Manchester Metropolitan University

Massey, Simon (2021) Using Emojis and drawings in surveys to measure children's attitudes to mathematics. International Journal of Social Research Methodology. ISSN 1364-5579

Routledge
Taylor & Francis Group

International Journal of Social Research Methodology

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/tsrm20

Using Emojis and drawings in surveys to measure children's attitudes to mathematics

Simon Massey

To cite this article: Simon Massey (2021): Using Emojis and drawings in surveys to measure children's attitudes to mathematics, International Journal of Social Research Methodology, DOI: 10.1080/13645579.2021.1940774

To link to this article: https://doi.org/10.1080/13645579.2021.1940774

INTERNATIONAL JOURNAL OF SOCIAL RESEARCH METHODOLOGY
https://doi.org/10.1080/13645579.2021.1940774

Routledge
Taylor & Francis Group

OPEN ACCESS Check for updates

Using Emojis and drawings in surveys to measure children's attitudes to mathematics

Simon Massey

Department of Sociology, Manchester Metropolitan University, Manchester, UK

ABSTRACT
This article considers the implementation of Emojis as responses within survey research, measuring attitudes towards mathematics in children aged eight and nine years old. Participants answered two multi-item scales. The first required them to provide an Emoji to provide their responses to statements, whilst the second additionally required them to draw the Emoji they wished to use. The rationale was to allow children to feel more familiar with the common means of communication used in a 'digital era' in order to aid reliability and validity of thge measures. Evidence suggests that future research be carried out to measure and assess children's attitudes with techniques from the current study to help them understand the nature of what is being researched. This article concludes that children as young as eight years old can be deemed reliable respondents for survey methods and that more research should be carried out to capture children's attitudes to concepts.

KEYWORDS
Emoji; child; child-centred research; quantitative; survey

Introduction

Quantitative research is less common with children respondents (Kellett, 2011) due to concerns such as whether they will understand the questions asked and remain engaged throughout the questionnaire (Kellett & Ding, 2004; Mabelis, 2019; Wadsworth, 2003). However, research with samples aged as young as five years old has produced evidence that suggests respondents engaged in surveys reliably (Beilock et al., 2010; Suinn et al., 1988). Research has found that children can and do provide reliable responses if questioned in a manner that they can understand and about events that are meaningful to them (Kellett & Ding, 2004). The minimum age a respondent should therefore be when answering a questionnaire is dependent on the questions and topic (Ghazi et al., 2014; Mabelis, 2019; Wadsworth, 2003). This paper wishes to add that the use of Emojis in a questionnaire for younger age groups may provide additional tools to engage younger respondents and therefore aid the reliability and validity of their responses.

Whilst the research assessing the usefulness of Emojis, much like this paper, concern psychology, an additional argument is that using such tools in social research is also beneficial. Literacy differences can provide added difficulties and this is often the case with child respondents (Mabelis, 2019). So far, Emojis have appeared to be useful in questionnaire-based research (Alismail & Zhang, 2018; Fane, 2017).

This paper discusses the uses of Emojis as responses in a 17-item scale that was inspired by Hunt et al.'s (2011) MAS-UK measure, adapted from an original Mathematics Anxiety study in University Students in the USA (Richardson & Suinn, 1972). The second measure, involving

CONTACT Simon Massey s.massey@mmu.ac.uk Department of Sociology, Manchester Metropolitan University, 343 Geoffrey Manton Building, All Saints, 4 Rosamond Street West, Manchester M15 6LL, UK
Supplemental data for this article can be accessed here.

drawing the Emojis, was a 6-item scale aiming to measure initial feelings of Children's attitudes to mathematics. Factor analysis identified two distinct factors of Children's' attitudes to mathematics within the 17-item scale and extracted one factor from the 6-item scale as originally designed. Reliability analysis produced evidence of high reliability within both factors. Additional evidence of validity allowed to conclude that the use of Emojis in attitudinal survey research with children as young as eight years old can yield reliable responses.

Survey research with Emojis

Over recent years, the use of Emojis in academic research has been introduced quite successfully (Alismail & Zhang, 2018; Danesi, 2016; Fane, 2017; O'Brien, 2016). In the fields of Education and Behavioural Sciences, the use of Emojis has been more concerned with learning efficiency (Brody & Caldwell, 2019; Dunlap et al., 2016), abilities in self-expression (Fane, 2017; Fane et al., 2018) and successfulness of communication (Danesi, 2016; O'Brien, 2016). An identified advantage is the familiarity with Emojis when communicating, particularly with younger age groups (McCulloch, 2019). Given the regular use of modern communication technology, it is suggested that Emojis exhibit familiar behaviour in young people's everyday lives (Fane, 2017; Greig et al., 2013). The use of Emojis in research is increasing (Bai et al., 2019). This paper will draw on the findings of a recent study of eight and nine-year-old children's attitudes to mathematics, providing details of exploratory factor analysis and reliability analysis on two separate measures and providing evidence to suggest the measures were reliable.

Fane (2017) used Emojis to measure children's perception of their own well-being, using child-centred methods to collect responses as recommended by Kellett (2011). This research carried out similar techniques, using a combination of provided Emojis to allow children to respond, whilst additionally providing opportunities to draw the Emoji they wished to respond with.

Limitations

Whilst the use of Emojis provides notable advantages, such as familiarity in communication (Alismail & Zhang, 2018; McCulloch, 2019) and bridging differences in literary expression (Mabelis, 2019), limitations have also been identified. Specifically, Emojis' usefulness is evidently within self-reporting studies (e.g. Questionnaires), meaning there are still common disadvantages with the associated methods. Bai et al. (2019) note that respondents' emotions are still complex and simply cannot be captured through one particular Emoji and that more qualitative studies understanding peoples' use of Emojis may prove beneficial. This argument is particularly relevant to the current self-completion-based research. This paper therefore recognises the use of Emojis should not be considered a solution nor a means of reducing limitations of questionnaires whilst equally recognising they do provide an alternative strategy to gather responses from younger people, based on the advantages discussed.

Methods

Closed, self-completion questionnaires were used with pupils in Year 4 (8–9 years), within Primary Schools in North West England, to measure their attitudes to mathematics. The questionnaires were completed on paper in enclosed booklets without the help of teachers or the researcher. The researcher was present in the classroom and made it clear to pupils that this was not work and they did not need to complete the questionnaire if they did not want to. The questionnaire was enclosed in a booklet and pupils therefore could complete (or not complete) the questionnaire without the researcher's knowledge of who they were.

An important aspect of ensuring respondents are engaged is making sure that the questionnaire used to measure their responses is easy to understand (Kellett, 2011; Mabelis, 2019). When considering young respondents, there must be more effort to ensure that the respondents understand the questions they are answering and the responses they give (Kellett, 2011). This also concerns the ethical nature of the approach in ensuring respondents are aware of what is being researched (McLeod, 2009).

By adopting already existing techniques to maintain good practice such as Likert Scales (LaMarca, 2011), this research aimed to increase reliability and validity by using means of language commonly expressed amongst the age group of the sample, which was eight and nine year old pupils. Two different measures were used to assess how children respond to multi-scale measures and offer different techniques of using Emojis to provide responses. Those two techniques were circling provided Emojis and drawing the Emoji to represent the intended response.

Participants

The sample consisted of 508 (Males, n = 243, 49.1%; Females, n = 252, 50.9%) pupils from 10 different schools located across Greater Manchester, Lancashire and Nottinghamshire. Additionally, the sample was predominantly White (n = 334, 69.3%). Due to a multitude of different ethnic minorities and a small sample size of 508, Ethnic minorities were grouped together. This established a proportion of Black and Minority Ethnic (BAME) pupils (30.7%) similar to the nationally reported percentage (33%) (Department for Education, 2018) for that academic year.

Missing data

A total of 69 respondents were removed from failing to answer one or more of the 17 items, and a total of 58 were removed from failing to answer one or more of the additional 6 item measure. The sample for analysis was therefore reduced to 439 for the 17-item measure and 450 for the 6-item measure. This was prior to factor analysis, which will be discussed in the following section.

Factor analysis, reliability and construct validity

The study aimed to provide a methodology that appropriately assessed whether multiple variables measured the intended latent constructs (Martin, 2021), whether those constructs had sufficient internal consistency to be regarded as reliable measures (Cronbach, 1951) and whether those measures demonstrated construct validity. This followed a very similar process to Hunt et al. (2011), who inspired aspects of the current study, and is recommended practice in quantitative social research (Giannoulis, 2021; Osborne, 2015). Details of each stage will be discussed.

Factor analysis

An exploratory factor analysis was carried out on both scales. This meant that principal axis factoring (PAF) would be used to assess how well the 17 and 6 items relate to one another and together measure the latent constructs (factors) that are attitudes to mathematics or alternatively identify if there are more than one factors being measured (Martin, 2021). In social science research, correlation amongst factors is usually expected due to nature of people's behaviour not being independent of one another (Osborne, 2015), which would warrant an oblique rotation method that takes such a correlation into account (Brown, 2009; Rahn, 2021). On both occasions, PAF was carried out using an oblique rotation method, direct oblimin, assuming that the variables were measuring distinct or related concepts. Evidence from the factor correlation matrix (produced in IBM SPSS 25) indicated this to be the appropriate method of rotation for both scales.

Reliability

Following the extraction of two factors from the 17-item scale and one from the 6-item scale, a series of reliability analysis was carried out using the Cronbach's Alpha (1951) test. Following the reliability analysis, validity was assessed by carrying out correlations between the multi-item scales.

Construct validity

Additionally, assessing if those who stated mathematics to be their favourite subject had higher attitudinal scores than those who did not was also used to test construct validity. Literature indicates importance in valuing mathematics in order to attain positive attitudes (Kalder & Lesik, 2011; Meece et al., 2006; Tapia & Marsh, 2004). Whilst value was measured in the attitudinal scale by asking whether they like maths and think maths is important, pupils were additionally asked outright what their favourite subject was. Respondents were required to answer a statement by providing the favourite subject by finishing the following statement: 'My favourite subject is ______'. This was dichotomously coded into maths or other. Any subject that was not mathematics was coded as other in order to assess whether those who value mathematics as their favourite subject had more positive attitudes than pupils favouring any other subject. All analysis was conducted in IBM SPSS Statistics 25.

Introducing the measures

Behavioural attitudes to mathematics (BAM)

This research originally aimed to measure maths anxiety amongst children in KS2 (7–11 Years Old). Maths Anxiety measures are not uncommon, and have received much attention and development over the last four decades (Beasley et al., 2001). However, as the memory and cognitive processes of children between 7–12 years of age are still developing, there is a requirement for careful examination of questions used for data collection (de Leeuw, 2011). Reviewing the draft questionnaire with year 4 (age 8–9 years) primary school teachers highlighted the issue that the term 'anxiety' may not be understood by the sample who would be of year 4 ages. A decision was therefore made to provide neutral statements that provided the respondents their own opportunity to express enjoyment or worry about different mathematical scenarios, as this is terminology practitioners advised the respondents would understand. This was in attempt to measure children's attitudes to mathematics. Measures of Maths Anxiety commonly used tend to address older respondents, such as undergraduate students (Hunt et al., 2011; Suinn & Winston, 2003). Whilst some research on maths anxiety has been conducted on 11–12 year olds, this was in the USA (Beasley et al., 2001) and children have remained understudied in the UK.

A decision was made to use an adapted version of the UK maths anxiety measurement, Maths Anxiety Scale-UK (MAS-UK) (Hunt et al., 2011), which evidenced validity and permission from the authors was granted. Given the survey was provided to university students about mathematics in their classes, which reflected the method of the current research, it was felt that many questions, if reworded, could be applicable to school pupils. For example, statement 1 in the current study, 'having a teacher watch you multiply 4 × 3 on paper' was adapted from the original statement, 'having someone watch you multiple 12 × 23 on paper'. This was also practiced in Hunt et al. (2011) as they adapted their measure from the original MARS (Richardson & Suinn, 1972). An additional decision was made to remove questions not applicable to the sample as they would not have yet studied the level of mathematics, such as the statement, 'reading the word algebra'. This also helped condense the questionnaire for the age group to meet a certain time frame (Mabelis, 2019). Research suggests that attention spans in eight and nine year olds can be very short in comparison to adults. The Student Coalition for Action in Literacy Education present a formula to predict attention span that is 'attention span for learning = chronical age + 1'. In this case, the respondents should be expected to have an attention span of no longer than 9–10 minutes.

Figure 1 is the image provided to the child respondents prior to answering the measure, indicating which Emoji should be circled to provide their intended response, along with the coding for responses.

Like other previously validated measures (Richardson & Suinn, 1972; Suinn et al., 1988; Tapia & Marsh, 2004) the current research provided different scenarios associated with mathematics and provided respondents with the option to indicate how they would feel in that particular situation. This research took the same approach as previous methods to uphold consistency within methods used to measure attitudes that are reliable and valid.

Table 1 lists each of the 17 items used.

Child attitudes to mathematics: a more interactive measure

The 17-item statement measuring Behavioural Attitudes to Mathematics was based on how the respondent would react to a certain situation that involved some sort of mathematics. However, this did not concern the initial feelings that may influence attitudes towards mathematics, such as motivation and how pupils may value mathematics (Tapia & Marsh, 2004), which have been identified as crucial to positive learning (Bandura & Cervone, 1986; Schunk, 1991). It is also recommended that a smaller number of items should be used with younger ages (Kellett, 2011;

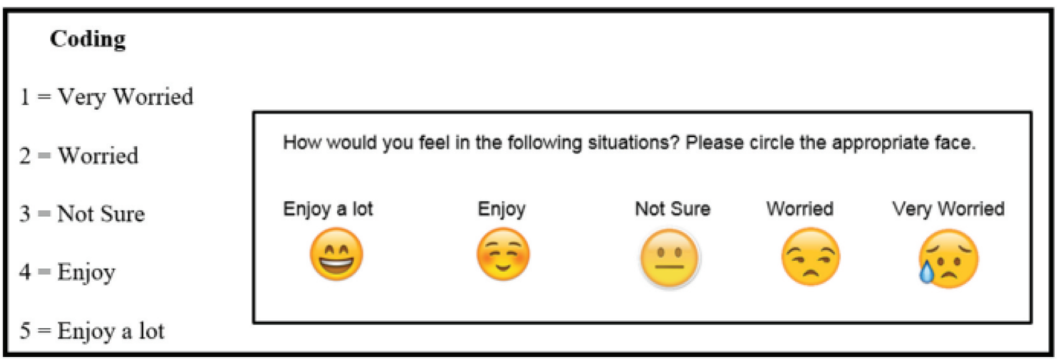

Figure 1. Behavioural attitudes to mathematics response system.

Table 1. Items for behavioural attitudes to mathematics.

Section	Item
S1	Having a teacher watch you multiply 4 × 3 on paper
	Being asked to add up the number of people in a room
S2	Being asked to write an answer on the board in front of your class
	Being asked to calculate £10 divided by four in front of your teacher
	Being asked a maths question by a teacher in front of your class
S3	Taking a maths test
	Being asked to calculate a percentage
	Working out how much time you have left before you set off to school
	Deciding how many sweets each friend can have if you are all sharing
S4	Calculating with a pencil on paper
	Adding up a pile of change
	Calculating how many days until somebody's birthday
	Working out how much change you should have after buying sweets
S5	Listening to someone talk about maths
	Watching someone multiply a one-digit number by a two-digit number
	Sitting in a maths class
	Watching the teacher doing times table on the board

Mabelis, 2019). This led to the decision to design another more concise multi-item scale known as ‘Child Attitudes to Mathematics’. The measure focused on the recommendations listed above whilst still measuring children’s feelings towards the subject as opposed to different mathematical experiences. Therefore, this scale only aims to measure initial attitudes towards mathematics, whilst attempting to provide evidence of validity through correlating with the other measure.

The main objective however, was to provide an additional element of interactivity to further aid concentration, which is not uncommon when working with child respondents. Kellett (2011) discussed the new wave of participatory research that has emerged, which consults with and listens to children by directly involving them within the research process itself. When discussing the measure with the respondents, this was done so in a way that informed the respondents of how they were required to draw their own Emojis whilst providing their responses. Therefore, the respondents had to respond to statements by drawing the provided Emoji in the appropriate column. As it was of utmost importance that the whole questionnaire was designed in a way to maintain concentration and within a timeframe recommended and dependent on age (SCALE, 2014), it was decided that there must be an additional set of rules in how one could respond to the 6-item measures.

The measure was designed by opting to use a five-point Likert Scale response system from ‘Strongly Agree’ to ‘Strongly Disagree’. There were six statements that respondents had to answer, all of which included five blank Emojis (one for each response). Respondents had to fill in one blank Emoji per statement. That Emoji had to be filled in the correct column in order to provide the answer they wished. Figure 2 provides the measure as seen by the respondent prior to answering the survey.

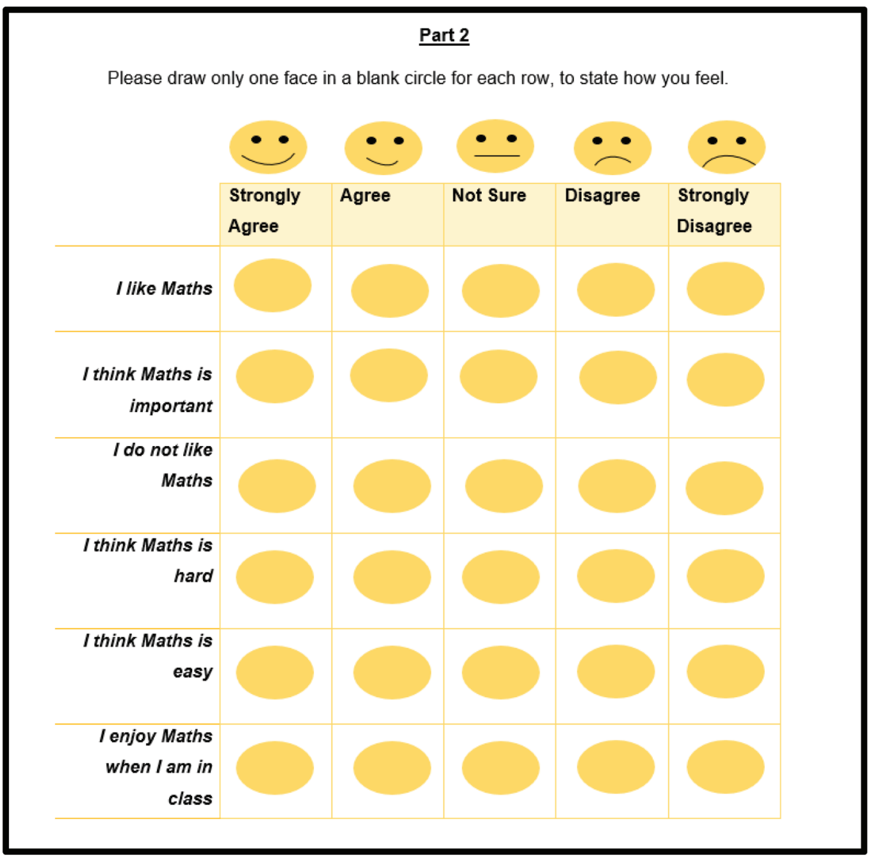

Figure 2. Child attitudes to mathematics.

Therefore, if a respondent wished to 'Strongly Agree' with a statement, they had to provide the correct Emoji to represent 'Strongly Agree' and provide that face in the 'Strongly Agree' column for that answer.

The measure was coded by using a scale of 0–4, with 4 representing 'Strongly Agree'. The negative statements were reverse coded. The measure aimed to provide another layer of reliability in measuring the respondents' attitudes by ensuring that different responses were provided for different statements. For example, the statements: 'I like Maths' and 'I don't like Maths' were intentionally written as opposing statements with reverse coding for the latter. In providing consistent responses, along with the correct face in the correct column, the measure itself builds evidence to suggest that the respondents understood the statements throughout their answering of the survey. Whilst there is concern about negative statements and whether they confuse respondents (Mabelis, 2019), psychological evidence such as Piaget's 'Concrete Operations' (in Wadsworth, 2003) argues that this age group is capable of logical thought (Ghazi et al., 2014). This warranted the attempt to further the reliability of the measure, whilst ensuring statements remained short and worded clearly (de Leeuw, 2011; Mabelis, 2019).

This measure combined techniques such as a 'Draw a Person' task (Beilock et al., 2010; Syyeda, 2016) and visible acts of meaning in the form of using Emojis to develop response techniques in academic research (Alismail & Zhang, 2018). A similar technique was carried out with older pupils (Syyeda, 2016), where respondents answered Likert scale items and were additionally asked to draw pictures about their perception of mathematics and how it impacts their lives, inspired from other studies (Smith, 2011; Di Martino & Zan, 2010; Adelson & McCoach, 2011 in Syyeda, 2016). In the USA, Beilock et al. (2010) had their respondents, who were as young as five years old, complete a similar task, where they had to draw a person who they knew that fitted a story about a fictional character's mathematics ability. Whilst this measure did not require the drawing of pictures, it did still require the drawing of Emojis and similarly directly involved the young participants in the research (Kellett, 2011). The techniques discusses appeared to consistently maintain respondents' engagement in the task (Mabelis, 2019) and statistical analyses produced evidence of reliability, which will be discussed in the following chapter.

Findings

Exploratory factor analysis

Behavioural attitudes to mathematics (17-item measure)

Principal Axis Factoring was used with a direct oblimin rotation. Echoing the findings of Hunt et al. (2011), the 17-item measure extracted three factors, with factor 2 extracting the originally intended construct. Factor 1 was extracted with six items and factor 3 with two items. A total of five items were found to have small coefficients (lower than 0.4) in all factors and were therefore not recognised as measuring the intended constructs. Therefore, of the 17 items used to measure pupils' attitudes to mathematics, 10 sufficiently did so, extracting two multi-item scales.

More specifically, the five subscales originally presented were extracted into two sufficient new subscales, combining elements of scales 1, 2 and 3, and extracting subscale 5 as originally designed. This provides evidence to suggest that this age group may have less complex attitudes to mathematics than older counterparts, which may be valid given their more limited experiences with mathematics up to their point of education and expected level of cognitive development.

Table 2 provides the details of the exploratory factor analysis, including the factor loadings.

Reliability: internal consistency

A reliability analysis was carried out for the entire measure, as would have been originally intended, followed by the two extracted subscales. Cronbach's Alpha for the overall scale was

Table 2. Exploratory factor analysis of 17-item scale.

Exploratory Factor Analysis: 17-Item Measure			
	1	2	3
Having a teacher watch you multiply 4 × 3 on paper	.502		
Being asked to add up the number of people in a room			
Being asked to write an answer on the board in front of your class	.753		
Being asked to calculate £10 divided by four in front of your teacher	.527		
Being asked a maths question by a teacher in front of your class	.675		
Taking a maths test			
Being asked to calculate a percentage	.514		
Working out how much time you have left before you set off to school	.422		
Deciding how many sweets each friend can have if you are all sharing			
Calculating with a pencil on paper			
Adding up a pile of change			−.679
Calculating how many days until somebody's birthday			
Working out how much change you should have after buying sweets			−.748
Listening to someone talk about maths		.704	
Watching someone multiply a one-digit number by a two-digit number		.519	
Sitting in a maths class		.487	
Watching the teacher doing times table on the board		.742	

highly reliable (a = .89) with reliability being identified in the newly extracted Factors 1 and 3 (a = .79; a = .75).

Factor labelling

Following Hunt et al.'s (2011) labels of their factors respectively, Factor 1 was labelled Evaluative Attitudes to Mathematics and Factor 2 Observational Attitudes to Mathematics. Looking at the EFA of the 17-item measure, Factor 1 appears to consist of items that require the respondent to state how much they enjoy carrying out specific tasks and more so in front of a teacher or others. An additional item asking them how much they enjoy working out how much time left before school was also extracted. Factor 2 was extracted as the originally intended subscale. This will therefore be labelled Observational Attitudes to Mathematics in respect to Hunt et al.'s (2011) Observational Anxiety. The wording of all items implies observing others carrying out mathematical tasks. The lower number of constructs identified should be expected given the wealth of research that shows children respondents should not be expected to possess the same complexity in their cognitive structuring (Kellett, 2011).

Child attitudes to mathematics (6-item measure)

Principal Axis Factoring was used with a direct oblimin rotation. With a KMO value of .767 indicating sufficient sampling adequacy, one factor was extracted with all items above .4. Details regarding the factor loadings can be found in the supplementary online material (table i).

The Cronbach's Alpha (1951) test provided evidence of high reliability for the six item measure (a = .827). This provides evidence to suggest that the six items collaboratively measure attitudes to mathematics well and do so consistently.

Descriptive data

All measures indicated negative skews, implying the majority of the sample had positive attitudes to mathematics. Child Attitudes had a strong negative skew and a relatively high mean of 18.5 (standard deviation = 4.2) in a range of 8 to 24. The mode answer was the maximum possible score of 24. As the findings coincide with that of the 17-item BAM measure, we can argue that pupils answered both scales consistently and this will be discussed in more detail in the following section.

A potential reason for the skews in all three measures could be associated with sampling. Specifically, the average maths progression scores and average scores in maths were significantly higher than the national average. This must therefore be taken into account when assessing any potential associations between attitudes and pupil characteristics.

Missing data appeared to be similar amongst all three measures and in most cases those who were missing from the 17-item measure were also missing from the 6-item measure. This was either due to failing to answer one or more statements, providing the incorrect emoji in the appropriate column for the 6-item measure or providing the same answer to opposing statements in the 6-item measure. Whilst no patterns were identified in the current study, a more detailed analysis could prove beneficial with larger studies.

Construct validity: assessing attitudes according to favourite subject

Independent sample *t*-Tests were due to be used for all three measures with the independent variable measuring pupils' favourite subject. Due to two of the measures failing to meet parametric assumptions, Mann-Whitney tests were ran alternatively. This was due to the lack of homogeneity amongst the sample when comparing those who indicated mathematics to be their favourite subject and those who did not.

The bivariate tests carried out consistently identified a significant difference between the two groups where those who stated mathematics to be their favourite subject reported higher attitudinal scores. All three tests yielded p values of <.001. Details of the bivariate tests can be found in the supplementary online material (table ii).

Assessing the relationship between the measures

Pearson's correlation tests were carried out to test the relationship between each measure. All three correlations yielded highly significant, positive relationships between all measures, providing additional evidence of validity.

Table 3 provides details of the correlations ran between all three measures.

Discussion

Previous evidence indicates the age of range of the current sample (8–9 years) can reliably answer questionnaires (Beilock et al., 2010; Bloom, 2008; Ghazi et al., 2014; Wadsworth, 2003). This paper set out to identify if we can add to that evidence and reliably measure Children's Attitudes to Mathematics through Emojis. Additionally, this research aimed to assess whether the use of more engaging methods such as drawing Emojis would aid in increasing the reliability and validity of responses. Overall, the conclusion is that these techniques can be regarded examples of good practice when conducting survey research with younger children.

All three measures indicated sufficient reliability and sufficient validity, providing evidence to suggest the techniques discussed can be regarded as good practice in survey research with children. All three measures however, also provided strong negative skews with the majority of the sample displaying positive attitudes, which must equally be considered.

Table 3. Correlations between scales.

	Evaluative	Observational
Child Attitudes	.42***	.52***
Evaluative	NA	.51***

*** = P < .001.

Discussing measurement of pupils' overall attitudes to mathematics

The decision to use Emojis as responses highlighted the benefits in their use when questioning young respondents who are 'natives' of the digital world and its modes of communication (Alismail & Zhang, 2018; Danesi, 2016; O'Brien, 2016) through evidence of reliability, validity. The vast majority of the sample had positive attitudes to mathematics and previous research has also identified established attitudes around this age (Beasley et al., 2001; Beilock et al., 2010; Bloom, 2008).

Asking respondents to draw people has been successful in other academic research in both young (Beilock et al., 2010) and older people (Syyeda, 2016). Figure i in the supplementary materials provides an example of a respondent's answers were the opposing statements have been answered consistently. This provides an example of having pupils directly participate in the research through answering responses in a more interactive nature that increases engagement and their reliability as respondents (Kellett, 2011).

We can therefore aim to understand children better by directly involving them in the research process (Kellett, 2011). Furthermore, using additional methods such as clear, concise statements to ensure understanding of the questions (Mabelis, 2019) enables respondents to provide responses they also clearly understand (Alismail & Zhang, 2018).

Reflecting on the limitations of the research: improving future study

Dimensionality

Dimensionality was first identified in the exploratory factor analysis of the original 17-item measure. Whilst two factors were identified a number of items were not included. The original scale was therefore not assessed despite evidence of high reliability through Cronbach's Alpha (1951). It is therefore suggested that more research be carried out with the measure. For example, the current study did not conduct a confirmatory factor analysis of the two extracted factors, nor the original scale in its 17-item form. The evidence of dimensionality must be considered, particularly given the recommendations to use fewer questions and clearly worded items with children (Kellett, 2011; Mabelis, 2019). The 6-item measure for Child Attitudes provides evidence to support this argument. It is therefore recommended that smaller subscales be used in future study with this age group.

Methods of testing psychometric properties

Alternative methods are recommended for repeated studies. For example, the Exploratory Factor Analysis used to test dimensionality of the measures assumes the scales being used are continuous. In the case of the current research, the items used were ordinal Likert scales, therefore failing to meet this assumption. Alternative and more robust measures, such as Item Response Theory, could provide a more holistic analysis of the properties of the measure.

The range of methods available to test psychometric properties should not be overlooked and more evidence can be gathered to identify whether the measures used in this research are in fact reliable and valid. The methodological strengths in this study are still important to acknowledge, whilst welcoming other methods to increase the overall strengths of survey research with children respondents.

Other considerations for future study

Whilst evidence of high reliability was identified along with some evidence of validity, there were additional limitations to be addressed in order to recommend how this methodology should be repeated. Firstly, whilst this research did not have a sufficiently large amount of missing data, larger studies with presumably more missing data would benefit from a detailed missing data analysis. For example, this study coded responses as missing where pupils provided the incorrect drawing of an Emoji or provided the same answer to opposing statements. A deeper analysis of larger missing data should be carried out in order to assess whether the methods used in this age group do lead to any associated consequences.

The wording of items, like other research, can also be criticised. Specifically, the wording of response options in observational and evaluative attitudes (worry and enjoy) require reflection. Whilst presented to be different in the questionnaire, an argument can be made that one may not enjoy something whilst also not worrying about it. It must be noted that this wording was advised by year 4 practitioners and that for more international audiences and research with different samples should consider alternative wording. In addition, the research consisted of a series of limitations associated with measurement validity and the distribution of the data gathered.

Conclusion

This research aimed to identify whether the use of Emojis and specifically requiring child respondents to draw Emojis would elicit highly reliable multi-item attitudinal measures. With a comparable sample of a pupil population in Year 4 (eight to nine years) from UK primary schools and evidence of high reliability, this measure provides evidence of a reliable methodology to measure young children's attitudes of this age.

It can be argued that based on the evidence discussed, children respondents can be reliable in survey research and the following techniques can be regarded as good practice when working with younger children in research. Using the techniques of this research and previous studies can provide opportunities to build an understanding of issues from the child perspective. In the specific context of education, this could be an important step in beginning to understand why certain attitudes to important subjects differ and more importantly, when this begins to happen.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Notes on contributor

Dr Simon Massey is a Lecturer in Quantitative Sociology at Manchester Metropolitan University. Simon holds a PhD, an MSc in Applied Quantitative Methods, a BA in Sociology and Education Studies and is a fellow of the Higher Education Academy. His research interests currently lie in the Sociology of Education, Quantitative Methodologies with Children and developing pedagogical approaches for teaching Social Statistics. In his PhD thesis, he focused on children's attitudes to mathematics and identified a series of associated factors, including child demographics, teacher's attitudes and school characteristics.

References

Alismail, S., & Zhang, H. (2018). The use of emoji in electronic user experience questionnaire: An exploratory case study. *51st Hawaii International Conference onSystem Science*. [Online]. Retrieved February 2, 2019, from https://scholarspace.manoa.hawaii.edu/bitstream/10125/50315/paper0428.pdf

Bai, Q., Dan, Q., Mu, Z., & Yang, M. (2019). A systematic review of Emoji: Current research and future perspectives. *Frontiers in Psychology*, *10:2221*. Retrieved April 21, 2021, from https://doi.org/10.3389/fpsyg.2019.02221

Bandura, A., & Cervone, D. (1986). Differential engagement of self-reactive influences in cognitive motivation. *Organizational Behavior and Human Decision Processes*, *38*(1), 92–113. https://doi.org/10.1016/0749-5978(86)90028-2

Beasley, M. T., Long, J. D., & Natali, M. (2001). A confirmatory factor analysis of the mathematics anxiety scale for children. *Measurement and Evaluation in Counseling and Development*, *34*(1), 14–26. https://doi.org/10.1080/07481756.2001.12069019

Beilock, S., Gunderson, E., Ramirez, G., Levine, S., & Smith, E. (2010). Female maths anxiety affects girls' math achievement. *Proceedings of the National Academy of Science of the United States of America*, *107*(5), 1860–1863. https://doi.org/10.1073/pnas.0910967107

Bloom, A. 2008. *Attitudes to maths fixed by the age of 9*. [Online]. Retrieved April 15, 2019, from https://www.tes.com/news/attitudes-maths-fixed-age-9

Brody, N., & Caldwell, L. (2019). Cues filtered in, cues filtered out, cues cute, and cues grotesque: Teaching mediated communication with emoji pictionary. *Communication Teacher*, *33*(2), 127–131. https://doi.org/10.1080/17404622.2017.1401730

Brown, J. J. (2009). Choosing the right type of rotation in PCA and EFA. *JALT Testing & Evaluation SIG Newsletter*, *13*(3), 20–25. https://hosted.jalt.org/test/PDF/Brown31.pdf

Cronbach, L. J. (1951). Statistical methods applied to rorschach score: A review. *Psychological Bulletin*, *46*(5), 393–429. https://doi.org/10.1037/h0059467

Danesi, M. (2016). *The semiotics of Emoji: The rise of visual language in the age of the internet*. Bloomsbury Publishing.

de Leeuw, D. (2011). Improving Data Quality when Surveying Children and Adolescents: Cognitive and Social Development and its Role in Questionnaire Construction and Pretesting. *Annual Meeting of the Academy of Finland.*https://www.aka.fi/globalassets/tietysti1.fi/awanhat/documents/tiedostot/lapset/presentations-of-the-annual-seminar-10-12-may-2011/surveying-children-and-adolescents_de-leeuw.pdf.

Department for Education. (2018). *Schools, pupils and their characteristics: January 2018*.

Dunlap, J. C., Bose, D., Lowenthal, P. R., York, C. S., Atkinson, M., & Murtagh, J. (2016). 'What sunshine is to flowers: A literature review on the use of emoticons to support online learning.' *Emotions Technology Design & Learning*, Elsevier, London, 163–182. https://doi.org/10.1016/B978-0-12-801856-9.00008-6

Fane, J. (2017). Using emoji as a tool to support child wellbeing from a strengths-based approach. *Learning Communities: International Journal of Learning in Social Contexts [Special Issue: 2017 30th ACHPER International Conference]*, *21*, 96–107. https://doi.org/10.18793/lcj2017.21.08

Fane, J., MacDougall, C., Jovanovic, J., Redmond, G., & Gibbs, L. (2018). Exploring the use of emoji as a visual research method for eliciting young children's voices in childhood research. *Early Child Development and Care*, *188*(3), 359–374. https://doi.org/10.1080/03004430.2016.1219730

Ghazi, S. R., Khan, U. A., Shahzada, G., & Ullah, K. (2014). Formal operational stage of pieaget's cognitive development theory: An implication in learning mathematics. *Journal of Educational Research*, *17*(2), 72–84. https://www.thefreelibrary.com/Formal+Operational+Stage+of+Piaget%27s+Cognitive+Development+Theory%3A+An...-a0450281694

Giannoulis, C. (2021). *Life after exploratory factor analysis: Esimtating internal consistency*. The Analysis Factor 2021. Retrieved April 21, 2021, from https://www.theanalysisfactor.com/life-after-exploratory-factor-analysis/

Greig, A., Taylor, J., & Mackay, T. (2013). *Designing and doing research with children* (3rd ed.). SAGE.

Hunt, T., Clark-Carter, D., & Sheffield, D. (2011). The development and part validation of a U.K scale for mathematics anxiety. *Journal of Psychoeducational Assessment*, *29*(5), 455–466. https://doi.org/10.1177/0734282910392892

Kalder, R. S., & Lesik, S. A. (2011). A classification of attitudes and beliefs towards mathematics for secondary mathematics pre-service teachers and elementary pre-service teachers: An exploratory study using latent class analysis. *Issues in the Undergraduate Mathematics Preparation of School Teachers*, 5.

Kellett, M. (2011). *Researching with and for children and young people*. Centre for Children and Young People [Online]. Retrieved July 14, 2016, from https://epubs.scu.edu.au/cgi/viewcontent.cgi?article=1044&context=ccyp_pubs

Kellett, M., & Ding, S. (2004). 'Middle childhood.' In: Fraser, Sandy; Lewis, Vicky; Ding, Sharon; Kellett, Mary and Robinson, Chris eds.*Doing research with children and young people*. Sage. London. 161–175.

LaMarca, N. (2011). The Likert Scale: Advantages and Disadvantages. *Field Research in Organizational Psychology* [Online]. https://psyc450.wordpress.com/2011/12/05/the-likert-scale-advantages-anddisadvantages/

Mabelis, J. (2019). *Design and developing a questionnaire for children in the growing up in scotland study*. ScotCen [Online]. Retrieved March 1, 2019, from http://the-sra.org.uk/wp-content/uploads/sra-scotland-gus-seminar.pdf

Martin, K. G. (2021). *The fundamental difference between principal component analysis and factor analysis*. The Analysis Factor. Retrieved April 21, 2021, from https://www.theanalysisfactor.com/the-fundamental-difference-between-principal-component-analysis-and-factor-analysis/#:~:text=One%20of%20the%20many%20confusing,and%20Factor%20Analysis%20(FA).&text=Despite%20all%20these%20similarities%2C%20there,model%20of%20a%20latent%20variable

McCulloch, G. (2019) *Children are using emoji for digital-age language learning*. Wired [Online]. Retrieved August 8, 2019, from https://www.wired.com/story/children-emoji-language-learning/

McLeod, S. (2009). *Attitude measurement*. Simply Psychology. [Online]. Retrieved November 2, 2018, from https://www.simplypsychology.org/attitude-measurement.html

Meece, J. L., Glienke, B. B., & Burg, S. (2006). Gender and motivation. *Journal of School Pyshcology*, *44*(5), 351–373. https://doi.org/10.1016/j.jsp.2006.04.004

O'Brien, G. (2016). *The word on the street is not a word: It's anfj*. [Online]. Retrieved May 29, 2019, from http://www.digitalamerica.org/the-word-on-the-street-is-nota-word-its-an-grace-obrien/
Osborne, J. W. (2015). What is rotating in explanatory factor analysis. *Practical Assessment, Research & Evaluation*, *20*(2), 1–7. https://scholarworks.umass.edu/cgi/viewcontent.cgi?article=1251&context=pare
Rahn, M. (2021). *Factor analysis: A short introduction, part 2-rotations*. The Analysis Factor 2018. Retrieved June 20, 2018, from https://www.theanalysisfactor.com/rotations-factor-analysis/
Richardson, F. C., & Suinn, R. M. (1972). The mathematics anxiety rating scale: Psychometric data. *Journal of Counseling Psychology*, *19*(6), 551–554. https://doi.org/10.1037/h0033456
Schunk, D. H. (1991). Self-efficacy and academic motivation. *Educational Psychologist*, *26*(3-4), 207–231. doi/abs/10.1080/00461520.1991.9653133
Suinn, R. M., Taylor, S., & Edwards, R. W. (1988). Suinn mathematics anxiety rating scale for elementary school students (MARS-E): Psychometric and normative data. *Educational and Psychological Measurement*, *48*(4), 979–986. https://doi.org/10.1177/0013164488484013
Suinn, R. M., & Winston, E. H. (2003). The mathematics anxiety rating scale, a brief version: Psychometric data. *Psychological Reports*, *92*(1), 167–173. https://doi.org/10.2466/pr0.2003.92.1.167
Syyeda, F. (2016). Understanding attitudes towards mathematics (ATM) using a multimodal model: An exploratory case study with secondary school children in England. *Cambridge Open-Review Educational Research e-Journal*, *3*(1), 32–62. https://doi.org/10.17863/CAM.41157
Tapia, M., & Marsh, G. E. (2004). An instrument to measure mathematics attitudes. *Academic Exchange Quarterly*, *8*(2), 16–21. http://www.rapidintellect.com/AEQweb/cho25344l.htm
The Student Coalition for Action in Literacy Education. (2014). *Behaviour Management: Important Facts*. [Online]. http://readwriteact.org/files/2014/07/BehaviorManagement-ImportantFacts.pdf
Wadsworth, B. J. (2003). *Piaget's theory of cognitive and affective development: Foundations of constructivism*. Allyn and Bacon.