CooC11 and CooC7: The Development and Validation of Age Appropriate Children's Perceived Cooking Competence Measures

Moira Dean
Queen's University Belfast
Johann Issartel
Dublin City University
Tony Benson
Queen's University Belfast
Amanda McCloat
St. Angela's College Sligo
Elaine Mooney
St. Angela's College Sligo
Claire McKernan
Queen's University Belfast
Laura Dunne
Queen's University Belfast School of Social Sciences Education and Social Work
Sarah F Brennan
Queen's University Belfast Centre for Public Health
Sarah E Moore
Queen's University Belfast Centre for Public Health
Danielle McCarthy
Queen's University Belfast
Jayne V Woodside
Queen's University Belfast Centre for Public Health
Fiona Lavelle (flavelle01@qub.ac.uk)
Queen's University Belfast https://orcid.org/0000-0002-1211-0261

Research

Keywords: Measure, Development, Validation, Cooking, Children, Intervention, Assessment, Nutrition, Motor skills, Competence

DOI: https://doi.org/10.21203/rs.3.rs-56637/v1

Abstract

Background

Learning cooking skills during childhood and adolescence is associated with positive dietary outcomes in adulthood as well as being tracked from adolescence to adulthood. In addition studies have found that perceived competence to be a greater motivator to perform a behaviour than actual competence. However, a lack of validated tools that effectively measure behavioural and dietary changes and other related measures in children is a limitation. Therefore, this research aimed to develop and validate age-appropriate perceived cooking competence measures for younger and older primary school aged children.

Methods

Two measures of perceived **Coo**king **C**ompetence (**CooC11** and **CooC7**) for older (8–12 years) and younger (6–7 years) children were developed from a critical evaluation of publically available recommendations and expert consultation. The cooking skills within the measures were illustrated by a graphic designer in consultation with a chef and reviewed in an iterative manner by the research team. The measures were piloted for clarity, ease of use and initial face validity. Multiple studies were used for both **CooC11** and **CooC7** to establish psychometric properties of the measures, temporal stability, internal consistency reliability, construct validity, as well as responsiveness to change for **CooC11**. Analysis included Exploratory Factor Analysis, Confirmatory Factor Analysis, Intraclass Correlation Coefficients, Pearson's Correlations, ANOVAs and Cronbach's Alphas.

Results

Both measures had high levels of face validity and received positive user feedback. Two factors were shown in both measures with the measures showing excellent temporal stability (ICC > 0.9) and good internal consistency (Cronbach's Alphas > 0.7). Both measures showed initial discriminant validity, with significant differences ($P < 0.001$) between those who reported assisting their parents with dinner preparation and those who did not. Additionally, **CooC11** was significantly correlated with an adult cooking measure and had a significant responsiveness to change ($P < 0.01$).

Conclusions

The **CooC11** and **CooC7** are the first validated age-appropriate measures for assessing children's perceived **Coo**king **C**ompetence for ages 8–12 and 6–7 years respectively. They can be used to evaluate the efficacy of children's cooking intervention studies or school nutrition education programmes.

Background

With global childhood obesity at epidemic rates, preventative strategies have become instrumental in tackling this issue [1, 2]. Nutrition education programmes are one of the preventative methods being used for changing children's dietary patterns and intake [3]. Within this area, cooking interventions have been highlighted as a promising method for changing children's food-related attitudes, preferences and behaviours [4, 5]. Research shows that learning cooking skills at younger ages is associated with positive dietary outcomes in adulthood and this tracks from adolescence to adulthood [6, 7]. Additionally, consumption of meals prepared in the home environment, which require cooking skills, has been associated with a normal BMI and body fat percentage [8]. However, a lack of validated measurement tools that effectively measure behavioural and dietary competencies in children is a limitation not only in cooking research [5] but is also an issue in the wider nutrition area [9, 10].

In recent years, a small number of child-orientated measures have been developed in the nutrition area covering topics such as Nutrition and Food Label Literacy [11, 12]. Yet, parental perspectives of child behaviours are still often used as a measure which can lead to bias [13]. Within children's cooking interventions, while efforts have been made to develop validated measures [14], these measures tend to focus on broader concepts such as preparing a snack with fruit or vegetables, following a recipe or making a salad etc. and are not specific to measuring individual cooking skills.

In both adults and children, increased confidence and self-efficacy are key contributors to engaging in cooking practices and repeating the behaviour [15–19]. In addition, studies have found perceived competence to be a greater motivator to perform a behaviour than actual competence [20]. This has been extensively studied in the area of physical activity, where children with higher levels of perceived competence participated in a greater amount of physical activity [21]. Additionally, higher levels of perceived competence at younger ages predicted higher levels of perceived competence and physical activity at older ages [22]. Furthermore, children with low levels of perceived competence, even with high actual competence, were shown to have lower levels of motivation for physical activity than children with high levels of perceived competence (with or without matching levels of actual competence) [23]. Therefore, being able to measure perceived competence effectively is essential for understanding behaviour change and for evaluating successful interventions. While measuring perceived competence in motor skills exist [24, 25] currently there is no equivalent perceived competence measuring tools in the area of cooking, which is also a learned and modifiable behaviour.

The developmental differences between children and adults require consideration when conducting research with children [26]. Therefore, when developing measures appropriate to children, the developmental stages and capabilities of the child must be taken into consideration, including a child's attention span, the format of the measure, the validity and reliability of the responses and the clarity of the language [26, 27]. In addition, recommendations from the literature [26, 28] suggest that, when children are involved, research methods using visual and/or game-like measurements are preferred. These methods are more engaging to children and are similar in formats to teaching methods used at school [26, 28]. These strategies have been implemented in the children's perceived motor competence measure [24, 25]. They have shown to be effective in multiple studies, globally [29–33]. However, while

using these methods may be engaging for the children, it must also obtain relevant data [26]. Therefore, it is necessary to develop appropriate and relevant items within the measure. The specific cooking skills within the measure must be relevant to the children's developmental capacity to ensure that children are rating their perceived competence on items that they are able to achieve (i.e. appropriate for their age) [34]. Therefore, this research aimed to develop and validate age-appropriate perceived cooking competence measures for children.

Methods

2.1 Item selection

The cooking skills that children should be learning at different ages were obtained through a critical evaluation of publically available children's recommendations and the addition of new recommendations based on children's developmental skills [34]. From this review, for the two **Coo**king **C**ompetence measures, 14 cooking skills for 8–12 year olds (**CooC11**) and 10 skills for 6–7 year olds (**CooC7**) were identified as being frequently occurring and culturally neutral. The items were selected to ensure they were both developmentally appropriate and relevant [26]. An expert panel including an educational researcher, a primary school teacher, an early year's educator, movement scientist and Home Economists, with a minimum of 10 years' experience in their respective fields, reviewed the selected skills for age appropriateness and level of difficulty. An age range was proposed for each skill and skills were then ranked in order of difficulty from easiest to hardest, see Table 1.

Table 1: Cooking skills identified for younger and older children

Level of difficulty	Cooking Skills	
	Younger (ages 6-7 years)	*Older (ages 8-12 years)*
Easiest		
	Tearing Leaves	Tearing Leaves
	Washing Vegetables	Washing Vegetables
	Stirring/Mixing ingredients	Stirring/Mixing ingredients
	Mashing	Mashing
	Measuring liquids[a]	Measuring liquids[a]
	Weighing ingredients[a]	Weighing ingredients[a]
	Chopping	Chopping
	Grating	Using a blender[c]
	Peeling	Grating
	Using a tin opener[b]	Peeling
		Using a microwave[d]
		Using a tin opener
		Using the oven[d]
Most difficult		Using the stove/hob[e]

a – measuring liquids and weighing were separated in the measure; b - tin opener was placed in the younger age before the expert panel review moved it into the 9 + age category; c – blender replaced mixer as mixer was more associated with baking as opposed to cooking; d – oven and microwave were separated in the measure; e – Using the stove/hob was added as a means of factoring in the use of a cooker/cooker top for those that may not have an oven/as a means of trying to include stirring over heat

2.2 Development and implementation of measure

The design of the children's perceived cooking competence measure was based on a published perceived motor competence measure [24]. However, in the cooking skills measure the child was asked first whether they engaged in a particular cooking skill (in line with Lavelle et al. [35]), before they rated their level of competence. This aims to reduce positive illusory and social desirability biases [26]. In the measure, each skill was illustrated as a child-friendly character performing the skill. Using an iterative process, the child

characters were drawn by a graphic designer in consultation with a chef and reviewed by the research team for accuracy and suitability. The illustrations provided a visual 'cue' to the cooking skill as some cooking terminology relating to skills may not be familiar to the children. In line with Barnett et al. [24], the child is shown an image of a child, boys are presented with images of boys performing the skills and girls are shown images of girls. This promotes a peer modelling effect, as it is argued that a child is more likely to relate to a character that is more like themselves [36, 37]. The child is asked whether they do the skill shown (see figure 1 as an example). If the child responds yes, then they are shown two more images of the child performing the skill, one performing it well and the other performing it poorly. The child is then asked which image represents their perceived level of competence on a five point Likert scale.

The five response options result in five possible levels of competence for each skill (see figure 2 as an example). However if the child responds that they do not perform that particular skill, they move on to the next skill.

The cooking skills are presented in ascending level of difficulty as rated by the expert panel. Additionally, the sequence of presentation of 'good' competence of a skill alternated in position on the page with 'poor' competence of a skill [24]. Each child completes the measure individually. However, if a child's literacy levels were not at a sufficient level that they could read the questions, then the researchers assisted the child by reading out the questions so that the child could complete the task.

2.3 Piloting and Initial Face Validity

The measures were reviewed by the research team and a primary school teacher for language, readability and literacy levels [26]. Based on the feedback minor amendments were made to the language, such as changing 'in between A and B' to 'A bit like A and B,' as it was suggested that children would interpret the original phrasing to mean physically in between the two characters. Additionally, the font size of the text was increased for the younger age group. Furthermore, the characters' expressions were all changed to neutral, so that the children would not choose their responses based on how happy or sad they were feeling but on their perceived level of competence. Thus, the research team assessed the measures for initial face validity.

The designed measures were also piloted with a number of children of differing ages [38]. This piloting allowed the research team to assess the usability, length of time of completion, enjoyability as well as further face validity such as recognition of the skills and differentiation between the 'good,' and 'poor' performance of the skill.

Further validation assessments were undertaken for both the older age measure (**CooC11**) and the younger age measure (**CooC7**), which will be detailed in the following section. For both measures, endpoint user feedback from both the children and teachers were received. Five teachers and three teaching assistants, from samples 2 and 5, provided their perceptions around the measures including the suitability, usability and length. Each class in these samples were asked about their experiences using the measure, whether they liked this type of activity, about the characters and if there was anything they

would change. Additionally, informal qualitative feedback was gathered across all samples. Prior to data analysis, where necessary, items were reversed coded so that a higher score indicated greater perceived cooking competence for all items. All analyses were conducted using IBM SPSS Statistics v25 and IBM SPSS Amos v25, with a significance level of 0.05.

2.4 CooC11 (8-12 year olds)

2.4.1 Participants and Procedure

Sample 1: Data from 469 primary school children aged 10 – 11 years completed baseline measurements as part of a larger study [39]. 50.32% of this sample were female. Schools from both rural and urban areas with varying socioeconomic levels were included. Data was collected in February-March 2019.

Sample 2: Children (N=38) between the ages of 8-9 years and 10-11 years (two year groups in the primary school system in Northern Ireland) were recruited. Children from one primary school were recruited for this study. 52.6% of the sample were female. Children in this sample completed the measure at two time points two weeks apart in May 2019.

Sample 3: Children (N=32) between the ages of 10-12 years who participated in a one week cooking camp intervention in August 2019. 78.1% of this sample were female. These children completed the measure before and after the cooking camp intervention.

2.4.2 Psychometric testing, Validation and Data Analysis

Exploratory Factor Analysis

Sample 1 was randomly split to conduct Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA), with 269 children included in the EFA. EFA (maximum likelihood) with direct oblimin rotation was used. This oblique rotation was used as it was believed that factors would be related [40]. Sample adequacy was assessed using Kaiser-Meyer-Olkin (KMO) value [41] and Bartlett's Test of Sphercity [42]. Factors were assessed using Eigenvalues greater than 1 [43] and a minimum of 3 items per factor [44]. Items were removed based on communalities and factor loadings.

Confirmatory Factor Analysis and Face Validity

The remaining 200 randomly selected children from sample 1 were used for CFA. The final model identified by the EFA was assessed as a confirmatory factor analysis with maximum-likelihood estimation, using IBM SPSS Amos v25. The following fit statistics were used to assess the model [45]:

- Chi-square (χ^2) – A non-significant chi-square value ($p > 0.05$) which is two or three times larger than its value divided by the degrees of freedom (df) at its maximum indicates that the model can be accepted.
- Root Mean Square Error of Approximation (RMSEA) – A preferred value is 0.05 or less.

- Comparative Fit Index (CFI), Normed-Fit Index (NFI), Tucker-Lewis Index (TLI) – For these indices a value of 0.90 or greater indicates that the model can be accepted.

To establish face validity of the measure structure, five researchers in the areas of food, nutrition, health psychology, Home Economics and human movement science, reviewed the final model and factor structure. Cooking skills in each factor were assessed upon general relation in cooking as well as underlying developmental skills including fine and gross motor skills in addition to numeracy, literacy and safety considerations. All items were assessed to ensure they measured what they claimed to measure.

Construct Validity – Convergent and Discriminant Validity

Sample 1 was used for Construct validity. Convergent validity shows that measures are valid by identifying a relationship with an existing similar measure using correlation analysis. As there are no similar children's measures to establish convergent validity, the cooking method section of an adult measure was used [35]. This measure has not been used previously with children due to the levels of literacy required. However, as the current sample is at the older end of the age range for the measure, the research team decided to include the measure as a means of establishing some level of convergent validity. Additionally, due to the lack of measurements available, the children were asked whether they help their parents making the dinner. It was expected that those who assist with dinner preparation would have a reported higher cooking competence. Due to a larger number of children answering 'sometimes' or 'always', compared with those answering 'never', only a random selection of those who responded 'sometimes' or 'always' were selected to compare against never. This ensured that there was a relatively equal number of participants in each group for the one-way ANOVA.

Internal Consistency Reliability

Internal consistency reliability was used to examine agreement between the items in a scale. Cronbach's Alpha was used to assess internal consistency reliability. A value of 0.7 or higher shows good reliability [46]. Sample 1 and 2 were used to establish internal consistency of the measure.

Temporal Stability

Sample 2 was used to assess Temporal Stability of the measure. The temporal stability of the scales was examined using the Intraclass Correlation Coefficient (ICC). This illustrates the level of agreement between item answers over time. A stronger ICC indicates greater agreement, suggesting greater temporal stability. Moderate reliability is seen with an ICC value of 0.50–0.75, good reliability is a value of 0.75–0.90, while a value of greater than 0.90 suggests excellent reliability [47].

Responsiveness to Change

Sample 3 was used to assess the responsiveness to change of the measure, a further indication of validation [48]. This was established through investigating changes in the measure scores before and after the children receive a cooking focused intervention using T-tests.

2.5 CooC7 (6-7 year olds)

2.5.1 Participants and Procedure

Sample 4: Data from 514 primary school children aged 6 - 7 completed baseline measurements as part of a larger study [39], are used as Sample 4. 48.63% of this sample were female. Schools with varying socioeconomic levels and from both rural and urban areas were included. Data was collected in February-March 2019.

Sample 5: Children (N=13) between the ages of 6 – 7 years old were recruited as part of Sample 5 from the same school as sample 2. 46.2% of this sample were female. Children in this sample completed the measure at two time points two weeks apart in May 2019.

2.5.2 Psychometric testing, Validation and Data Analysis

The same criteria as in 2.4.2 were used for testing the **CooC7** measure. The samples used, and differences in analysis to **CooC11** are detailed below.

Exploratory Factor Analysis

Sample 4 was randomly split to conduct Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA), with 314 children included in the EFA.

Confirmatory Factor Analysis and Face Validity

The remaining 200 randomly selected children from Sample 4 were used for CFA. The same procedure was used for the CFA and face validity as in section 2.4.2.

Construct Validity – Discriminant Validity

Sample 4 was used for construct validity. There are no similar children's measures to establish convergent validity and the cooking method section of the adult measure [35] is above the literacy and cognitive capacity of this age group. Due to the lack of measurements available, the children were asked whether they help their parents making the dinner, with the expectation again that a higher cooking competence score would be seen in those that help with dinner preparation. The responses for the children were 'never', 'sometimes' or 'always'. Comparisons between children in the 3 categories were conducted using an ANOVA with Scheffe post hoc analysis due to differences in numbers in the groups.

Internal Consistency Reliability

Sample 4 and 5 were used to establish internal consistency of the measure.

Temporal Stability

Sample 5 was used to assess Temporal Stability of the **CooC7**.

2.6 Ethical Considerations

All schools partaking in the research (Samples 1, 2, 4 and 5) signed and returned a memorandum of understanding. An opt-out parental consent system was implemented. In sample 3, due to the nature of the intervention and the demand for places, an opt-in system was used. In all samples, parents were made aware that they were not obliged to allow their child to take part in the study and that they could withdraw their child at any time point up to data analysis without reason or consequence. Additionally, the children were made aware that they did not have to take part. The research was conducted in accordance with the Declaration of Helsinki. Ethical approval was received from The School of Social Sciences, Education and Social Work Ethics Committee, Queen's University Belfast (Reference number 038_1819) for Samples 1 and 4 and from The School of Biological Sciences Ethics Committee, Queen's University Belfast (0519/LavelleFA, 0519/LavelleFB), for Samples 2, 3 and 5.

Results

3.1 Overall usability, face validity, user feedback

The research team established initial face validity to ensure that all items measured what they claimed to measure. Piloting of the measures established that children could distinguish between 'good' and 'poor' performance of an illustrated skill and that they found the measure easy to use. Teacher feedback relating to the characters was positive and the teachers felt that the illustration would help the children struggling with literacy and/or would help children who had learning difficulties. However, it was noted that some children using the **CooC7** may still need help reading. Teachers recommended that a larger font size for **CooC11**, would be beneficial for the younger age group (8–9 years) to help with their reading. The children's enjoyment completing the measure, especially using the measure on a tablet, and the short duration of time required to complete the measures were seen as positives.

Qualitative feedback showed that children completing the measure enjoyed doing it and wanted more questions and suggested that they should be given an opportunity to provide a reason why they don't do certain skills. They also identified with the illustrated characters, *"That guy is just like me except the hair – like it's me"* (P7 male pupil, sample 1).

3.2 CooC11 (ages 8 – 12 years)

3.2.1 Exploratory Factor Analysis

The results showed an excellent KMO value of 0.86 and a significant ($p < .001$) Bartlett's Test of Sphericity, indicating sample adequacy for analysis. Initially three factors were apparent in the data. 'Tearing leaves,' 'Using a blender,' and 'Using a microwave' were removed due to communalities <0.25 and cross loading across factors. Given this the analysis was conducted again, to ensure that the factor structure and results were acceptable after the modification. Two factors were now apparent in the data, as shown by Eigenvalues greater than 1. Both factors had a minimum of 3 items, no items cross-loaded

on more than one factor, and the minimum factor loading was 0.3. In addition, the internal reliability values for each factor were 0.77 and 0.72 respectively, therefore, all 11 items were retained. The overall Cronbach's alpha for the measure was 0.82 in this sample.

3.2.2 Confirmatory Factor Analysis

When entered as a CFA, the final EFA model did not have optimal fit (significant χ^2, RMSEA 0.06, NFI 0.83, TLI .89). To improve this, the modification indices suggested some of the error terms should be allowed to covary. Following these amendments, fit was acceptable. Specifically, the χ^2 was significant, but with a χ^2/df ratio below 2 (1.50). RMSEA was 0.05. While the NFI was .87, the CFI was .95 and TLI .93, indicating overall acceptable fit. All standardised loadings were .40 or above. Face validity was established through the agreement that all items were appropriate for their factor, after discussion around 'stirring.'

3.2.3 Construct Validity (Convergent and discriminant Validity)

In sample 1 (N=469), the adults cooking methods confidence score had a Cronbach's Alpha of 0.82. Spearman's rank correlation analyses showed that the children's cooking competence measure in the current study was significantly correlated with the adults cooking methods confidence score, 0.49 (P<0.001). Those children that reported helping their parents with preparing the dinner had a significantly higher cooking competence than those who did not (P<0.001), see Table 2.

Table 2: Differentiating between those that report helping prepare dinner and those that don't

Measure	Total Sample (N = 272)	Do not help with dinner (N=136)	Help with dinner (N=136)	Significance
	M(SD)	M(SD)	M(SD)	P
CooC11	17.04 (12.88)	10.57 (9.65)	23.51 (12.47)	0.000

3.2.4 Internal Consistency and Temporal Stability

The internal consistency reliability of **CooC11** was very good for the 8-9 years and 10-11 years, with a Cronbach's of 0.86 and 0.84, respectively, and 0.85 overall.

In terms of temporal reliability **CooC11** had an ICC of 0.91, indicating an excellent temporal stability, with the two subscales having good temporal stability, as detailed in Table 3.

Table 3: Temporal Stability of CooC11 and factors

Scale	T1	T2	ICC
	M(SD)	*M(SD)*	
Factor 1	7.50 (8.04)	6.97 (7.35)	0.89
Factor 2	6.37 (6.44)	7.61 (7.11)	0.85
CooC11	**13.87 (13.42)**	**14.58 (13.16)**	**0.91**

3.2.5 Responsiveness to change

The measure is responsive to change, as seen by a significant increase (P<0.01) from pre-cooking camp intervention **CooC11** mean (SD), 21.75 (7.89), to post camp CooC11, 26.13 (8.89).

3.3 CooC7 (ages 6 – 7 years)

3.3.1 Exploratory Factor Analysis

The results showed an excellent KMO value for **CooC7** of 0.81 and a significant (p < .001) Bartlett's Test of Sphericity, indicating that the sample was adequate for factor analysis. Two factors were seen in the data, as shown by Eigenvalues greater than 1. All factors had a minimum of 3 items. 'Tearing leaves' and 'Stirring/mixing' were removed due to communalities <0.15. Furthermore, 'Using a tin opener' was removed as it did not meet the minimum factor loading of 0.3 and cross loaded across factors. Given this the analysis was conducted again to ensure that the factor structure and results were acceptable following the previous modification. All factors contained at least three items, no items cross-loaded on more than one factor, and the minimum factor loading was 0.3. In addition, the Cronbach's Alpha values for each factor were 0.65 and 0.62, respectively, therefore, all 7 items were retained. The overall measure had an internal consistency reliability of 0.71.

3.3.2 Confirmatory Factor Analysis

The final EFA model fit the data well in the confirmatory model (figure 4). The χ^2 was non-significant, with a χ^2/df ratio of 1.24, and the RMSEA was 0.04. The CFI, NFI, and TLI were all excellent at .98, .93, and .98 respectively. In addition, all standardised loadings were above .4. Face validity was established through the agreement that all items were appropriate for their factor after discussion around the factoring of weighing and measuring on separate factors.

3.3.3 Construct Validity (Discriminant Validity)

Discriminant validity results for **CooC7** can be seen in Table 4 below.

Table 4: Differentiating between the different levels of assisting preparing dinner

Measure	Total Sample (N=513)	Never help with dinner (N=190)	Sometimes help with dinner (N=205)	Always Help with dinner (N=118)	Significance
	M(SD)	*M(SD)*	*M(SD)*	*M(SD)*	*P*
CooC7	11.83(8.66)	8.12(7.71)[a]	12.17(8.17)[b]	17.20(8.02)[c]	0.000

Superscript letters depict where significant differences (P < 0.001) fall between the groups

3.3.4 Temporal stability

In terms of temporal reliability the measure had an ICC of 0.92, indicating an excellent temporal stability, with the two subscales having good temporal stability.

Table 5: Temporal Stability of measure and factors

Scale	T1	T2	ICC
	M(SD)	*M(SD)*	
Less Complex skills	7.00 (4.81)	7.62 (7.07)	0.85
Greater fine control & Safety	5.23 (5.00)	4.77 (4.89)	0.86
CooC7	**12.23 (9.00)**	**12.39 (10.14)**	**0.92**

Discussion

To the best of our knowledge, this research is the first to develop and validate age appropriate children's measures, **CooC11** and **CooC7,** for the use in nutrition and cooking interventions. Both measures were developed to ensure they were age appropriate and engaging for children [28, 26]. They have high levels of face and construct validity and excellent internal consistency reliability and temporal stability. Additionally, **CooC11** demonstrated responsiveness to change validity. For both measures endpoint user feedback was generally positive and children found it enjoyable completing the measures.

Factors

The EFA and CFA confirmed a two-factor structure for both **CooC11** and **CooC7**. For **CooC11**, face validity of the two factors was established, Factor 1 consists of cooking skills that encompass basic motor skills and Factor 2 consists of cooking skills that need additional developmental skills such as numeracy and literacy. Stirring was accepted in Factor 2, as this cooking skill is often performed over heat and therefore needed safety considerations, which was also noted in the original recommendations [34]. While the skill

‘using a stove/hob’ was added to encompass this type of stirring, e.g. stirring over heat, the skill ‘stirring’ is shown to the child before ‘using a stove/hob’ so they may still consider ‘stirring’ as over heat.

CooC7, also has two factors. Factor 1 consisted of the less complex skills for this age group whereas, Factor 2 consisted of cooking skills that required greater fine motor control and safety aspects. While there was some initial discussion around ‘grating’ factoring onto Factor 1, it was established that this cooking skill requires less fine motor control than ‘using a peeler’ or ‘chopping.’ Additionally, in this age group, ‘measuring liquids’ and ‘weighing’ factored onto different factors. It is suggested that for this age group, ‘measuring liquids’ is a more complex skill requiring greater fine motor control to accurately measure out liquids correctly.

While these factors are apparent within the measures, using **CooC11** and **CooC7** in their entirety is currently recommended, as these measure are quick to complete and there is a lack of validated measures to assess the factor construct validity.

Validity and reliability

The **CooC11**, was correlated with an adult cooking confidence measure [35], which showed some convergent validity. Both measures were able to distinguish between children who reported different levels of assisting their parents with preparing the dinner, highlighting initial discriminant validity. Furthermore, **CooC11** showed it was responsive to change, as there was a significant increase in perceived cooking competence by children attending the cooking camp intervention. It is worth noting that due to the nature and recruitment for this intervention, these children had an initial interest in cooking, shown by their higher initial **CooC11** scores compared to the children in samples 1 and 2 who were recruited from schools. As changes were detected pre and post intervention, this demonstrates that the measures can be used with participants who have some level of initial cooking competence to measure changes.

Both measures showed that they had high levels of internal consistency reliability, indicating that they are measuring coherent concepts, demonstrated by the Cronbach’s alphas being greater than 0.7, which is satisfactory for non-clinical samples [49, 50]. Additionally, both overall measures showed excellent temporal stability demonstrated by the test-retest analysis, where the ICC scores were greater than 0.9 [47], showing that the scores are highly reliable over time.

Strengthening the research area

The reported decline in child involvement in cooking in the home environment [51, 52], has led to an increase in children’s cooking interventions [4, 5]. New models are being created, such as the Cook-Ed^{TM} model [53] to help guide the design, development and evaluation of the quality and success of the interventions using validated measures. The new **CooC11** and **CooC7** are a necessity in this area and will contribute to the strengthening of the global research by providing validated measurements to use in the evaluation of intervention studies.

Future Research

Future research should assess the responsiveness to change of **CooC7.** Due to the difficulty in recruiting this age group within the available resources this was not assessed within the reported studies. Endpoint user feedback from teachers suggest that these new measures can be adapted to be used with people with learning difficulties and/or disabilities. Future research could develop and diversify the characters to make the measures suitable to use with these target populations.

Strengths and Limitations

The new measures involved extensive development, underpinned by a review, expert consultation and existing measures [24, 35] and illustrated by a graphic designer in consultation with a chef. The illustrated characters were highlighted as helpful and relatable. Additionally, the use of tablets to complete the measure was enjoyable to the participating children and the use of characters and a tablet to undertake the measures, enabled a more 'game' feeling rather than a test, which was found to be beneficial [28]. However, it was noted, to help with literacy for those at the younger end of the age range using **CooC11**, an increased font size would be beneficial.

The developed measures were found to be highly reliable and valid. The cooking skills included were based on evidence based age-appropriate recommendations developed from global publically available cooking recommendations and deconstructed for their underlying motor skills [34], thus increasing the generalisability of the measures outside of a UK/Irish population. Additionally, to increase the cross-cultural applicability of the measures, a range of diverse character illustrations are available to use to ensure that all children can identify with the characters illustrated. Furthermore, if individual factors in the measures are to be used as standalone measures then construct validity of the factor structure is necessary when additional measures are available.

Conclusions

The **CooC11** and **CooC7** are the first extensively developed and validated age-appropriate measures for assessing children in nutrition related interventions. The measures assess children's perceived **Coo**king **C**ompetence for children aged 8-12 and 6-7 years respectively and can be used to evaluate the efficacy of children's cooking intervention studies or school programmes.

Declarations

Ethics Approval and Consent to Participate

Ethical approval was received from The School of Social Sciences, Education and Social Work Ethics Committee, Queen's University Belfast (Reference number 038_1819) for Samples 1 and 4 and from The School of Biological Sciences Ethics Committee, Queen's University Belfast (0519/LavelleFA, 0519/LavelleFB), for Samples 2, 3 and 5.

Consent for Publication

Not applicable.

Availability of Data and Materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing Interests

The authors declare that they have no competing interests.

Funding

Funding for character illustrations and Project Daire was received from the AGRI-FOOD QUEST Competence Centre (Invest NI).

Authors' Contributions

FL created the initial concept with development and research design contributions from MD and JI. JI, AMC, EM and LD were involved in the expert review. JVW, CMC, DMC, SFB, SEM and FL were involved in recruitment and data collection. FL and TB conducted the majority of the analysis with input from JI, AMC and EM. FL and MD drafted the manuscript. All authors reviewed and edited the manuscript.

Acknowledgements

The authors would like to thank the pupils and their parents, principals, teachers from all the schools, from the piloting phase and from the 'Cook Like A Boss' cooking intervention that participated in the research. Additionally, the authors are grateful for the input from the experts involved in the initial review of the items. The authors would like to thank Lucy Patterson (@lucy_graphicdesigner) for her design work.

Footnote

The measures are freely available to use and can be obtained by contacting the corresponding author. Additionally, the measure has been translated into the Irish language which is also available from the corresponding author. W*here appropriate the corresponding author is willing to assist with back translation for other translations.*

References

1. Pandita A, Sharma D, Pandita D, Pawar S, Tariq M, Kaul A. Childhood obesity: prevention is better than cure. Diabetes, metabolic syndrome and obesity: targets and therapy. 2016;9:83.

2. Sahoo K, Sahoo B, Choudhury AK, Sofi NY, Kumar R, Bhadoria AS. Childhood obesity: causes and consequences. Journal of family medicine and primary care. 2015 Apr;4(2):187.
3. World Health Organization. Report of the Commission on Ending Childhood Obesity. Geneva: WHO, 2016. Available online: http://www.who.int/end-childhood-obesity/ publications/echo-report/en/. Accessed 17 December 2019.
4. Utter J, Fay AP, Denny S. Child and youth cooking programs: more than good nutrition?. Journal of Hunger & Environmental Nutrition. 2017 Oct 2;12(4):554-80.
5. Hersch D, Perdue L, Ambroz T, Boucher JL. Peer reviewed: the impact of cooking classes on food-related preferences, attitudes, and behaviors of school-aged children: a systematic review of the evidence, 2003–2014. Preventing chronic disease. 2014;11.
6. Lavelle F, Spence M, Hollywood L, McGowan L, Surgenor D, McCloat A, Mooney E, Caraher M, Raats M, Dean M. Learning cooking skills at different ages: a cross-sectional study. International Journal of Behavioral Nutrition and Physical Activity. 2016 Dec;13(1):1-1.
7. Laska MN, Larson NI, Neumark-Sztainer D, Story M. Does involvement in food preparation track from adolescence to young adulthood and is it associated with better dietary quality? Findings from a 10-year longitudinal study. Public health nutrition. 2012 Jul;15(7):1150-8.
8. Mills S, Brown H, Wrieden W, White M, Adams J. Frequency of eating home cooked meals and potential benefits for diet and health: cross-sectional analysis of a population-based cohort study. International Journal of Behavioral Nutrition and Physical Activity. 2017 Dec 1;14(1):109.
9. Burrows TL, Martin RJ, Collins CE. A systematic review of the validity of dietary assessment methods in children when compared with the method of doubly labeled water. Journal of the American Dietetic Association. 2010 Oct 1;110(10):1501-10.
10. Burrows T, Golley RK, Khambalia A, McNaughton SA, Magarey A, Rosenkranz RR, Alllman-Farinelli M, Rangan AM, Truby H, Collins C. The quality of dietary intake methodology and reporting in child and adolescent obesity intervention trials: a systematic review. Obesity Reviews. 2012 Dec;13(12):1125-38.
11. Doustmohammadian A, Omidvar N, Keshavarz-Mohammadi N, Abdollahi M, Amini M, Eini-Zinab H. Developing and validating a scale to measure Food and Nutrition Literacy (FNLIT) in elementary school children in Iran. PLoS One. 2017 Jun 27;12(6):e0179196.
12. Reynolds JS, Treu JA, Njike V, Walker J, Smith E, Katz CS, Katz DL. The validation of a food label literacy questionnaire for elementary school children. Journal of nutrition education and behavior. 2012 May 1;44(3):262-6.
13. Musher-Eizenman D, Holub S. Comprehensive feeding practices questionnaire: validation of a new measure of parental feeding practices. Journal of pediatric psychology. 2007 Sep 1;32(8):960-72.
14. Lohse B, Cunningham-Sabo L, Walters LM, Stacey JE. Valid and reliable measures of cognitive behaviors toward fruits and vegetables for children aged 9 to 11 years. Journal of nutrition education and behavior. 2011 Jan 1;43(1):42-9.

15. Lavelle F, Hollywood L, Caraher M, McGowan L, Spence M, Surgenor D, McCloat A, Mooney E, Raats M, Dean M. Increasing intention to cook from basic ingredients: A randomised controlled study. Appetite. 2017 Sep 1;116:502-10.
16. Garcia AL, Reardon R, McDonald M, Vargas-Garcia EJ. Community interventions to improve cooking skills and their effects on confidence and eating behaviour. Current nutrition reports. 2016 Dec 1;5(4):315-22.
17. Dixon EJ, Condrasky MD, Sharp JL, Corr AQ. Cooking confidence and healthy eating choices of preadolescent participants at a cooking camp. Topics in Clinical Nutrition. 2013 Jan 1;28(1):21-33.
18. Wrieden WL, Anderson AS, Longbottom PJ, Valentine K, Stead M, Caraher M, Lang T, Gray B, Dowler E. The impact of a community-based food skills intervention on cooking confidence, food preparation methods and dietary choices–an exploratory trial. Public health nutrition. 2007 Feb;10(2):203-11.
19. Caraher M, Seeley A, Wu M, Lloyd S. When chefs adopt a school? An evaluation of a cooking intervention in English primary schools. Appetite. 2013 Mar 1;62:50-9.
20. Harter S. Effectance motivation reconsidered. Toward a developmental model. Human development. 1978;21(1):34-64.
21. Crocker PR, Eklund RC, Kowalski KC. Children's physical activity and physical self-perceptions. Journal of sports sciences. 2000 Jan 1;18(6):383-94.
22. Davison KK, Downs DS, Birch LL. Pathways linking perceived athletic competence and parental support at age 9 years to girls' physical activity at age 11 years. Research quarterly for exercise and sport. 2006 Mar 1;77(1):23-31.
23. Bardid F, De Meester A, Tallir I, Cardon G, Lenoir M, Haerens L. Configurations of actual and perceived motor competence among children: Associations with motivation for sports and global self-worth. Human movement science. 2016 Dec 1;50:1-9.
24. Barnett LM, Ridgers ND, Salmon J. Associations between young children's perceived and actual ball skill competence and physical activity. Journal of Science and Medicine in Sport. 2015 Mar 1;18(2):167-71.
25. Barnett LM, Vazou S, Abbott G, Bowe SJ, Robinson LE, Ridgers ND, Salmon J. Construct validity of the pictorial scale of perceived movement skill competence. Psychology of sport and exercise. 2016 Jan 1;22:294-302.
26. Punch S. Research with children: the same or different from research with adults?. Childhood. 2002 Aug;9(3):321-41.
27. Boyden, J. and J. Ennew. Children in Focus: A Manual for Experiential Learning in Participatory Research with Children. Stockholm: Rädda Barnen; 1997.
28. Mann G, Tolfree D. Children's participation in research: Reflections from the care and protection of separated children in emergencies project. Stockholm: Save the Children Sweden; 2003.
29. Morgan PJ, Young MD, Barnes AT, Eather N, Pollock ER, Lubans DR. Engaging fathers to increase physical activity in girls: the “dads and daughters exercising and empowered”(DADEE) randomized

controlled trial. Annals of Behavioral Medicine. 2019 Jan;53(1):39-52.

30. Brian A, Bardid F, Barnett LM, Deconinck FJ, Lenoir M, Goodway JD. Actual and perceived motor competence levels of Belgian and United States preschool children. Journal of Motor Learning and Development. 2018 Oct 1;6(s2):S320-36.
31. Estevan I, Molina-García J, Abbott G, Bowe SJ, Castillo I, Barnett LM. Evidence of reliability and validity for the pictorial scale of perceived movement skill competence in Spanish children. Journal of Motor Learning and Development. 2018 Oct 1;6(s2):S205-22.
32. Farmer O, Belton S, O'Brien W. The relationship between actual fundamental motor skill proficiency, perceived motor skill confidence and competence, and physical activity in 8–12-year-old Irish female youth. Sports. 2017 Dec;5(4):74.
33. Peers C, Issartel J, Behan S, O'Connor N, Belton S. Movement competence: Association with physical self-efficacy and physical activity. Human Movement Science. 2020 Apr 1;70:102582.
34. Dean M, O'Kane C, Issartel J, McCloat A, Mooney E, Gaul D, Wolfson J, Lavelle F. Guidelines for designing age-appropriate cooking interventions for children: the development of evidence-based cooking skill recommendations for children, using a multidisciplinary approach. *Appetite, Under Review.*
35. Lavelle F, McGowan L, Hollywood L, Surgenor D, McCloat A, Mooney E, Caraher M, Raats M, Dean M. The development and validation of measures to assess cooking skills and food skills. International Journal of Behavioral Nutrition and Physical Activity. 2017 Dec;14(1):1-3.
36. Horne PJ, Tapper K, Lowe CF, Hardman CA, Jackson MC, Woolner J. Increasing children's fruit and vegetable consumption: a peer-modelling and rewards-based intervention. European journal of clinical nutrition. 2004 Dec;58(12):1649-60.
37. Lowe CF, Horne PJ, Tapper K, Bowdery M, Egerton C. Effects of a peer modelling and rewards-based intervention to increase fruit and vegetable consumption in children. European journal of clinical nutrition. 2004 Mar;58(3):510-22.
38. Kirby P. Involving young researchers: How to enable young people to design and conduct research. York: York Publishing Services; 1999.
39. Brennan SF, Lavelle F, Moore SE, Dean M, McKinley MC, McCole P, Hunter RF, Dunne L, O'Connell NE, Cardwell CR, Elliott CT, McCarthy D, Woodside JV. Food Environment Intervention Improves Food Knowledge, Wellbeing and Dietary Habits in Primary School Children: Project Daire, a Randomised-Controlled, Factorial Design Cluster Trial. *IJBNPA, Under Review.*
40. Yong AG, Pearce S. A beginner's guide to factor analysis: Focusing on exploratory factor analysis. Tutorials in quantitative methods for psychology. 2013 Oct;9(2):79-94.
41. Kaiser HF. An index of factorial simplicity. Psychometrika. 1974 Mar;39(1):31-6.
42. Field A. Discovering statistics using IBM SPSS statistics. sage; 2013 Feb 20.
43. Kaiser HF. The application of electronic computers to factor analysis. Educational and psychological measurement. 1960 Apr;20(1):141-51.

44. Carpenter S. Ten steps in scale development and reporting: A guide for researchers. Communication Methods and Measures. 2018 Jan 2;12(1):25-44.
45. Hinkin TR, Tracey JB, Enz CA. Scale construction: Developing reliable and valid measurement instruments. Journal of Hospitality & Tourism Research. 1997 Feb;21(1):100-20.
46. Hair JF, Black WC, Babin BJ, Anderson RE, Tatham RL. Multivariate data analysis. Upper Saddle River, NJ: Prentice hall; 1998 Mar 23.
47. Koo TK, Li MY. A guideline of selecting and reporting intraclass correlation coefficients for reliability research. Journal of chiropractic medicine. 2016 Jun 1;15(2):155-63.
48. Hays RD, Hadorn D. Responsiveness to change: an aspect of validity, not a separate dimension. Quality of Life Research. 1992 Feb 1;1(1):73-5.
49. Bland JM, Altman DG. Statistics notes: Cronbach's alpha. Bmj. 1997 Feb 22;314(7080):572.
50. Rattray J, Jones MC. Essential elements of questionnaire design and development. Journal of clinical nursing. 2007 Feb;16(2):234-43.
51. Lavelle F, Benson T, Hollywood L, Surgenor D, McCloat A, Mooney E, Caraher M, Dean M. Modern transference of domestic cooking skills. Nutrients. 2019 Apr;11(4):870.
52. Ronto R, Ball L, Pendergast D, Harris ND. Food literacy at secondary schools in Australia. Journal of School Health. 2016 Nov;86(11):823-31.
53. Asher RC, Jakstas T, Wolfson JA, Rose AJ, Bucher T, Lavelle F, Dean M, Duncanson K, Innes B, Burrows T, Collins CE. Cook-EdTM: A Model for Planning, Implementing and Evaluating Cooking Programs to Improve Diet and Health. Nutrients. 2020 Jul;12(7):2011.

Figures

Figure 1

Exemplar of a cooking skill (female version)

Figure 2

Exemplar of poor and good performance of a cooking skill presented to a child if they have indicated that they perform the skill

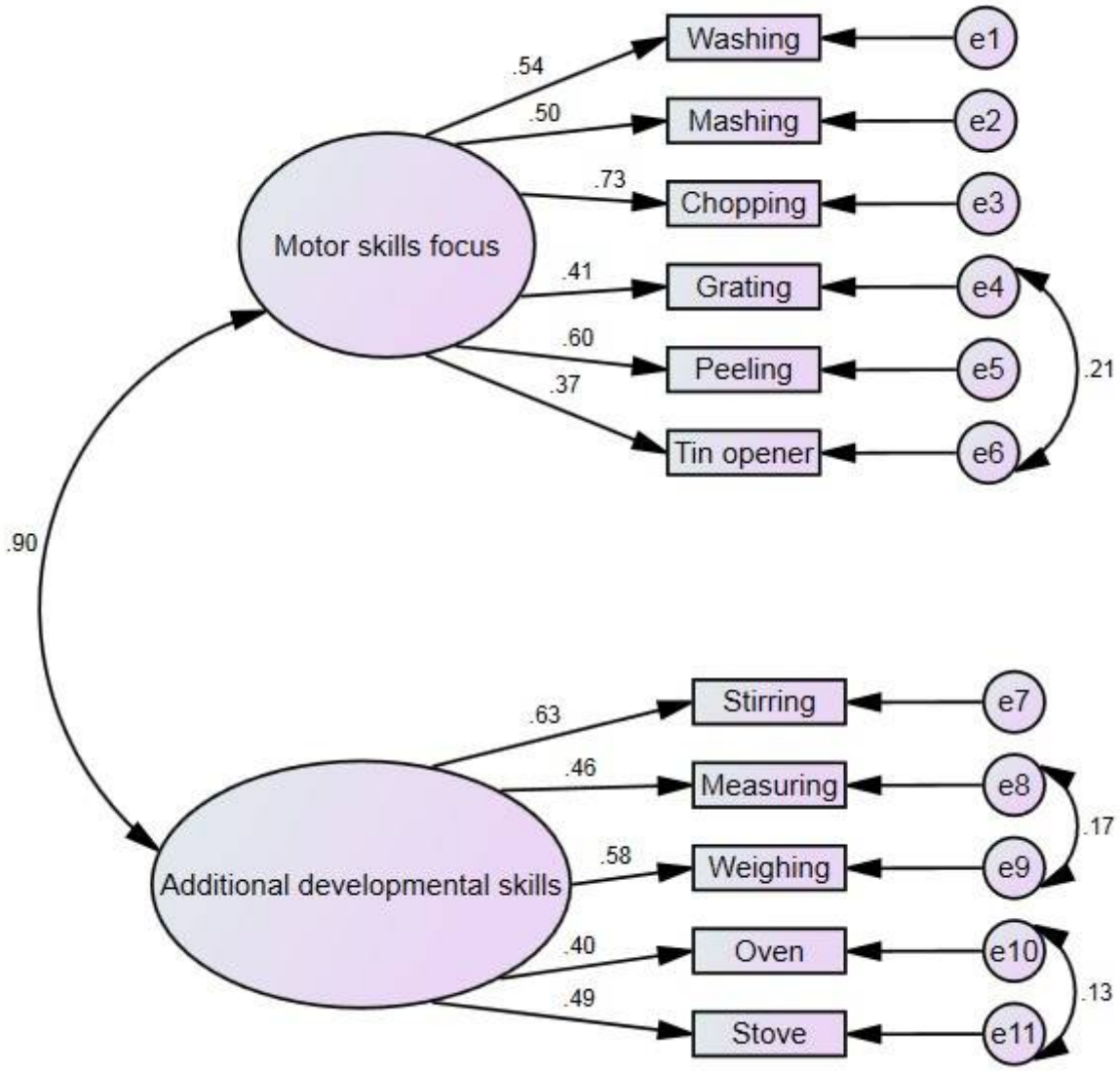

Figure 3

Final measurement model for CooC11 with standardised factor loadings and correlations

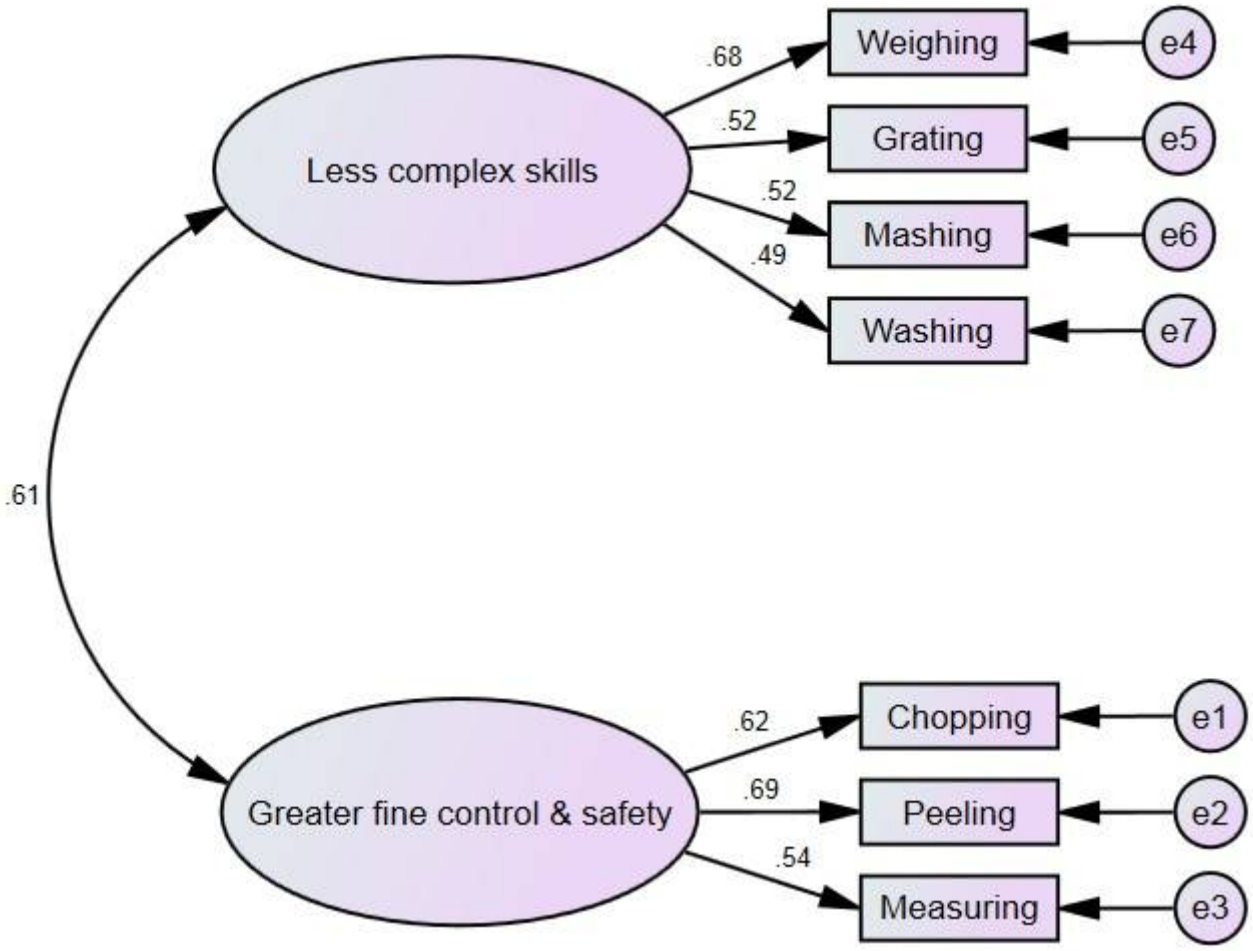

Figure 4

Final measurement model for CooC7 with standardised factor loadings and correlations