quality preservation; and food processing techniques (Fordyce-Voorham, 2016).

Component 2: School organisation, ethos and environment

School organisation

Barriers

Research reveals the following areas of concern regarding the ability of schooling sectors to support food-literacy education in Australia:

a) inconsistencies in the school sectors' food policies and food environments, leading to incongruent outcomes for students' food literacy (Boddy et al., 2019)
b) inconsistencies in budget for activities related to food literacy, with some schools being labelled as well-resourced compared to others
c) inconsistencies in complying with guidelines for healthy canteens; public schools were more inclined to follow healthy guidelines (Ronto et al., 2016b).

Budget restrictions have been implicated as a barrier to the implementation of effective nutrition education programs (Markow et al., 2012). In a recent qualitative study, home economics teachers stated that they needed considerable financial assistance for updating teaching resources and for professional development. Teachers also highlighted that some high schools were restricted in their choice of employing professional teachers and resorted to employing unqualified staff to teach programs such as kitchen gardens at a much lower cost (Ronto, 2017). Additionally, one study revealed that it is not uncommon for funding for food education to be withdrawn in favour of other school and educational programs (Weaver-Hightower, 2011).

School ethos

Enablers

Climate-change emergency is a rapidly rising concern among adolescents that can act as an enabler for integration and enhancement of food literacy and food numeracy in schools. Enhanced food-literacy and food-numeracy education encompasses concepts such as the costs of food practices and production, ethical farming and manufacturing practices, food waste, animal welfare, foreign investment in Australian agriculture, and the rising power of multinational commercial supermarkets (Ballantyne-Brodie et al., 2013).

Environmentalists raise serious concerns over rapid population growth, increased food demand, the loss of ecosystems and reduced biodiversity, as well as higher energy expenditure on the production of ultra-processed food. These concerns are compounded by growing consumer demands for new food products, and by constant food-supply demands of the numerous retail outlets and institutions such as schools, calling for immediate government action on food-regulatory policies (Turner, 2016). The New South Wales Government has been reported as emphasising that 'education in local food production is an important priority at all ages and stages of education' (Turner, 2016, p. 18). Such exposure of students during their secondary years may result in attracting next-generation farmers and informed citizens who

> *"Experiential food-skill sessions must accompany lessons based on declarative knowledge to ensure a joyful, engaging and accomplishing learning process"*

> *One major barrier to developing food literacy was parents' negative attitude towards choosing Home Economics in favour of more academic subjects*

can think critically about the challenges of food-sustainability projects, develop social capital for local food projects, harness technology to innovate eco-friendly food choices and make sustainable long-term decisions concerning food supply. The literature acknowledges the impact of healthy and sustainable dietary behaviours on the environmental sustainability of food systems (Friel et al., 2013).

School environment

Enablers

School canteens can have an impact on the enhancement of food literacy and food numeracy by providing real-life everyday examples of healthy food options. Concerns over the nutritional quality of food provided in school canteens has been the subject of much debate over the years, resulting in some positive outcomes following the introduction of several mandated guidelines. A 2006 study identified unanimous consensus for policies that reinforce providing healthy food and beverages for all schoolchildren (Worsley, 2006). In 2008, the National Healthy School Canteens project commenced across Australia, facilitating training for canteen employees (Australian Institute of Health and Welfare, 2017).

Barriers

Despite the positives of school canteens, studies have shown that due to lack of monitoring authorities to check adherence, privately operated canteens are commonly driven by the need to make profits and students' demands, rather than the mandated guidelines. Adherence to such policies requires government authorities to monitor them regularly (Hawkes et al., 2015). In another study, the higher cost of fresh, healthier items in school canteens has been indicated as a deterrent for students to choose them (Ronto et al., 2017; Boddy et al., 2019).

Component 3: Partnerships and services

Enablers

Partnerships among curriculum developers, food-system professionals, parents, governmental organisations and tertiary institutions can be enablers of food literacy and food numeracy. A 2016 study recommended that curriculum developers, in consultation with food-system professionals and teachers, should ensure that food literacy is covered more comprehensively and broadly, with attention to both the knowledge and skill components (Ronto, 2017).

At a tertiary level, there is a growing interest by local and global university researchers in the common objective of enhancing food literacy in secondary schools. Tertiary institutions have conducted in-depth studies, and qualitative and quantitative surveys with diverse stakeholders, and have designed food-literacy models for implementation in schools.

Governmental health agencies provide valuable resources for all stakeholders and make a significant contribution to the development of nutrition interventions for schoolchildren and adolescents. For instance, in Victoria, the Healthy Eating Advisory Service is a health-promoting agency that implements strategies at state and local levels to create healthier food environments in diverse settings, including schools. Similarly, in Western Australia and the Australian Capital Territory, educators are provided with continuous training to incorporate food and nutrition in school curricula (Australian Institute of Health and Welfare, 2017).

Barriers

In a recent study it was reported that there is a lack of collaboration among schools, educational authorities, universities and experienced experts from different food-related disciplines (Sadegholvad et al., 2017b), which is impacting the development of food literacy.

With respect to parents, a 2017 study reported that it is often the low level of parents' food literacy that results in adolescents' low food literacy and high consumption of processed and packaged food (evidenced by the contents of school lunch boxes) (Ronto et al., 2017). Teachers, in particular, were dismayed by the unsupportive actions of some parents who delivered fast food to students at lunch time (Boddy et al., 2019). In a more recent study, it was established that one major barrier to developing food literacy was parents' negative attitude towards choosing Home Economics in favour of more academic subjects. Conversely, a more positive attitude was displayed by adolescents, which can elevate hopes that these young adults are beginning to realise the benefit of enhanced food literacy for a healthier future and for career options (Nanayakkara, 2018). Additionally, home economics teachers have stated that due to reduced occurrence of family mealtimes, kitchen environments in high schools need to become conducive to learning food skills and social interaction (Pendergast et al., 2011). It is hoped that such provisions will reverse the current situation in that adolescents will start to teach their parents food literacy. However, teachers have also stated that the enhancement of food

literacy can only happen through a partnership between home and school (Nanayakkara et al., 2017).

While the inclusion of food literacy concepts in teacher-training courses is an enabler of food literacy enhancement in secondary schools (Fordyce-Voorham, 2015), in general, in secondary-education training courses, these are confined to those courses for which food and nutrition concepts are core to the programs, for example, Technologies, and Health and Physical Education. Even so, food-system professionals have raised serious concerns over some teachers' uninformed and incorrect judgments and advice on issues such as eating disorders, weight management, fad diets, and the use of weight-loss methods without any proper qualifications concerning adolescents' nutritional requirements (Sadegholvad et al., 2017b).

Summary

This paper describes the potential positive contribution of enhanced food literacy and food numeracy in secondary schools on adolescents' dietary behaviours and their overall success. This is important because for many years there has been greater attention paid to individuals' healthy eating (nutrition education) and not enough attention paid to the environmental and societal factors that influence individuals' eating behaviours and individuals' contributions (Worsley, 2015).

In this paper we have endeavoured to reiterate the definition, application and contribution of food literacy and to combine it with the introduction of food numeracy for the first time. Like literacy and numeracy, food literacy and food numeracy are distinct but complementary capabilities·

The paper has also introduced the term 'integration capacity' and has shown that approximately 50 per cent of the curriculum has some integration capacity to enhance food literacy and food numeracy to varying degrees.

Another important aspect of this paper is the use of the Health Promoting Schools Framework to categorise enablers and barriers to strengthening food literacy and food numeracy in schools. Consideration of these enablers and barriers can be important in formulating a model that can facilitate the integration of food literacy and food numeracy across the curriculum.

Limitations

One of the limitations of this paper is the lack of studies specific to the Australian secondary-school context, as contexts can vary between school sectors, regions and countries. Additionally, the actual terms 'food literacy' and 'food numeracy' are not yet used in any related curriculum documents or studies. Finally, all studies have looked at Home Economics as the sole subject responsible for the implementation of food and nutrition education. Hence, the first author will conduct a study in 2020 that incorporates the perceived opinions of teachers of all subjects about the feasibility of the integration of food literacy and food numeracy across the curriculum.

Implications for future research

Further definition, application and implications of food numeracy will be explored in subsequent studies by the authors.

Further research and actions are also required to facilitate the potential incorporation of food literacy and food numeracy as additional cross-curriculum priorities in the Australian curriculum to ensure comprehensive integration in teachers' programs. Such actions require collaboration with all stakeholders to overcome the barriers to the integration of food literacy and food numeracy across the entire curriculum, specifically teacher training and teaching resources.

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"Food-system professionals have raised serious concerns over some teachers' uninformed and incorrect judgments and advice"

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