

Development of the Adapted Fennema-Sherman Mathematics Attitudes Scales: A Tool for Use with Students Aged 9-11

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Abstract

Nearly 50 years ago, in an attempt to understand the factors influencing differences in students' learning of mathematics and their uptake of mathematics courses, Fennema and Sherman (1976) developed the Fennema-Sherman Mathematics Attitudes Scales (FSMAS). While developed in the US for secondary students, the tool remains useful in understanding several components of students' attitudes towards mathematics and continues to be widely used. However, the FSMAS presents limitations, particularly a misalignment with social changes in family structures and an insensitivity to educational contexts. This methodological paper describes the process of constructing and validating the Adapted FSMAS (AFSMAS) – a survey fit for use with preadolescent students in contemporary England. Adaptations to the FSMAS (AFSMAS) were informed by input from teachers ($n = 5$), cognitive interviews with students ($n = 10$), and trials with English primary school students ($n = 147$). Validation and reliability were assessed through content validity index scores, elimination of student misunderstanding of items, item-rest correlations, factors loading on their intended factor with no cross-factor loadings, and examination of the survey for items that lowered reliability or contained a high percentage of students failing to respond. The resulting AFSMAS scales, which reflect five of the original nine subscales (Attitude Toward Success in Mathematics, Teacher, Confidence in Learning, Mathematics Anxiety, and Effectance Motivation), constitute the first valid and reliable tool for measuring preadolescent students' attitudes towards mathematics in England.

INTRODUCTION

Understanding student attitudes towards mathematics is critical as these attitudes can influence the amount of time spent studying mathematics, the approach to subject content (Carey et al., 2016; Dowker et al., 2019; Mignogna et al., 2023), and the uptake of secondary, post-16, and university courses (Hart & Ganley, 2019). Attitudes are influenced by demographics, such as parental attainment, and student experiences, including teacher affective support and classroom instruction (Lei et al., 2018). Girls often view themselves more negatively in mathematics than their male peers (Pomerantz et al., 2002). These negative attitudes towards mathematics, particularly for girls, can be compounded by adverse classroom experiences from as early as primary school (aged 4–11) (Dowker et al., 2019) and have been reported to further decline between Key Stage 1 (aged 5–7) and Key Stage 2 (aged 7–11) (Henderson et al., 2022) and again at entry to post-16 mathematics (Biatchford, 1996; Krinzing et al., 2009).

Unfortunately, despite the early onset of students' attitudes formation, research in attitudes to date has focused almost exclusively on students in secondary school (Smith et al., 2021; Tapia, 1996; Yasar, 2016) and university settings (Aiken, 1974; Hodges & Kim, 2013; Yusof & Tall, 1998), with only a handful of recent studies exploring factors that contribute to primary students' attitudes towards mathematics (Adelson & McCoach, 2011; Chapman, 2003; Ganley & Lubienski, 2016). Crucially, however, to fully understand the factors that shape students' attitudes towards mathematics, interventions need to be trialled at an age when students' attitudes towards the subject are still forming. The ongoing Mathematics and Dialogue Study explores the role that dialogic teaching strategies might play in preadolescent girls' attitudes towards mathematics and responds directly to this need. The study depends upon a reliable and valid instrument to measure preadolescent students' attitudes towards mathematics in their final years of primary school. Consequently, the first stage of the ongoing study set out to develop a valid and reliable tool to measure multiple dimensions of attitudes towards mathematics that could be administered to preadolescent students in England in a group setting. This article presents the development of the Adapted Fennema-Sherman Mathematics Attitudes Scales (AFMAS). It then presents the AFSMAS as a final product of this process and demonstrates its validity and reliability. The resulting AFSMAS provides a quantitative tool for understanding the role interventions may play in improving the attitudes of preadolescent students in England towards mathematics.

Instruments for Measuring Attitudes Towards Mathematics

For decades, researchers have sought to gather data supporting an understanding of attitudes towards mathematics through observation or self-reporting surveys (Dwyer, 1993; Källberg & Roos, 2025). Self-reporting surveys allow the collection of data associated with attitudes directly from students rather than being interpreted through the observations of a third party. Many existing instruments ask students to self-report their attitudes towards mathematics (Willis, 2005). Understanding experiences, beliefs and emotions from their perspectives provides a foundation for developing interventions that may improve students' attitudes towards mathematics (Källberg & Roos, 2025). However, some attitudinal surveys have been described as imprecise, potentially leading to false correlations between attitudes and achievement (Ma & Kishor, 1997). One reason suggested for this imprecision is a failure to define *attitude* (Hannula, 2002). Indeed, despite literature frequently addressing attitudes toward mathematics, there is no universally accepted definition of attitude. Some studies utilise definitions that describe attitudes as simple favourable or unfavourable responses toward the subject (Moenikia & Zahed-Babelan, 2010). Others include an emotional response, beliefs related to mathematics, and behaviour related to the subject (Hart &

Ganley, 2019). In this study, we adopt Zan and Di Martino's multidimensional definition of attitudes towards mathematics, which describes attitudes as the "beliefs and emotions associated with mathematics" (2007, p. 157).

A literature review indicates that a proliferation of studies exploring attitudes towards mathematics began in the 1970s. At that time, the Fennema-Sherman Mathematics Attitudes Scales (FSMAS) were developed in response to a perceived gender difference in student attitudes towards mathematics (Fennema & Sherman, 1976). Fennema and Sherman recognised a higher rate of male students, compared to female students at a similar level of mathematics, electing into secondary mathematics classes. Using a five-point Likert scale, Fennema and Sherman measured nine components thought to have the strongest influence on attitudes towards mathematics: Attitude Towards Success in Mathematics, Mathematics as a Male Domain, Confidence in Learning, Mathematics Anxiety, Effectance Motivation in Mathematics, and Mathematics Usefulness, and (the student's perception of the interest, encouragement and confidence of their) Father, Mother, and Teacher. Data were collected from students in Grades 6–8 (aged 11–14: $n=1500$) and Grades 9–12 (aged 14–18: $n=1233$). Providing consistent information about individuals' attitudes and the differences between groups' attitudes, these early scales for measuring attitudes towards mathematics remain in prominent use.

At nearly the same time, Aiken (1972) developed the Attitudes Towards Mathematics Scale (ATMS) using a broad definition of attitudes, categorising them as "approximately the same thing as enjoyment, interest, and to some extent, level of anxiety" (Aiken, 1972, p. 229). He initially suggested attitudes towards mathematics included two components: recognising the importance and relevance to the individual and to society, and enjoyment of mathematics. However, two years after the release of his original ATMS, Aiken separated the Enjoyment of Mathematics subscale from the Recognising the Importance and Relevance to the Individual and to Society, suggesting that these subscales might measure separate dimensions of attitudes (Aiken, 1974). Aiken combined the Enjoyment of Mathematics with questions he described as addressing the value of mathematics, interests, and achievement, to create the Revised ATMS (Aiken, 1974). Aiken's Revised ATMS measured two factors: Enjoyment and Value. While the Enjoyment factor provides a holistic measure of attitudes towards mathematics, it does not allow for, as the FSMAS does, the separation of specific components of attitudes, which might be affected by interventions designed to improve attitudes towards mathematics. As such, it proves limited in its usefulness for the current study.

Another prominent attitudinal scale, cited in numerous recent studies (Häsä et al., 2023; Lim & Chapman, 2013; Lin & Huang, 2016), is the Attitude Towards Mathematics Instrument (ATMI) scale of Tapia (1996). Designed for students aged 11–18, the ATMI was developed decades after the surveys of Fennema and Sherman, and Aiken. The ATMI scale explores six components underlying attitudes (Value, Anxiety, Motivation, Confidence, Enjoyment, and Adults' Perspectives) through 49 items on a 5-point Likert scale ranging from "strongly disagree" to "strongly agree". In her 1996 article introducing the tool, Tapia included excerpts from seven ATMI statements, each of which bears a strong resemblance to items from the FSMAS. For instance, the ATMI prompts students to indicate their degree of agreement with the phrases "mathematics makes me feel uncomfortable" and "I have a lot of self-confidence when it comes to mathematics" (Tapia, 1996, p. 9); these are similar to FSMAS statements of "mathematics makes me feel uncomfortable and nervous" and "I have a lot of self-confidence when it comes to math". In the final iteration of the ATMI, Tapia (1996) eliminated the Adults' Perspectives subsurvey due to low item-to-total correlations and combined Anxiety and Confidence, creating a subsurvey of Security. While the ATMI appears to be an abbreviated version of the FSMAS, it remains unsuitable for the current study because it was designed for older students and in a different geographic region.

The main limitation of the aforementioned tools is that they were designed for and, until recently, used almost exclusively with students in the United States aged 14 through to university. For an English primary school audience, aged 9–11, these surveys include complex and unfamiliar language and concepts that are not immediately relevant, such as references to their future jobs. Furthermore, the number of items in many surveys makes completion in a single session impractical. More recently designed tools focus specifically on some of these limitations, aiming to measure primary students' attitudes towards mathematics. For example, Adelson and McCoach (2011) sought to measure three components of attitudes towards mathematics of elementary students (aged 5–12) in the US using the Math and Me Survey: Mathematical Self-Perceptions, Enjoyment of Mathematics and Perceived Usefulness of Mathematics. Enjoyment was thought to contribute to motivation (Wigfield & Eccles, 2002). Mathematical Self-Perceptions were aligned with Bandura's (1982) definition of self-efficacy alongside Fennema and Sherman's (1976) Confidence in Learning. Perceived Usefulness of Mathematics included Fennema and Sherman's Mathematical Usefulness scale (Adelson & McCoach, 2011). However, in the final version of the survey, the Perceived Usefulness scale was removed; this action was likened to the removal of questions about the usefulness and importance of mathematics on the Trends in International Mathematics and Science Study (TIMSS) for grade 4 students (aged 9–10) (Adelson & McCoach, 2011; Metsämuuronen, 2012). It was suggested that students aged 8–11 may not yet have a concept of their future jobs and the usefulness of mathematics in relation to these jobs (Adelson & McCoach, 2011). The resulting Math and Me Survey (Adelson, 2006), comprising 18 questions, was set to measure elementary students' (aged 5–12) mathematical self-perceptions and enjoyment of mathematics in the US. The survey has since been translated into Spanish for students aged 7–9 (Paz-Albo & Hervás-Escobar, 2023) and

Turkish for students aged 14–18 (Takunyaci et al., 2019). In considering a scale to measure attitudes towards mathematics among preadolescent students in England, the Math and Me Scale initially appeared more closely aligned with the target age group. Moreover, the survey's brevity would allow it to be administered in a single sitting. However, the Math and Me Survey excludes some components of attitudes towards mathematics, including mathematics anxiety, motivation, and teacher, that are of interest in the Mathematics and Dialogue Study. Furthermore, small wording changes to the Math and Me Survey, such as those required to adapt it to reflect the lexicon and classroom experiences of English primary students, were shown to negatively affect factor fits in earlier studies (Paz-Albo & Hervás-Escobar, 2023). Consequently, the Math and Me Survey was not fit for purpose in this study.

In contrast to the aforementioned surveys, the Mathematics Attitudes and Anxiety Questionnaire (MAAQ) was developed specifically for use with primary children (aged 6–9) in England (Dowker et al., 2019). However, in addition to being designed for students younger than those in the current study, the MAAQ uses four rating scales and is administered in a one-on-one interview, precluding its use in the Mathematics and Dialogue Study, which calls for administration in a whole-class setting. Moreover, while the MAAQ measures seven domains: Maths in General, Written Sums, Mental Maths, Easy Maths, Difficult Maths, Maths Tests, and Understanding the Teacher, the inclusion of items containing specific mathematics content raises concern that students may hold attitudes toward specific components of mathematics, such as adding fractions or completing word problems that require long division, that may not generalise to their overall attitudes towards mathematics (Aquilina et al., 2025).

In short, despite numerous reliable and valid tools for measuring attitudes towards mathematics (Adelson, 2006; McCarthy, 2019; Mulhern & Rae, 1998), no existing instrument emerged from the literature as an appropriate tool for measuring preadolescent students' attitudes towards mathematics in England. To develop a new tool for the audience of interest, a survey could have been created, components of the existing tools could have been combined, or a single existing tool could have been adapted. It seemed plausible that the FSMAS could be successfully adapted to be reliable and valid for an audience of preadolescent students in England by aligning its statements to the vocabulary, language, and experiences associated with England's classrooms. In the 50 years since the FSMAS was originally administered, it has been modified to reduce the length of the survey (Mulhern & Rae, 1998; O'Neil et al., 1988; Quaye & Pomeroy, 2022), altered to apply to subject areas other than mathematics (Dantzler et al., 2014; Downing & Filer, 1999), and translated into languages other than English (Alibraheim, 2021; Takunyaci et al., 2019). Maintaining the original 108 questions of the FSMAS and nine subscales, Takunyaci translated the FSMAS into Turkish and to reflect Turkish culture (2019), while Alibraheim translated the survey into Arabic (2021). Mulhern and Rae (1998) abbreviated the nine subscales for use with Irish primary students. Moreover, a shortened version of the FSMAS is used internationally as part of both the TIMSS and the PISA assessment frameworks (Metsämuuronen, 2012). Consequently, this study set out to develop the first valid and reliable tool for measuring the attitudes of preadolescent students in England by abbreviating and adapting the FSMAS for use with the target participants.

METHOD

Method of Survey Development

The Standards for Educational and Psychological Testing (American Educational Research Association [AERA] et al., 2014) describe aggregating purposeful information to measure a construct. In this instance, the AFSMAS was designed to measure attitudes in the form of "beliefs and emotions associated with mathematics" (Zan & Di Martino, 2007, p. 157) of students aged 9–11. Scores on the AFSMAS can be utilised as an indicator of individuals' or groups' attitudes towards mathematics. Meanwhile, the subscales of the AFSMAS may be used to understand the variables that influence individual or group attitudes towards mathematics. In constructing the AFSMAS, Kyriazos and Stalikas's (2018) steps of survey design were followed. This included sourcing potential items (i.e. *Sourcing*), item wording (i.e., *Wording*), item evaluation (i.e. *Evaluation*), and testing the psychometric properties of the scale (i.e., *Testing*). Further, to meet the needs of the ongoing intervention study, the survey needed to be designed for administration in a single whole-class setting (i.e., *Feasibility*). Below, we describe this AFSMAS survey development process (summarised in Fig. 1).

Stage 1: Sourcing

As suggested by Kyriazos and Stalikas (2018), survey items were sourced from an existing scale, in this instance the FSMAS. This allowed for building upon a survey shown to be reliable and valid in a variety of contexts while including items already aligned with the concepts being measured.

Subscales of the FSMAS

The FSMAS comprises 9 subscales, each formed of 12 statements, rated by survey takers on a 5-point Likert scale ranging from strongly disagree to strongly agree. Within each subscale, six statements are worded positively, such as “I like...”, while six are worded negatively, such as “I dislike” or “I do not like”. The nine subscales of the FSMAS include:

- The Attitude Toward Success in Mathematics Scale (AS) is designed to measure the extent to which students anticipate positive or negative consequences as a result of success in mathematics. They demonstrate their fear by anticipating negative consequences of success as well as by a lack of acceptance or responsibility for the success, for example, “It was just luck.” (Fennema & Sherman, 1976, p. 325)
- The Mathematics as a Male Domain Scale (MD) is intended to measure the degree to which students see mathematics as a male, neutral, or female domain in the following ways: (a) the relative ability of the sexes to perform in mathematics; (b) the masculinity/femininity of those who achieve well in mathematics; and (c) the appropriateness of this line of study for the two sexes (Fennema & Sherman, 1976, p. 325)
- The Mother (M)/Father (F) Scale is designed to measure students' perception of their mother's/father's interest, encouragement and confidence in the student's ability. It also includes the student's perception of their mother's/father's example as an individual interested in, confident of, and aware of the importance of mathematics (Fennema & Sherman, 1976, p. 325)
- The Teacher Scale (T) is designed to measure students' perceptions of their teacher's attitudes toward them as learners of mathematics. It includes the teacher's interest, encouragement, and confidence in the student's ability (Fennema & Sherman, 1976, p. 325).
- The Confidence in Learning Mathematics Scale (C) is intended to measure confidence in one's ability to learn and to perform well on mathematical tasks. The dimension ranges from a distinct lack of confidence to definite confidence. The scale is not intended to measure anxiety or mental confusion, interest, enjoyment, or zest in problem-solving (Fennema & Sherman, 1976, p. 326).
- The Mathematics Anxiety Scale (A) is intended to measure feelings of anxiety, dread, nervousness, and associated bodily symptoms related to doing mathematics. The dimension ranges from feeling at ease to feeling distinct anxiety. The scale is not intended to measure confidence in, or enjoyment of, mathematics (Fennema & Sherman, 1976, p. 326).
- The Effectance Motivation Scale in Mathematics (E) is intended to measure effectance as applied to mathematics. The dimension ranges from lack of involvement in mathematics to active enjoyment and seeking of challenge. The scale is not intended to measure interest in, or enjoyment of, mathematics (Fennema & Sherman, 1976, p. 326).
- The Mathematics Usefulness Scale (U) is designed to measure students' beliefs about the usefulness of mathematics currently, and in relationship to their future education, vocation, or other activities (Fennema & Sherman, 1976, p. 326).

In adapting the FSMAS, the constructs of the original survey were maintained while accounting for cultural differences (Epstein et al., 2015). Adaptation of a survey for a new cultural context requires affirmation that the content measured by the instrument, in this instance, attitudes towards mathematics, exists in the target population. The UK media frequently refers to students' attitudes towards mathematics in the English primary student population (aged 9–11) (Pepin, 2011), thereby supporting the construct in this population.

Stage 2: Feasibility

Stage 2 focused on ensuring the instrument was aligned with the needs of learners aged 9–11 in England and that the survey could feasibly be administered in a single session aligned with the attention span of students aged 9–11. The time required to administer all 108 questions of the FSMAS necessitated adaptations to the survey to allow it to be administered to students aged 9–11 in a single sitting. To maintain consistency with most abbreviated versions of the FSMAS, the decision was made to include complete subscales of the FSMAS rather than reduce the number of items in each subscale. To ascertain alignment and feasibility in administration, five experienced teachers, each with at least 10 years of teaching experience in England's primary schools and all currently responsible for teaching mathematics to preadolescent students, reviewed the first version of the AFSMAS and provided feedback regarding its use with students aged 9–11 in England. Four of the teachers expressed concern regarding the term “father” in the survey, indicating it is not a term used on forms completed by their students. One teacher referenced the 3.2 million lone-parent families and the potential challenge for primary students to identify a person they most closely identify with “father” or “mother” (Office for National Statistics, 2025) or that students might find the inclusion of the term upsetting. This, coupled with research indicating that factors related to parents (such as a parent's attainment in mathematics) appear to have a weaker effect on attitudes towards mathematics than classroom experiences (Davadas & Lay, 2017; Tapia, 1996), led to the removal of the father and mother subscales.

Additional considerations led to the exclusion of the Usefulness and the Mathematics as a Male Domain subscales. The Usefulness subscale was excluded because it refers to events in the distant future of those to be surveyed. For instance, it includes items about the usefulness of mathematics to students in their adult lives. Concerns about the unreliability of asking students to project their thoughts about ideas that will not occur for nearly ten years were the same reason items about usefulness were excluded from both the TIMSS and the Math and Me Survey. The Mathematics as a Male Domain subscale was also excluded. The FSMAS reflects cultural norms from the time of its development by suggesting that if mathematics were not considered a male domain, it would be considered a neutral domain. What seemingly had not been considered was that a respondent might consider mathematics a female domain, as has been documented at a later date (Forgasz et al., 1999). As a result, it can be argued that many items on this subscale no longer measure the intended construct. While the question of whether mathematics is a gendered domain remains an important component of understanding students' attitudes towards mathematics, alternative tools or methods can be used for obtaining these data (Brandell & Staberg, 2008; Forgasz et al., 1999).

Consideration was given as to whether to include the Mathematics Anxiety and Confidence in Learning subscales separately or to combine them, reflecting the overlap of these concepts identified in some studies (O'Neil et al., 1988). Fennema and Sherman themselves found overlap between the Mathematics Anxiety and Confidence in Learning domains while also indicating "for certain purposes it is important to measure each variable separately" (1976, p. 326). In a pilot study that preceded the current study, students addressed their anxiety differently than their confidence; the former was described as an in-the-moment feeling, while the latter was described as an ongoing thought that influenced participation or the lack thereof. As a result, Mathematics Anxiety and Confidence in Learning were included in the AFSMAS as distinct subscales. At the conclusion of Stage 2, AFSMAS Version 1, an abbreviated version of the FSMAS, was produced. It included five subscales: Attitudes Towards Success in Mathematics, Mathematics Anxiety, Confidence in Learning, Effectance Motivation, and Teacher.

Stage 3: Wording

Stage 3 of the instrument development was designed to ensure that students understood each item and interpreted it the same way as the researchers. Ultimately, this stage also contributed to the method by which the survey was utilised in the classroom. The five teachers were asked to suggest changes to the AFSMAS Version 1 that would align survey items with the vocabulary and context typically found in English primary classrooms (aged 9–11) while maintaining the intent of the original statements. Adjustments were made to the lexicon and grammar to ensure accessibility for the study population of preadolescent students in England (Guidelines for Best Practice in Cross-Cultural Surveys, 2011). The teachers suggested several wording changes, examples of which are shown in Table 1.

Table 1
Teacher Suggestions for Rephrasing of Version 1 AFSMAS Survey Items

Phrasing in Version 1 of AFSMAS	Phrasing Post Teacher Review	Rationale for Change
It wouldn't bother me at all to have more maths lessons.	I wouldn't mind having more maths lessons.	Simplify the language used.
I have found it hard to win the respect of teachers during maths lessons	I have found it hard to gain the respect of teachers during maths lessons.	The term "win" was thought to be confusing in this context.
Maths is enjoyable to me.	I enjoy maths.	Simplify the language used.
I don't like people to think I'm smart in maths.	I don't like people to think I'm good at maths.	Align the term "smart" with the classroom language "good".

Several teacher comments pertained to the administration of the survey. For instance, it was suggested that before beginning the AFSMAS, the Likert scale was explained to students, including examples of what is indicated by a "1" or "5", particularly for questions utilising reverse scoring. The teachers also recommended reminding students of the Likert scale periodically during survey administration. This was accomplished by including two pauses in the survey administration protocol, after questions 20 and 40, to remind students of the Likert scale. When probed, teachers indicated they did not believe the AFSMAS required one-on-one administration. They indicated that students aged 9–11 would be accustomed to completing a task of this length in a whole-class setting, and suggested that the survey could be read to students to facilitate engagement (Corciega et al., 2025). Stage 3 produced the AFSMAS Version 2, an abbreviated version of the FSMAS with teacher-suggested adaptations to wording and directions for use with students aged 9–11 in England.

Stage 4: Evaluation

Stage 4 of the AFSMAS instrument design was conducted to ensure that the ratings selected by students represent what was intended by the survey questions. This pre-testing was instrumental in identifying ambiguity in the statements and problems in the survey before larger-scale use, ensuring respondents understood the questions in the same way and reducing threats to validity. Before a larger-scale test, Version 2 of the AFSMAS was tested with students randomly selected from four state-funded Year 5 and Year 6 classrooms (*aged 9–11: n = 10*) (see Table 2). The school populations ranged from 29.8% to 50% of students receiving Free School Meals and from 38.4% to 58.6% of students for whom English is not their first language. The percent of students meeting the expected standard on the national Standard Assessment Tests ranged from 62% to 96% in reading and from 81% to 85% in mathematics.

Table 2

Year Group and Gender of Student Participants

Gender	Year 5		Year 6			Total		
	N	%	Gender	N	%	Gender	N	%
Male	2	20	Male	3	30	Male	5	50
Female	3	30	Female	2	20	Female	5	50
Total	5	50	Total	5	50	Total	10	100

In one-to-one cognitive interviews (Parrish, 2010), students (*n = 10*) were asked to: paraphrase questions; identify words or phrases they did not understand; describe their thought process when determining their own response on the Likert scale; explain whether they found it easy or hard to answer the question and why; and share what it would mean if one marked a “5” for the question (Parrish, 2010). To better understand students’ interpretations of items, in some instances, students were asked to share their criteria for deciding whether to mark a score of 4 or 5 and examples of their own experiences or those of their peers. Each question from the cognitive interview was asked of at least two students. In instances where students identified statements or language that were confusing or did not match what was familiar to them, multiple students were asked to provide alternative language (see Table 3).

Table 3

Phrasing Changes to AFSMAS Version 2 Initiated by Cognitive Interviews

Phrasing in Version 2	Concern Identified by Student	Revised Language
“Maths puzzles”	Students wondered if this meant jigsaw puzzles.	“Puzzles” was replaced with “games” to reflect the language used in the classroom.
“Take all the maths”	The student was unsure of what the phrase meant.	The phrase was replaced with “learn more maths” to reflect the experiences of the students.

Based upon the cognitive interviews, adaptations were made to the phrasing of several questions, resulting in Version 3 of the AFSMAS. Guided by input from teachers and students, it includes language and content aligned with the language and experiences of students aged 9–11 in England.

Stage 5: Testing

Stage 5 was designed to ensure the AFSMAS is reliable. The AFSMAS Version 3 was administered to Year 5 and Year 6 students (*aged – 11: n = 147*) in three state-funded London primary schools. The school populations ranged from 9.55% to 50% of students receiving Free School Meals, from 9.55% to 23.6% with special educational needs, and from 23.6% to 58.6% for whom English was not their first language. National Standard Assessment Tests showed that 73% to 96% of students met the expected standard in reading and from 81% to 85% in mathematics. The percentages of students reaching a high score in mathematics ranged from 35% to 62%. The student participant group included 80 Year 5 students and 67 Year 6 students; 85 were female, and 62 were male (see Table 4).

Table 4
Year Group and Gender of Student Participants

Gender	Year 5		Year 6			Total		
	N	%	Gender	N	%	Gender	N	%
Male	41	66.1	Male	21	33.9	Male	62	42.2
Female	39	45.9	Female	46	54.1	Female	85	57.8
Total	80	54.4	Total	67	45.6	Total	147	100

Administered in whole-class settings, the survey was provided to approximately 25 students per sitting. The AFSMAS Version 3 consists of 60 questions, with questions randomly arranged within the survey. Concepts were presented positively and negatively for reliability checks. For instance, students were asked to respond to both “I am usually calm during a maths test” and “A maths test would scare me”. The AFSMAS Version 3 was administered as a paper-and-pencil survey, aligned with the teaching materials used in the classes. After an introduction to the five-point Likert scale from 1 (strongly disagree) to 5 (strongly agree), survey statements were read aloud to students, and they were asked to indicate their response. Emphasis was placed on keywords, such as negatives within the statements. The physical structure of the survey on the page was divided into three sections. Students were reminded of the Likert scale twice during the survey administration. In the first two classrooms, at least two student participants requested clarification of the word “appeal” in a survey item. Although not previously identified by teachers or students as a concern, this word was unfamiliar to some. In these instances, “appeal” was verbally defined for students. For further administration, the term “appeal” was replaced with “interest”, resulting in the AFSMAS Version 4. There were no questions of understanding in the subsequent administrations of the AFSMAS using Version 4.

The resulting AFMAS (Version 4) includes five subscales: Attitude Toward Success in Mathematics, Mathematics Anxiety, Confidence, Effectance Motivation, and Teacher. Students were asked to respond to 60 statements on a five-point Likert scale. AFSMAS scores for individuals were calculated as the sum of their points. Items phrased negatively were reverse-scored. For instance, a low level of agreement or a mark of 1 on a negative question, such as “Maths usually makes me feel uncomfortable and nervous”, would contribute 5 points toward one’s AFSMAS score. The minimum student score was 115, the maximum 297 and the mean score 227.1. The mean score for questions ranged from 2.55 to 4.59, with the minimum response to each question being 1 and the maximum response being 5. The standard deviation of questions ranged from 0.95 to 1.61.

Survey items were tested based upon six criteria: content validity index (CVI) from teachers (Messick, 1987), misunderstanding of items from students, weak item-rest correlations (Metsämuuronen, 2020), poor or cross-factor loadings (Costello & Osborne, 2005), items that lowered reliability (Cronbach, 1951) and items with a high percentage of students failing to respond (Mignogna et al., 2023). Suitability of the data for factor analysis was assessed using Bartlett’s Test of Sphericity (Bartlett, 1950), the findings of which were significant $\chi^2(1770) = 5109.35, p < .001$, indicate that the correlation matrix was not an identity matrix – sufficient interrelation of items justified factor analysis. The internal consistency of the 60-item AFSMAS was excellent ($\alpha = 0.9635$), indicating a highly consistent schema. As seen in Table 5, subscale consistency ranged from acceptable to excellent ($\alpha = 0.7834–0.9370$). The average inter-item covariance was moderate at 0.545, suggesting strong inter-item coherence. The item-rest correlations suggest that each item contributes to the overall scale. No single item was shown to reduce reliability.

Table 5
Subscales and Cronbach’s Alpha for each Subscale

Subscale	Cronbach’s Alpha
Mathematics Anxiety	0.9322
Attitude Toward Success in Mathematics	0.8318
Confidence in Learning	0.9370
Effectance Motivation	0.8119
Teacher	0.7834

Exploratory factor analysis was conducted on the 60 items of the AFSMAS, using a five-factor solution based on the AFSMAS subsurveys: Mathematics Anxiety, Attitude Toward Success in Mathematics, Confidence in Learning, Effectance Motivation, and Teacher. The factor analysis revealed that Attitude Toward Success in Mathematics accounted for the greatest proportion of variance (35%). Effectance Motivation accounted for 11% of the variation; Teacher and Confidence in Learning each accounted for 8% of the variation; and Mathematics Anxiety accounted for 5%. The cumulative variance across the five factors is 74%, suggesting that the majority of the

variability in the data has been accounted for. Most items loaded on Attitudes Toward Success with loadings exceeding 0.4, indicating this factor is dominant in the AFSMAS structure. Effectance Motivation and Teacher play secondary roles, while Mathematics Anxiety and Confidence in Learning play more minor roles, with only a few items loading on these dimensions. Nonresponse rates for individual survey items ranged from 0 to 2%. There was no pattern regarding the items students left blank. As a result, no items were excluded from the study due to a high percentage of students failing to respond. Taken together, these components indicate that the AFSMAS is a reliable tool for measuring student attitudes towards mathematics.

The need to exclude students ($n = 11$) posed a challenge for this study. Students were excluded due to significant missing data resulting from nonresponse. While data were missing at random (McKinley & Swoboda, 2025) in some instances, as seen in Table 6, the surveys of 11 students were excluded from the study due to significant nonresponse to avoid error in analysis (Fowler, 2014) and to avoid compromising the reliability of the AFSMAS. For this study, significant nonresponse was defined as 10% or more of the survey questions left blank. Among surveys excluded were those partially completed by students who entered the classroom midway through survey administration and those unable to access the survey in a whole-class setting without additional support due to special educational needs or limited access to English.

Table 6
Students and Number of Missing Responses

Number of Missing Responses	Number of Students
0	108
1	18
2	7
3	1
4	2
5	0
6+	11

RESULTS

The resulting AFSMAS is a 60-item tool that measures students’ attitudes towards mathematics (as available in Online Resource 1). It has been adapted for use by preadolescent students in England and for administration in a large-group setting. Based on high content validity index scores, elimination of student misunderstanding of items, item-rest correlations indicating each item contributes to the overall scale, each factor loading on their intended factor with no cross factor loadings, and no items that lowered reliability or contained a high percentage of students failing to respond, the AFSMAS is a reliable and valid tool for use by preadolescent students in England. Further, the alignment between AFSMAS and FSMAS and the process for testing reliability and validity was “rigorous enough to achieve equivalence between the original and the translated questionnaire” (Epstein et al., 2015, p. 436). The creation of the AFSMAS addresses the void in the literature by developing a tool for researchers and teachers in England seeking to understand preadolescent students’ attitudes towards mathematics.

DISCUSSION

The development of the AFSMAS and the instrument’s reliability and validity add to the growing body of literature seeking to understand students’ attitudes towards mathematics. This study adapted the Fennema-Sherman Mathematics Attitudes Scales to reflect the language and experiences of primary students in England. Seeking to develop an instrument accessible to primary students, the length of the survey, language utilised, and experiences described were key components of an age-appropriate and regionally appropriate instrument. The AFSMAS was abbreviated by removing sub-surveys not appropriate for this audience, in the same manner as Mulhern and Rae (1998), O’Neil et al. (1988), and Quaye and Pomeroy (2022). While others have translated the FSMAS into languages other than English (Alibraheim, 2021; Takunyaci et al., 2019), the shift from an American English audience to a British English audience also necessitated adaptations of the survey. Through these adaptations, the resulting instrument is both developmentally and regionally appropriate.

Conclusion and Limitations

Given the reliability and validity of the AFSMAS, it can be used in future studies investigating the attitudes of preadolescent students in England. Researchers and practitioners can use the AFSMAS as a quantitative tool to measure students' attitudes towards mathematics, both individually and for student groups. It can be administered multiple times over the course of the school year to identify changes in attitudes, whether introduced through targeted interventions or under typical classroom conditions. Item responses can be interpreted both as a holistic score and as individual sub-surveys. Higher total scores indicate more positive attitudes towards mathematics, while lower scores indicate less positive attitudes towards the subject. In addition, by adding the item responses of the twelve items composing a sub-scale score (as available in Online Resource 2), one can determine the extent to which this sub-scale contributes positively or negatively to one's attitudes towards mathematics. These studies can reliably explore factors that contribute positively and negatively to English preadolescent students' attitudes towards mathematics.

As with any instrument, the AFSMAS is not without its limitations. The instrument was developed for a preadolescent audience in England. Validity and reliability have not been demonstrated outside this context. At this time, the AFSMAS has not yet been utilised in a digital format. Should the survey remain reliable and valid when administered digitally, it is anticipated that the collection and review could be completed more expeditiously. In conducting further research using the AFSMAS, it is also important to note that the AFSMAS does not explicitly address gendered domain of mathematics. Researchers seeking to further understand what role this aspect may play in attitudes may wish to either extend the AFSMAS or combine it with a secondary instrument designed specifically for this purpose.

However, the AFSMAS allows teachers to collect data on five areas that contribute to students' attitudes towards mathematics by administering the tool in a whole-class setting. The AFSMAS could be used at the beginning of the school year to provide insight into students' attitudes or pre- and post-intervention. On a larger scale, school leaders may want to use the AFMAS to monitor students' attitudes towards mathematics as they progress through primary school and prepare for the transition to secondary school. The AFSMAS is useful as a tool to identify students with low attitudes towards mathematics, potentially for support, or for increasing understanding of the factors of attitude that most greatly impact individuals' attitudes towards mathematics, for instance, whether factors related to confidence or motivation play a more significant role in a student's attitudes towards mathematics. Furthermore, the AFSMAS shows promise as a tool for a more comprehensive understanding of primary students' attitudes. In addition to use with preadolescent students in England, the AFSMAS can now be tested in new contexts, particularly other areas of the UK, additional countries and educational systems. It allows for further adaptation into additional languages and can serve as the basis for creating a tool to measure early primary students' attitudes towards mathematics.

Declarations

Disclosures

Ethics Approval: Ethics approval for this study was granted by the University of Cambridge, Faculty of Education.

Consent to Participate: Informed consent was received from all participants.

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Figures

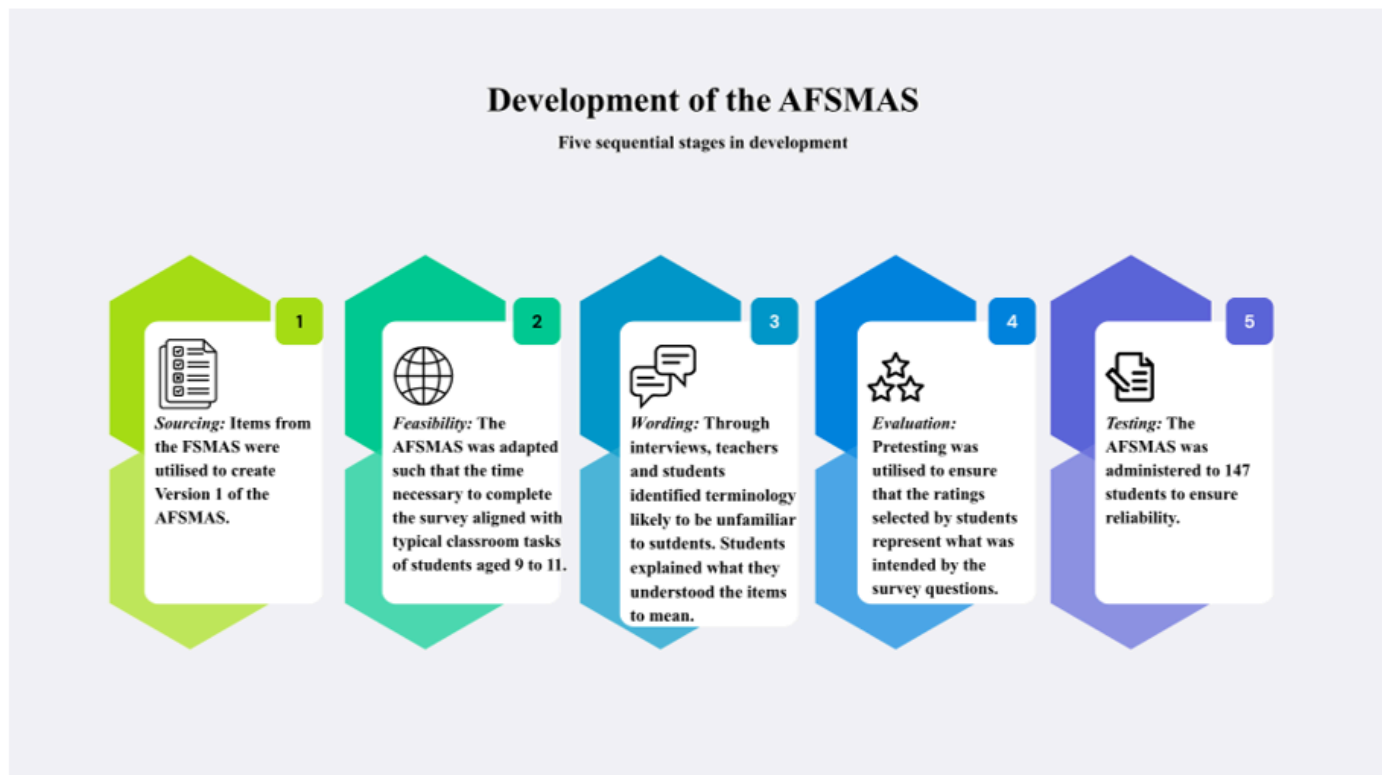


Figure 1

Development of the AFSMAS – Five sequential stages in development

Supplementary Files

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