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The Survey Research of Junior High School Mathematics Teachers about Early Childhood School Teaching Mental Calculation by Abacus

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Abstract: This study uses 431 junior high school math teachers as research subjects to survey opinion of junior high school mathematics teachers about early childhood school teaching mental calculation by abacus, and arrives at the three following conclusions. First, 50% of the teachers believe that learning mental calculation by abacus has positive effects; 45% of the teachers believe that learning mental calculation by abacus can improve attitudes in learning mathematics. Second, 53% of the teachers believe that the best time to learn mental calculation by abacus is elementary school; 43% of the teachers believe that it is better to first know the basics of math in addition, subtraction, and linear calculations before learning mental calculation by abacus. Approximately 70% of the teachers believe that learning mental calculation by abacus must also supplement the mathematics formally learned in school, thus kindergarten should not have mental calculation by abacus as a focus of education. Third, mental calculation by abacus should be taught in lively and innovative ways; for youngsters, their understanding has yet to be developed, so the inspiration of mathematical abilities in early education should be lively and diverse.

Key words: early childhood school, teaching the mental calculation by abacus, junior high school math teacher

1. Introduction

The Ministry of Education (MOE), Republic of China promulgated an act in 2004 to proscribe science and language supplementary education schools (i.e., cram schools) from recruiting children below the age of 6 years. MOE officials emphasized that the ministry was not opposed to and would not prohibit courses that were beneficial for the physical and mental development of children, but they strongly discouraged education that relied heavily on memorization and recitation. However, on January 30, 2013, the MOE announced the revised draft of the Supplementary Education Act, which further prohibited supplementary education schools from recruiting

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children below the age of 6 years for mental training courses that emphasized memorization and recitation, such as composition, English, abacus mental calculation (AMC), Go (w*eiqi*), and brain development. Parents and supplementary education schools have protested this action. Therefore, this study explored whether AMC education is appropriate for kindergarten children. The results can serve as a reference for the legislature and educational authorities.

During the financial crisis, one could observe which companies were thriving and operating soundly and which had been eliminated, said Warren Buffett, a well-known investor, who stated that 2009 was the worst year of the financial crisis for business operations. Similarly, "kindergarten operations and management" are encountering various difficulties and challenges because of low birth rates. However, according to arguments such as "profits are always in the bottom of the trend" and "pioneers are forever lonely" current kindergarten operations resemble oil, the black gold hidden under glaciers. In other words, this is the perfect time for kindergarten owners and managers to develop and expand their schools.

Achieving success in business requires adherence to client opinions and the satisfaction of client demands. To satisfy parental educational demands, such as "children should be the last to suffer, and education the last item deprived", early childhood-education businesses have marketed various superior educational courses and supplementary-education products to parents and attracted their attention through the presentation of outlines for their children's futures. The current efforts of kindergartens to promote AMC education provide the best evidence of early childhood educational courses marketing in early-childhood education businesses. Relevant schools promote the following concept, "Do not let your children lose out from the beginning!" and "Learning AMC lays a solid foundation for learning mathematics!" These arguments have inspired the following question: Is studying AMC beneficial to future mathematics education for children? Liu (2008) emphasized in the article "Does learning mental calculation improve students' math performance?" that numerous people who had learned AMC but considered it ineffective have not sufficiently mastered the skills taught during relevant courses. The researchers reviewed their personal backgrounds in mathematics education and noticed that mathematics education at the junior high-school level emphasized problem-solving abilities and logical thinking more than the training and cultivation of student calculation abilities. Therefore, whether learning AMC provides a comprehensive and integrated foundation for the future mathematical abilities of students should be explored.

Honoring the maxim that "research is a painstaking process of experimentation and refinement", this study investigated perspectives regarding the relationship between AMC education and the cultivation of mathematical abilities and examined the main points for marketing AMC education in early childhood education. The results of this study can serve as references for managers of kindergartens and supplementary education institutes to use in-depth analysis, rumination, and retrospection to innovate and begin anew.

The decision to use junior high-school (JHS) math teachers as the subjects of investigation was based on the following considerations: (a) JHS math teachers are professional representatives that have long-term experience with observing student mathematics learning; and (b) because of the novelty of the research topic, no studies have explored JHS math teachers' evaluations regarding AMC education at kindergartens. Therefore, examining the opinions of these teachers regarding AMC education has strong contributive value.

The contributions of this study are two-fold: (a) responding to current issues related to newly emerging policies concerning early childhood supplementary education, and (b) using the empirical results to provide scientific evidence for policy considerations. The respondents were JHS teachers, who observed, over a relatively long period, the delayed effects of AMC education; this is a subject related to mathematics education that is rarely

rigorously explored. Consequently, this study provides evidence to fill and overcome relevant knowledge gaps.

1.1 Objectives

Based on the mentioned research background and motivations, this study used JHS math teachers in Taiwan as the research subjects and respondents. An empirical survey was conducted to elucidate the relationship between AMC education and the cultivation of mathematical abilities. The results can serve as a reference for early childhood-education business owners when designing course curricula and structure. In addition, this study can be used as a reference for parents who are considering kindergarten options. The objectives of this study are two-fold:

(1) To investigate the opinions of JHS math teachers regarding AMC education in kindergartens and provide scientific evidence for policy considerations;

(2) To respond to current issues related to newly emerging polices concerning early childhood education and provide a reference for the legislature, educational authorities, early childhood-education business owners, and supplementary-education business owners based on research results.

To investigate objective (1), a survey was conducted to evaluate JHS math teacher opinions regarding the following five questions:

(1) What are respondent opinions regarding the positive functions of AMC education?

(2) What are respondent opinions of the negative evaluations regarding AMC education?

(3) What are respondent opinions regarding whether AMC education can improve student mathematics-learning attitudes?

(4) What are the respondents' opinions regarding the appropriate age for children to receive AMC education?

(5) According to the respondents, what basic math knowledge should students have before receiving AMC education?

The subjects or respondents in this study were math teachers currently employed at JHSs in Taichung City. JHS math teachers were selected as the respondents because they have a more in-depth understanding and perspective of the content, significance, and learning methods of math courses compared to teachers at other levels or teaching other subjects in the national education system. In addition, math courses at the JHS level emphasize comprehension and contemplation; therefore, teachers have increased knowledge and perspectives due to experience observing student mathematics learning. Moreover, a greater number of teachers for sampling exist at the JHS level. Thus, the responses of JHS math teachers regarding the effects of AMC education on mathematics learning possess expertise and are representative. The respondents were categorized based on the following five criteria: (a) whether they worked in regions that were originally known as Taichung City or Taichung County (based on considerations of urban-rural gaps or differences), (b) whether they had degrees in mathematics, (c) whether they had learned or studied AMC, (d) whether they would have their own children study AMC, and (e) gender. Five hypotheses were proposed according to the research questions:

(a) H1: The five categories of JHS math teachers have significant differences in their opinions regarding the positive functions of AMC education.

(b) H2: The five categories of JHS math teachers have significant differences in their opinions of the negative evaluations regarding AMC education.

(c) H3: The five categories of JHS math teachers have significantly different opinions regarding whether AMC education can improve student mathematics-learning attitudes.

(d) H4: The selected appropriate ages for AMC education are significantly correlated with the five categories of JHS math teachers.
(e) H5: The selected basic math knowledge necessary for AMC education is significantly correlated with the five categories of JHS math teachers.

1.2 Explanation of Key Terms

Kindergarten

According to Chapter 1 (General Provisions), Article 2 of the Early Childhood Education and Care Act, promulgated on June 29, 2011, young children are children over the age of 2 years but under the age required to attend elementary school; kindergartens are organizations and institutions that provide early childhood education and care services.

2. Literature Review

This section consists of four subsections: (a) Reviewing the correlation between AMC education and mathematical abilities, (b) mathematics-learning attitudes, (c) U.S. studies regarding mental arithmetic, and (d) a summary.

2.1 Correlation between AMC Education and the Mathematical Abilities

2.1.1 Studies Indicating No Significant Difference

Tsai (2001) studied upper kindergarten-level children in AMC classes, children not in AMC classes, and first graders, and found no significant differences in the ability to count numbers and objects between children in the upper-kindergarten level in AMC classes and those not in AMC classes. In addition, no significant differences were found for the two groups regarding their overall number and symbol representation abilities. Chang (2002) interviewed 12 sixth graders that had achieved high-level AMC education and analyzed the problem solving strategies used by these students regarding number sense problems. The results showed that students who had achieved high-level AMC education tended to possess poor number sense abilities, and that their performances in solving number sense problems did not differ significantly from those of other students. Huang (2003) studied 84 first graders at a public elementary school in Taipei City and found that approximately 38% of the students had received AMC education. Although a portion of the students who had learned AMC demonstrated superior performance on tests, certain students who had not receive AMC education also demonstrated superior performance. Therefore, no correlation was observed between AMC education and student mathematical abilities. Finally, Chou and Yang (2005) adopted a number sense-development perspective to explore the differences between math achievements and the number sense of students with various AMC abilities. Subsequently, they analyzed the performances of students with differing AMC abilities in solving number sense-based situational problems. An ex post facto study was conducted to investigate the performances of 649 fifth and sixth graders in the Yunlin and Chiayi regions in the following areas: number sense tests, math achievement tests, math grades, and IQ or intelligence tests. Subsequently, purposive sampling was employed to select 6 sixth graders with diverse AMC abilities for conducting interviews during which the students were assigned number sense-based situational problems to solve. The interview results implied that IQ (reasoning ability) might be a crucial transfer or transmission variable affecting whether AMC education was beneficial for number sense development in elementary school students.

2.1.2 Studies Indicating Significant Differences

Huang et al. (2000) observed that social change and the invention of computers and calculators have resulted in challenges regarding the promotion of abacus education. Based on historical reviews and future prospects, abacus education has developed from a subject of little interest into a prosperous topic and subsequently declined. However, abacus functions should not be confined to calculations and computations; instead, novel abacus applications can be developed for inspiring mental development. Empirical studies have shown that whether elementary-school students received abacus education, the duration of their abacus training, and their abacus levels were positively correlated with their cognitive and mathematical abilities, math achievements, and intellectual development performance. Lu (2003) applied AMC-ability or skill level as the independent variable; divided the participants into an experimental group (i.e., AMC learners) and control group (i.e., non-AMC learners); and used participant performances on various memory span and AMC tests as the dependent variables. The results showed that (a) the speed and accuracy of the AMC learners on mental arithmetic tests were significantly superior to those of the non-learners; and (b) on visuo-spatial span tests involving visuo-spatial templates, the AMC learners demonstrated significantly superior graphical or image and location memory compared to the non-learners. The results obtained by Chou and Yang (2005) indicated that elementary-school students with differing AMC-ability levels showed significant differences regarding their number sense, mathematical abilities, and study achievements or performances when the intelligence factor was controlled. In addition, the performance of students with high-level AMC education regarding calculation-related number sense, mathematical calculation abilities, and math achievements was significantly superior to those of students with lower-level training or no AMC abilities. Compared with other students, high-intelligence students with high-level AMC education demonstrated significantly superior performance in using number sense to solve problems. Furthermore, Guo (2007) proposed a “math integration” experimental teaching approach that combined AMC education with math, and the experiment has, to the present time, yielded superior effectiveness.

2.2 Mathematics-Learning Attitudes

Lee (2003) recruited 727 fifth graders, eighth graders, and eleventh graders as respondents and administered the Sex Role Inventory and a Mathematics Learning Attitude Scale. A statistical analysis of the results showed significant differences between the math achievements of male and female eleventh graders and significant differences between the mathematics-learning attitudes of students at differing grade levels. In addition, significant differences existed among certain mathematics-learning attitudes for female students, but no significant relationship was identified between gender roles and mathematics achievements. In this study, the scale developed by Lee (2003) was adopted to provide the indicators for the mathematics learning-attitude dimension; these indicators are presented in Items 15 to 19 in the formal questionnaire (Appendix III).

2.3 U.S. Studies Regarding Mental Arithmetic

Despite the lack of U.S. research regarding AMC, studies regarding mental arithmetic (e.g., Hope, 1987; Hope & Sherrill, 1987; Markovits & Sowder, 1994; Plunkett, 1979; Reys, 1985; Reys, 1984; Sowder, 1990, 1992a, 1992b) have indicated a positive correlation between mental arithmetic abilities and number sense development. In other words, students with superior mental arithmetic abilities demonstrate superior number sense abilities. However, whether AMC in Taiwan differs from the mental arithmetic taught in other countries remains unknown. The computational basis of AMC consists of numerous equations. To calculate rapidly and accurately, learners must memorize mnemonic rhymes or facts tables and the instructions or colloquialisms for using the AMC

method, and then conduct continual practice (Liao, 2007). Numerous international studies regarding mental arithmetic (e.g., Plunkett, 1979; Sowder, 1990) have indicated that a key feature required to perform mental arithmetic well is the ability to develop flexible and diverse problem-solving strategies, as well as the ability to develop appropriate problem-solving methods dependent on varying situations. Nevertheless, AMC is based on fixed equations, which lack problem-solving initiative or autonomy, variability, and flexibility. Therefore, AMC in Taiwan differs from the mental arithmetic taught in other countries.

2.4 Summary

In previous studies, the respondents were primarily elementary-school students. Although certain studies identified a significant relationship between AMC education and mathematical abilities, others did not. However, relevant studies have not been conducted on JHS math teacher evaluations of the relationship between AMC education and mathematical abilities. Hence, the purpose of this study was to survey and explore JHS math-teacher opinions regarding AMC education in kindergartens.

3. Methodology

The research methodology in this section consists of the following five subsections: (a) respondents and scope, (b) sampling method, (c) research framework, (d) questionnaire design, and (e) the operational definitions of variable scoring.

3.1 Respondents and Scope

A total of approximately 1,225 JHS math teachers work in Taichung City. According to data from the former Taichung County Office of Education and the former Taichung City Office of Education, approximately 742 JHS math teachers taught at schools that were located in areas formerly known as Taichung County prior to the Taichung City-Taichung County merger in 2010, and approximately 483 worked at schools that were located in the former Taichung City. In this survey, 431 JHS teachers were sampled, constituting a large sample.

3.2 Sampling Method

Random sampling was conducted based on student learning venues or occasions and learners' schools. According to Gay and Airasion (2000), a sample size should be determined by the research type: A descriptive study requires a sample size no smaller than 10% of the population and no smaller than 20% when the population is small (Wu, 2007). In this study, 431 respondents were sampled from a population of 1,225, which satisfied the sampling principle. Regarding the school distribution of the teachers, 483 respondents worked in the former Taichung City and 742 worked in the former Taichung County; therefore, based on this teacher ratio, 262 teachers were sampled from schools in the former Taichung County and 169 were sampled from schools in the former Taichung City.

3.3 Research Framework

The research framework of this study was developed based on the research motivation, objectives, and previous literature. In addition, independent samples *t* tests and chi-square test contingency tables were used for the statistical methods. The research framework is shown in Figure 1.

3.4 Questionnaire Design

A survey questionnaire was used in this study to obtain the evaluations of JHS math teachers regarding

kindergarten-level AMC education. The design process is explained using validity and reliability.

3.4.1 Expert Validity

The item content for the questionnaire was self-designed and adapted from previous studies. In addition, an expert validity review was conducted by 10 experts and scholars, comprising two associate professors from mathematics departments, an associate professor from a department of business administration, six JHS math teachers, and a Chinese teacher. The pre-test questionnaire consisted of 34 items, two of which were error detection items.

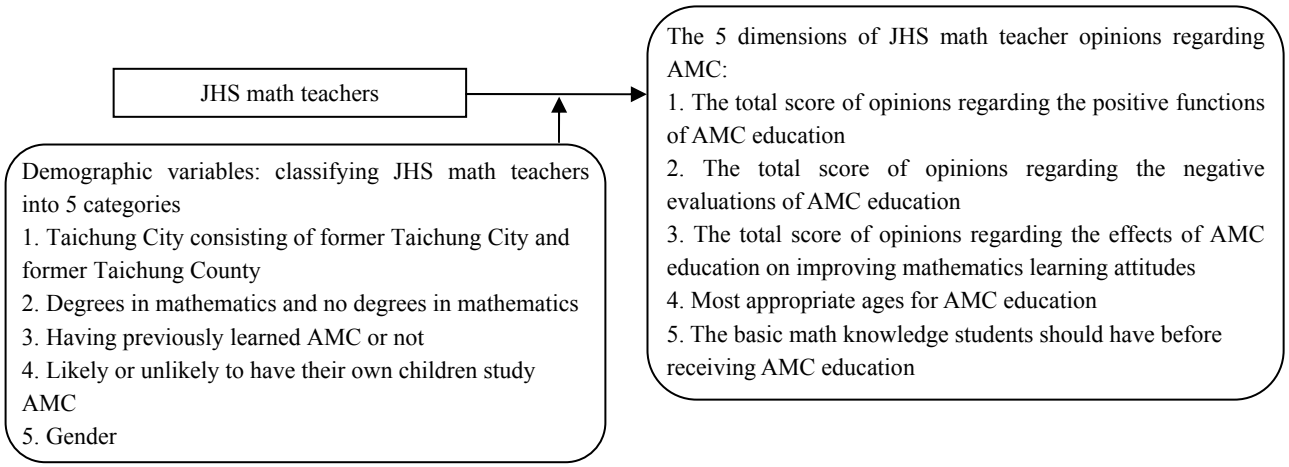

Figure 1 Research Framework

3.4.2 Construct Validity

Prior to official questionnaire implementation, a pre-test questionnaire was administered to 165 JHS math teachers to obtain references for questionnaire revision. Subsequently, an item analysis and factor analysis were conducted based on the recovered questionnaires and 22 items were retained. As a final step, an item confirmation and classification was performed based on the conclusions. In particular, Item 13 was an error detection item. In the formal questionnaire, Items 1 to 7 were concerned with positive evaluations regarding AMC education; Items 8 to 13 were related to negative evaluations of AMC education; Items 14 to 19 were related to whether AMC education could improve mathematics learning attitudes; and Items 20 to 22 were related to general recommendations for managers of AMC schools or operations.

3.4.3 Principles for Item Removal

Following an analysis of the 165 questionnaires using SPSS 12.0 software, inappropriate items were removed from the 34-item pretest, leaving 22 items in the formal questionnaire. The principles adopted to remove inappropriate items are as follows:

(1) In this study, *t* tests were conducted to examine the difference between items regarding high- and low-scoring groups. Items with a *p* value less than .05 were removed. Based on cohesion (*r*) analysis results, Item 31 was removed because its *p* value did not reach .05.

(2) Items were removed if their removal yielded an identical or increased Cronbach's α coefficient. When Items 12, 15, 17, 22, 32, 33, and 34 were removed, the reliability became greater than or equal to .905. Initially, Items 12, 15, 17, and 22 were removed, whereas Items 32 to 34 were retained. Subsequently, a further analysis was conducted.

(3) AKMO value set at .845 and a Bartletts value set at 2,442.776 are suitable for factor analysis. Following

factor analysis, Items 12, 22, 17, and 3 were removed because the factor categories of these items comprised less than three items. In addition, Item 18 was removed because it was the only negative evaluation item for Factor 1, whereas the other items represented positive evaluations; consequently, Item 18 was an item with different attributes than others within the same factor. Items 13, 14, and 24 were removed because they consisted of only a small number of similar factors: Although Factors 3 and 4 both represented negative evaluations, Factor 4 consisted of only three items (i.e., 13, 14, and 24). Furthermore, these items contained certain content that matched those in Factor 3, warranting elimination. Items 1 and 2 were also removed, because the factor they were contained within constituted only these two items and because certain content was repetitive regarding the positive evaluation items contained in Factor 1.

(4) Regarding the reliability analysis, a satisfactory reliability value for factor category subscales should be greater than .7, and a satisfactory reliability for an overall scale should exceed 0.8.

3.4.4 Questionnaire Reliability

According to the analysis of Cronbach's α by Wu (2003), for the reliability coefficients of a scale or questionnaire to be considered reliable, the reliability coefficient of the overall scale should exceed 0.8, and a reliability coefficient between 0.7 and 0.8 is acceptable. Table 1 shows an overall analysis of questionnaire reliability, indicating that the stability of the overall reliability for the questionnaire was excellent; hence, it could be used as the formal questionnaire.

Table 1 An Overall Analysis of the Reliability of the Pre-test and Formal Questionnaires

Cronbach's α			Factor 1	Factor 2	Factor 3	Factor 4
Analysis item	Sample size	All items	Mathematics-learning attitude	Positive functions	Negative functions	Recommendations to business owners and managers
Pre-test questionnaire	165	.892	.869	.813	.769	.715
Formal questionnaire	431	.900	.885	.815	.806	.708

3.4.5 Operational Definitions of Independent Variable Scoring

Items 1 to 7 on the questionnaire were related to respondent positive and supportive attitudes toward the effects of AMC education on improving student mathematical abilities. Items 8 to 13 were related to negative opinions regarding whether AMC education enhances student mathematical abilities. Items 14 to 19 involved opinions regarding mathematics-learning attitudes. The responses ranged from 1 (*strongly disagree*) to 5 (*strongly agree*; 2 represented *disagree*, 3 represented *neutral*, and 4 represent *agree*). The lowest total score for Items 1 to 7 was 7 and the highest was 35. The sum of these seven items represents the total score of respondent positive opinions regarding AMC education. The lowest total score for Items 8 to 13 was 6 and the highest was 30; the sum of these six items is respondent negative evaluations regarding AMC education. The lowest total score for Items 14 to 19 was 6 and the highest was 30. The sum of these six items denotes opinions regarding the ability of AMC education to improve student mathematics-learning attitudes.

4. Results

This section consists of three subsections: (a) an analysis of JHS math-teacher opinions regarding the functions of AMC education, (b) an analysis of the percentages of each response for all items in the formal questionnaire, and (c) hypothesis verification and item analysis based on demographic variable categories.

4.1 Percentages of Junior High-School Math Teacher Responses to the Demographic Items on the Questionnaire

Table 2 Percentages of Responses to Demographic Items

Gender: male 57.1%; female 42.9%
Ages: 20–29 years: 19.7%; 30 to 39 years: 44.1%; 40 to 49 years: 32.9%; 50 to 59 years: 2.7%; 60 to 69 years: 0.5%
Taichung City: former Taichung City: 38.7%; former Taichung County: 61.3%
Education: mathematics degree: 68.0%; no mathematics degree: 32.0%
Teaching experience: 0 to 10 years: 51.3%; 11 to 20 years: 43.3%; 21 to 30 years: 9.7%; 31 to 40 years: 0.7%
Previous AMC education: no: 82.6%; yes: 17.4%
Level achieved for AMC in the low-level category: Level 12: 0.5%; Level 11: 0%; Level 10: 0%; Level 9: 0%; Level 8: 0.2%; Level 7: 0%; Level 6: 0.9%; Level 5: 1.4%; Level 4: 1.2%; Level 3: 0.7%; Level 2: 2.1%; Level 1: 0.7%; Level 0: 0.2%
Level achieved for AMC in the high-level category: Level 1: 0.7%; Level 2: 0%; Level 3: 0.2%; Level 4: 0.2%; Level 5: 0.2%; Level 6: 0.2%; Level 7: 0%; Level 8: 0.2%; Level 9: 0%; Level 10: 0%

4.2 Percentages of the Responses to All Items

Table 3 Analysis of the Percentages of the Responses to All Items

A: strongly agree and agree; B: strongly disagree and disagree; C: neutral

Item	Content	A (%)	B (%)	C (%)
1	Learning AMC is beneficial for right brain development.	40.1	8.4	51.5
2	Learning AMC can enhance concentration.	81.0	3.3	15.8
3	Learning AMC enables students to memorize more rapidly.	40.8	17.6	41.5
4	Despite the development of calculators, students should continue to learn AMC.	51.1	11.1	38.7
5	Learning AMC enhances student sense of achievement in calculation.	71.7	9.6	18.8
6	Learning AMC enhances school math achievements and performances.	41.1	23.9	35.0
7	Learning AMC is beneficial for improving student mathematical abilities only when students reach the high training level.	27.8	25.5	46.6
8	AMC is inferior to written calculation, which can be applied to mathematics education (whereas AMC cannot).	24.3	39.7	36.0
9	The knowledge of AMC cannot be directly connected with algorithms or mathematical operations.	13.2	37.8	49.0
10	AMC is a treasured heritage of the Chinese culture, but it can only be used for historical research.	13.2	50.8	36.0
11	Calculation speeds are sufficient when students are familiar and proficient with calculations; excessive emphasis on speed is not beneficial for mathematical-ability development.	41.8	34.3	23.9
12	Mathematics education should be integrated with global trends; therefore, introducing AMC to mathematics education is unnecessary.	19.9	35.9	44.1
13	With the development of calculators, learning AMC has become unnecessary.	11.6	46.2	42.4
14	Learning AMC is beneficial for enhancing math comprehension abilities.	32.8	34.6	32.6
15	Learning AMC enhances student confidence in mathematics learning.	62.2	13.7	24.1
16	Learning AMC reduces student anxiety in mathematics learning.	45.9	19.0	35.0
17	Learning AMC enhances student motivations for math-related inquiry.	29.1	32.0	39.0
18	Learning AMC enhances student recognition of the usefulness of math.	48.5	20.7	30.9
19	Learning AMC encourages students to demonstrate proactive attitudes regarding successful math performance.	51.7	15.1	33.2
20	AMC education must supplement the regular math curricula of schools.	58.1	10.9	31.1
21	Innovative teaching methods should be used in AMC education to enhance student interest in learning.	68.2	3.5	28.3
22	The promotion of AMC education in kindergartens should be based on the normal development of young children.	73.1	5.8	21.1

The following conclusions were obtained based on the results presented in Table 3:

(1) A relatively low level of respondents (40.8%) agreed that learning AMC reduces the time that students spend on memorization, which was similar to the conclusions of Lu (2003).

(2) A relatively low level of respondents (41.1%) agreed that learning AMC enhances school math achievements and performances, which was similar to the results of Huang (2003).

(3) In response to Item 4: "Despite the development of calculators, students should continue to learn AMC," 51.1% of the respondents agreed and 11.1% disagreed; in response to Item 13: "With the development of calculators, learning AMC has become unnecessary", 46.2% of the respondents disagreed and 11.6% agreed. In addition, 44.5% of the respondents replied that they would have their own children study AMC. These results indicated that approximately half of the math teachers were in favor of AMC education.

(4) Only 40.1% of the respondents agreed that AMC education is beneficial for right brain development, and 32.8% agreed that it benefits the enhancement of mathematics comprehension abilities. This suggested that AMC education is generally considered ineffectual for enhancing mathematics comprehension abilities; this result was similar to the results of Huang (2003), Chang (2002), and Tsai (2001).

(5) A total of 41.8% of the respondents agreed that an excessive emphasis on calculation speed does not enhance student mathematical abilities and that adequate proficiency for calculation speed is sufficient. Consequently, teachers showed no specific support for this statement.

(6) A low number of respondents (29.1%) agreed that AMC education enhances student motivation for mathematics inquiry.

(7) Only 27.8% (a low number) of the respondents agreed that for AMC education to be beneficial in mathematical-ability development, students must attain a high training level. This result is similar to the conclusion of Lu (2003), indicating that the high-level AMC education comprehension is not necessarily beneficial for mathematical ability development.

(8) A total of 58.1% of the respondents agreed that "AMC education must supplement the regular math curricula of schools"; 68.2% agreed that "Innovative teaching methods should be used in AMC education to enhance student interest in learning"; and 73.1% agreed that "The promotion of AMC education in kindergartens should be based on the normal development of young children".

(9) A percentage analysis was conducted based on the factor analysis categories, and the results are shown in Table 4.

Table 4 Percentages of Opinions Regarding the Positive and Negative Functions of AMC and Attitudes

A: strongly agree and agree; B: strongly disagree and disagree; C: neutral.

	(Factor 2: Items 1 to 7) Positive opinions of AMC education	(Factor 3: Items 8 to 13) Negative evaluations of AMC education	(Factor 1: Items 14 to 19) Opinions regarding whether AMC education improves mathematics-learning attitudes
A	50.4%	20.7%	45.0%
B	14.2%	40.8%	22.5%
C	35.4%	38.5%	32.5%

4.3 Hypothesis Verification and Item Analysis Based on Demographic Variable Categories

The respondents of this study were math teachers currently teaching at JHSs in Taichung City; they were divided based on the following five categories of demographic variables: whether they worked at schools that were located in the former Taichung City or the former Taichung County; whether they had degrees in

mathematics; whether they had learned AMC; whether they would have their children study AMC; and gender. Hypothesis verification was conducted using independent samples *t* tests and chi-square test contingency table analysis. The results are presented in Table 5 (× indicates that the result did not reach a level of significance; A shows the total score of positive opinions; B shows the total score of negative opinions; C shows the total score of mathematics-learning attitude opinions; D shows the appropriate learning ages for AMC; E shows the necessary basic math knowledge prior to ACM training; and F shows whether respondents would have their own children study AMC). These results were compiled to provide responses for the hypotheses posed based on the research questions.

The following is an analysis of the significant results presented in Table 5, which addresses one of the objectives of this study (i.e., using quantitative methods to analyze and explore issues and questions).

Table 5 Hypothesis Verification and Item Analysis Based on Demographic Variable Categories

Variable / Dependent **Variable**	whether they had learned AMC	they worked at schools that were located in the former Taichung City or the former Taichung County	whether they had degrees in mathematics	gender	they would have their children study AMC
A	×	×	significance	significance	Significance
B	significance	×	significance	×	significance
C	significance	×	significance	significance	significance
D	×	×	×	×	significance
E	×	×	×	significance	significance
F	significance	×	×	×	

4.3.1 JHS Math Teacher Positive Opinions of AMC Education

(1) Respondents who agreed or strongly agreed to these statements accounted for 50.4%; those who disagreed or strongly disagreed accounted for14.2%. This result is consistent with that for the previously reported positive opinions of the respondents, suggesting that JHS math teachers are regarding their affirmative on AMC education.

(2) Analysis of items that reached a level of significance

(a) The average total scores representing the positive opinions of respondents with and without a degree in mathematics were 23.8 and 24.7, respectively (t = -2.145, p = .033 < .05).

(b) The average total scores representing the positive opinions of male and female respondents were 24.77 and 23.19, respectively (t = 3.946, p = .000 < .05).

(c) The average total scores representing the positive opinions of respondents who would or would not have their own children study AMC were 26.2 and 22.2, respectively (t = 10.730, p = .000 < .05).

4.3.2 JHS Math Teachers Negative Opinions of AMC Education

(1) The percentage of respondents (20.7%) who agreed or strongly agreed to these statements was lower than that of respondents that disagreed or strongly disagreed (40.8%). This result is consistent with that for the previously reported positive opinions of the respondents, suggesting that JHS math teachers are consistent

regarding their affirmative and positive views on AMC education.

(2) Analysis of items that reached a level of significance

(a) The average total scores representing the negative opinions of respondents who had or had not received AMC education were 20.44 and 19.09, respectively (t = -2.923, p = .004 < .05).

(b) The average total scores representing the negative opinions of respondents with and without a degree in mathematics were 19.09 and 19.83, respectively (t = -1.978，P = .049 ＜ .05).

(c) The average total scores representing the negative opinions of respondents who would or would not have their own children study AMC were 21.12 and 17.77, respectively (t = 10.007，P = .000 ＜ .05).

4.3.3 Respondent Opinions Regarding the Effects of AMC Education on Improving Student Mathematics-Learning Attitudes

(1) Respondents who agreed or strongly agreed to these statements accounted for 45.0%; those who disagreed or strongly disagreed accounted for 22.5% and those with no opinion or a neutral opinion occupied 32.5%. This demonstrates that the respondents did not maintain a strong positive perspective that AMC education improved student mathematics-learning attitudes.

(2) Analysis of items that reached a level of significance

(a) The average total scores representing opinions regarding the effects of AMC education on improving student mathematics-learning attitudes for respondents that had or had not received AMC education were 20.37 and 19.23, respectively (t = -2.118, p = .035 < .05).

(b) The average total scores representing opinions regarding the effects of AMC education on improving student mathematics-learning attitudes for respondents with and without a degree in mathematics were 19.12 and 20.09, respectively (t = -2.209，P = .028 ＜ .05).

(c) The average total scores representing opinions regarding the effects of AMC education on improving student mathematics-learning attitudes for respondents male and female were 20.11 and 18.51, respectively (t = 3.909, P = .000 ＜ .05).

(d) The average total scores representing opinions regarding the effects of AMC education on improving student mathematics-learning attitudes for respondents who would or would not have their own children study AMC were 21.70 and 17.43, respectively (t = 11.533，P = .000 ＜ .05).

4.3.4 Respondent Opinions Regarding the Appropriate Ages for Receiving AMC Education

(1) Percentages regarding the appropriate ages for receiving AMC education: below 3 years of age (0.5%); kindergarten level (27.1%); elementary school level (53.1%); JHS level (0.7%), high school level (0%); and college level or above (0.5%). In addition, 13.5% of the respondents considered the education unnecessary, and 4.6% provided other responses. This indicates that the optimal ages for children to enter AMC education is the elementary-school level, followed by the kindergarten level.

(2) Items that reached a level of significance in the chi-square test of the correlations between whether respondents would have their own children study AMC and their opinions regarding the appropriate ages for training

(a) The chi-square value was 143.778, and the value was significant at p = .000 < .05. This shows a significant correlation between the variables of whether the respondent would have their own children study AMC and their opinions regarding the appropriate ages for training.

(b) Regarding contingency table symmetry, the contingency coefficient was .500, which reached a level of significance at .05. This indicates a moderate correlation between whether respondents would have their own

children study AMC and their opinions regarding the appropriate ages for training.

(c) Among the 192 respondents that would have their own children study AMC, 0.0% considered below the age of 3 years as appropriate for receiving AMC education; 38.5% selected kindergarten level; 60.9% opted for the elementary school level; 0.5% the JHS level; 0.0% for the high school level; and 0.0% for the college or above level. Among the 205 respondents that would not have their own children study AMC, 1.0% considered below the age of 3 years as appropriate for receiving AMC education; 17.1% selected the kindergarten level; 46.8% chose the elementary school level; 1.0% opted for the JHS level; 0.0% selected the high school level; and 1.0% preferred the college or above level. Among all 431 respondents, 0.5% considered below the age of 3 years as appropriate for receiving AMC education; 27.1% opted for the kindergarten level; 53.1% selected the elementary school level; 0.7% chose the JHS level; 0.0% selected the high school level; and 0.5% chose the college or above level.

(d) Among the respondents that considered the kindergarten level as an appropriate period for AMC education, the number of respondents who would have their own children study AMC (38.5%, AR = 4.8) was significantly greater than that of respondents who would not do so (17.1%, AR = -4.5). Among the respondents who selected the elementary school level as the appropriate period for AMC education, the number of respondents who would have their own children study AMC (60.9%, AR = 2.9) was significantly greater than that of respondents who would not do so (46.8%, AR = -2.5).

4.3.5 Respondent Opinions Regarding the Basic Math Knowledge Necessary to Receive AMC Education

(1) A total of 24.6% of the respondents considered no basic knowledge necessary; 42.9% considered a basic knowledge of addition and subtraction computations necessary; 14.4% considered basic knowledge of the four arithmetic operations necessary; 14.2% considered AMC education unnecessary; and 3.9% offered other comments. This indicates that a basic knowledge of addition and subtraction computations is the optimal foundation for receiving AMC education.

(2) Significance levels in the chi-square test of the correlation between gender and basic math knowledge for AMC education

(a) The chi-square value was 16.086, and was significant (p = .003 < .05). This suggested a significant correlation between gender and basic math knowledge for AMC education.

(b) Regarding contingency table symmetry, the contingency coefficient was .190, which reached the significance level of .05. This shows a low level of correlation between respondent gender and their opinions regarding the necessary basic math knowledge for AMC education.

(c) Among the 246 male respondents, 25.6% considered no basic math knowledge necessary for AMC education; 43.5% considered a basic knowledge of addition and subtraction computations necessary; 17.9% considered basic knowledge of the four arithmetic operations necessary; and 11.4% considered AMC education unnecessary. Among the 185 female respondents, 23.2% considered no basic math knowledge necessary for AMC education; 42.2% considered a basic knowledge of addition and subtraction computations necessary; 9.7% considered basic knowledge of the four arithmetic operations necessary; and 17.8% considered AMC education unnecessary. Among the total 431 respondents, 24.6% considered no basic math knowledge necessary for AMC education; 42.9% considered a basic knowledge of addition and subtraction computations necessary; 14.4% considered basic knowledge of the four arithmetic operations necessary; and 14.2% considered AMC education unnecessary.

(d) The proportion of male respondents who selected the option of basic knowledge of the four arithmetic

operations (17.9%, AR = 2.4) was significantly higher than that of female respondents (9.7%, AR = -2.4). In addition, the proportion of female respondents who thought that no education was necessary (17.8%, AR = 1.9) was significantly higher than that of male respondents (11.4%, AR = -1.9).

4.3.6 Significance Levels in the Chi-Square Test Regarding the Correlation between Whether Respondents Would Have Their Own Children Study AMC and Their Opinions Regarding the Necessary Basic Math Knowledge

(1) The chi-square value was 106.656 and the $p = .000 < .05$, which reached a level of significance. This indicates a significant correlation between whether respondents would have their own children study AMC and their opinions regarding the necessary basic math knowledge for AMC education.

(2) Regarding contingency table symmetry, the contingency coefficient was .445, which reached the significance level of .05. This indicates a moderate correlation between whether JHS math teachers would have their own children study AMC and their opinions regarding the necessary basic math knowledge for AMC education.

(3) Among the 192 respondents that would have their own children study AMC, 30.7% considered no basic math knowledge necessary for AMC education; 54.7% considered a basic knowledge of addition and subtraction computations necessary; 10.4% considered basic knowledge of the four arithmetic operations necessary; and 1.0% considered AMC education unnecessary. Among the 205 respondents that would not have their own children study AMC, 18.5% considered no basic math knowledge necessary for AMC education; 33.7% considered a basic knowledge of addition and subtraction computations necessary; 17.1% considered basic knowledge of the four arithmetic operations necessary; and 28.8% considered AMC education unnecessary. Among the total 431 espondents, 24.6% considered no basic math knowledge necessary for AMC education; 42.9% considered a basic knowledge of addition and subtraction computations necessary; 14.4% considered basic knowledge of the four arithmetic operations necessary; and 14.2% considered AMC education unnecessary.

(4) Among respondents that selected the option of no basic knowledge necessary, the proportion of respondents who would have their own children study AMC (30.7%, AR = 2.7) was significantly higher than that of respondents that would not do so (18.5%, AR = -2.8). Among respondents who selected the option of a basic knowledge of addition and subtraction computations, the proportion of respondents who would have their own children study AMC (54.7%, AR = 4.4) was significantly higher than that of respondents that would not do so (33.7%, AR = -3.7). Among respondents who selected the option of basic knowledge of the four arithmetic operations, the proportion of respondents who would not have their own children study AMC (17.1%, AR = 1.5) was significantly higher than that of respondents that would do so (10.4%, AR = -2.1).

4.3.7 Significance Levels in the Chi-Square Test Regarding the Correlation Between Whether the Respondents Had Learned AMC and Whether They Would Have Their Own Children Study AMC

(1) The chi-square value was 15.997 and $p = .000 < .05$, which reached a level of significance. This suggests a significant correlation between whether respondents had learned AMC and whether they would have their own children receive such education. In other words, these two variables are inter-dependent.

(2) Regarding contingency table symmetry, the contingency coefficient was .189, which reached a significance level of .05. This denotes a low level of correlation between whether JHS math teachers had learned AMC and whether they would have their own children receive such education.

(3) A total of 356 respondents did not receive AMC education (82.6% of the sample), and only 75 respondents had received this training (17.4%).

(4) Among the 356 respondents that had not received AMC education, 40.2% would have their own children receive such education, 51.1%would not have their own children receive such education, Among the 75 respondents that had received AMC education, 65.3% would have their own children receive such education, 30.7% would not have their own children receive such education, Among the total 431espondents, 44.5% would have their own children receive such education, 47.6% would not have their own children receive such education

(5) Among the 75 respondents that had received AMC education, 65.3% would have their own children receive such education, which was significantly higher than the proportion for the 356 respondents that had not received such education (40.2%).

5. Conclusion and Recommendations

According to Lee (2008), the Preparatory Office of the National Academy for Educational Research sampled students in 686 classes at 276 schools across the country in 2006 to conduct a "Survey on the Effects of the Second-Stage Implementation of Mathematics Education in National Elementary and Junior High Schools". The results showed that among the sampled fourth and fifth graders, 23% attended math classes at daycare centers or after-school programs; 34.1% attended math classes at supplementary-education schools; and 15.2% either attended AMC classes or had private math tutors.

These data demonstrate the current demand for supplementary-mathematics education at the elementary-school level, but they also highlight the severe challenges that AMC education already faces within static educational models. Based on the research results, this study offers diagnostic conclusions and recommendations regarding the implementation of AMC education among business and operational strategies for early childhood education. This can serve as a reference for business owners who do or who wish to provide AMC education services, and provides points of importance concerning marketing decisions.

5.1 Conclusion

After an analysis of JHS math teacher opinions regarding the effects of AMC education on mathematics learning, the following conclusions were reached. The results can serve as a reference for the legislature, educational authorities, early childhood-education business owners, and supplementary-education schools to formulate policies and administrative decisions regarding AMC education.

(1) Respondent opinions regarding the functions of AMC education: an analysis of three dimensions (i.e., positive opinions, negative opinions, and opinions regarding the effects of AMC on improving mathematics-learning attitudes).

(a) JHS math teachers generally favored and supported AMC education.

(b) JHS math teachers generally disagreed with items stating negative opinions regarding AMC.

(c) JHS math teachers did not show strong support for the effects that AMC education might have on improving mathematics-learning attitudes. However, the number of respondents that had learned AMC and supported the effects was significantly greater than those who did not; the number of respondents that did not have degrees in mathematics and supported the effects was significantly greater than those that did have degrees; the number of male respondents who supported the effects was significantly greater than female respondents; and the number of respondents that would have their own children study AMC and supported the effects was significantly greater than those who would not.

(2) Respondent opinions regarding the approaches or methods of AMC education: the appropriate ages for

AMC education; necessary basic math knowledge; appropriate teaching methods; the promotion of innovative AMC education; emphasis on the normal development of young children; and integration or complementary relationships with regular mathematics curricula. Conclusions were based on the following five aspects:

(a) JHS math teachers considered the elementary school level the appropriate period or age for AMC education.

(b) JHS math teachers considered a basic knowledge of addition and subtraction computations a prerequisite for AMC education.

(c) Approximately 60% of the respondents considered it necessary for AMC education to supplement regular math curricula in schools.

(d) Approximately 70% of the respondents stated that AMC teaching methods must be innovative to enhance student interest in learning.

(e) Approximately 73% of the respondents agreed that promoting AMC education in kindergartens should be based on the normal development of young children.

The results of this study can serve as references for the managers and teachers of public and private kindergartens who wish to identify the collective or group characteristics in the early childhood-AMC education market and who wish to enhance the service quality of early childhood education. By analyzing teacher opinions regarding AMC education in early childhood education, this study encourages the normalization of kindergarten education.

5.2 Recommendations

This study explored JHS math-teacher perceptions of and reflections on AMC education in early childhood-education businesses and operational strategies. The results can serve as a reference for the legislature, educational authorities, and business owner operations and management. Hence, two recommendations are proposed:

(1) The optimal timing for receiving AMC education is at the elementary school level. Because the basic knowledge of addition and subtraction computations is necessary, AMC education should not be the focus of kindergarten-level education.

(2) AMC education should be lively and innovative. From the perspective of young children, their intellectual abilities are in the process of and require further development; therefore, the mathematical ability-cultivation activities in early childhood education should adopt lively and diverse approaches. AMC education should be integrated in elementary-level and mathematics curricula to improve the integration and effectiveness of the transition and connection between early-childhood and elementary-level mathematics education.

5.3 Limitations and Directions for Future Studies

The contributions of this study are as follows: (a) responding to current issues related to newly emerging policies regarding early-childhood supplementary education, and (b) providing scientific evidence for future policy considerations based on an empirical study. Because this study was a quantitative survey, future researchers can conduct qualitative interviews with relevant personnel based on the qualitative results of the study, thereby enabling future scholars to further clarify actual conditions and situations. The following directions are proposed for subsequent studies:

(1) Further analysis of why JHS math teachers are in favor of AMC education will provide added value and

offer strong support for policy considerations. Therefore, conducting qualitative interviews with relevant personnel is recommended.

(2) The results indicate that compared to respondents that had not received AMC education, those who had received such training yielded a significantly higher average rating regarding the negative functions of AMC education. To further explore this phenomenon, qualitative interviews with relevant personnel should be conducted.

(3) The reasons that JHS math teachers did not strongly support the concept that AMC education could improve student mathematics-learning attitudes should be examined. Therefore, qualitative interviews with relevant personnel should be conducted.

Adding variables to the study will broaden the scope of inquiry. For example, the participants could be elementary-school and high-school math teachers. Using students as participants in empirical studies and investigating the relationship between student AMC abilities and the transfer of their math performance at the JHS level should also be considered.

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