American Journal of Educational Research, 2019, Vol. 7, No. 1, 104-108
Available online at http://pubs.sciepub.com/education/7/1/16
Published by Science and Education Publishing
DOI:10.12691/education-7-1-16

Development and Validation of an Instrument to Measure Attitudes towards the Use of Computer in Learning Mathematics

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Received November 11, 2018; Revised December 22, 2018; Accepted January 24, 2019

Abstract The aim of the study was to develop and validate an instrument suitable to measure attitudes towards the use of computer in learning mathematics (ATCLM). A total of 214 (132 = males: 82 = females) teacher trainees participated in the study. Factor Analysis (FA) was performed on 47 items relating to the use of computer in learning mathematics using Principal Component Analysis with Varimax (orthogonal) rotation. With Eigen values greater than 1, FA retained 13 factors with the first accounting for 15.56% of the variability and a total of 62.39% of the variance for the entire set of variables. To examine the strength of relationship among the items, the Kaiser Meyer Olkin (KMO) and Bartlett's test were used. The KMO measure of sampling adequacy was 0.78 whiles the Bartlett's test of sphericity was significant with $x^2 = 3510.253$ ($p< 0.0001$). A factor loading cut-off point of 0.40 was used as the inclusion criterion for factor interpretation. Based on these, seven factors namely: Confidence in Mathematics (CM), Confidence with Computer (CC), Mathematics Anxiety (MA), Computer Anxiety (CA), Value of using Computer for Learning Mathematics (VCLM), Interest in using Computer for Learning Mathematics (ICLM), and Anxiety in using Computer for Learning Mathematics (ACLM). Cronbach's alpha values for the 7 scales ranged from .735 to .880.

Keywords: *anxiety, attitudes, confidence, computer, development, instrument, mathematics*

Cite This Article: Osman Kasimu, and Ibrahim Nantomah, "Development and Validation of an Instrument to Measure Attitudes towards the Use of Computer in Learning Mathematics." *American Journal of Educational Research*, vol. 7, no. 1 (2019): 104-108. doi: 10.12691/education-7-1-16.

1. Introduction

Information and Communication Technology (ICT) have become one of the fundamental building blocks of modern society. Many countries, including Ghana now regard the mastering of the basic skills and concepts of ICT as an important part of our educational system. With the introduction of ICT into the school curriculum, students are now expected to use ICT effectively within their lessons, regardless of the subject they are learning [1]. ICT plays a critical role in the educational systems [2]. To this end, various new models of education are evolving in response to the new opportunities that are becoming available by integrating ICT into the teaching and learning environment. The effective integration depends to a large extent on teacher's familiarity and ability in the information technology learning environment. Teachers' roles in the integration process are to create an effective, efficient atmosphere and a multimedia environment with the help of technologies. These environments are important for teacher-student interaction and communication [3].

Mathematics teachers need to know exactly how ICT is used as a teaching and learning tool, for their own purposes and to help students to use them. It has therefore become necessary to monitor how teacher trainees perceive ICT and how it can be used in the learning of mathematics in the classroom. This study is therefore aimed at developing and validating an instrument suitable to measure students' attitudes towards the use of computer in learning Mathematics.

2. Literature Review

Researches on the development of instrument to measure attitudes towards mathematics and computer have been done by many in the field of mathematics education. Table 1 outlines researchers and the instruments developed.

From Table 1, it is evident that little research has been conducted in terms of developing instruments for attitudes towards the use of computer in learning mathematics as in the case of [5,6,9]. The rest are either measuring attitudes towards mathematics or computer as in the case of [4,8,9,13,14]. Hence the development of this instrument will be a useful tool in determining students' attitude towards using computer in learning mathematics.

Table 1. Previous Works by Other Researchers

S/N	Validated Instruments	Author(s)/Year	Computer/Mathematics Related Scales
11	Students' Attitudes Towards Mathematics	[4]	Anxiety, Confidence, Enjoyment, and Benefit/Value
22	Developing an attitude scale towards using instructional technologies for pre-service teachers	[5]	Believe regarding usage of instructional technology in lesson, -Appreciation to usage of instructional technology in lesson, -Unappreciated using instructional technology, -Disinclination to make use of instructional technology, Believe in usefulness of instructional technology
33	Validation of a Questionnaire to Measure Mathematics Confidence, Computer Confidence, and Attitudes to the Use of Technology for Learning Mathematics	[6]	-General confidence in mathematics, -General confidence with computer use, -General confidence using computers to learn mathematics
44	Construct Validity for the Teachers' Attitudes Toward Computers Questionnaire	[7]	- Interest, - Comfort, - Accommodation, - Concern, - Utility, - Perception, - Absorption, - Significance
55	Development and Validation of an Inventory for Measuring Student Attitudes Toward Calculus	[8]	-Self-confidence, - Value, - Enjoyment, - Motivation
66	A scale for monitoring students_ attitudes to learning mathematics with technology	[9]	-Mathematics confidence, -Confidence with technology, -Attitude towards use of technology for learning mathematics, -Affective and behavioral engagement
77	The Computer Usefulness Attitude Scale (CAS)	[10]	- Confidence, - Liking, - Anxiety, - Usefulness
88	An Instrument to Measure Mathematics Attitudes	[11]	-Self-confidence, - Value, - Enjoyment, - Motivation
99	The Computer Attitudes Scale for Secondary Students (CASS)	[12]	- Avoidance of, -Negative attitudes toward, - Caution with computers, - Cognitive, affective, and behavioral attitudes
110	The Computer Attitude Questionnaire (CAQ)	[13,14]	- Computer importance, - Computer enjoyment, - Computer anxiety, - Computer seclusion
111	The Computer Survey Scale	[15]	- Efficacy and anxiety

3. Methodology

3.1. Participants

The participants for the study were level 200 teacher trainees from three colleges of education in the northern region of Ghana. A total of 214 (132 = males: 82 = females) teacher trainees responded to the questionnaire. Of this number, 124, 21, 56 and 13 were offering General programme, Mathematics, Science, and French respectively. The researchers personally administered the questionnaire to the participants in their various colleges.

3.2. Instrument Development Process

The instrument (ATCLM) was designed as a tool for measuring attitudes towards the use of computer in learning mathematics. The ATCLM consisted of 47 items, some of which were generated by the authors with some selected and modified from [1,9,16]. Each item was presented as a statement with 7 statements each for the Confidence in Mathematics (CM), Confidence with Computer (CC), Mathematics Anxiety (MA), and Computer Anxiety (CA) scales. The other scales such as the Value of using computer for learning mathematics (VCLM), Interest in using computer for learning mathematics (ICLM) and Anxiety in using computer for learning mathematics (ACLM) had 5, 8 and 6 items respectively. A mixture of both positive and negative worded items were used to reduce response bias. A five – point Likert scale was used to rate each item in terms of, 1 = Strongly Disagree (SD), 2 = Disagree (D), 3 = Undecided (U), 4 = Agree (A) and 5 = Strongly Agree (SA). In responding to each of the items under a particular scale, respondents were asked to indicate the extent to which they agree or disagree to the items on the five-point Likert scale. A higher score indicated a more positive attitude towards using computer in learning mathematics. The negatively worded items

were reverse coded before the computation of the Cronbach's alpha coefficient.

3.3. Factor Analysis Process

Exploratory Factor Analysis (EFA) was performed on 47 items relating to the use of computer in learning mathematics using Principal Component Analysis with Varimax (orthogonal) rotation. Using Eigen values greater than 1, the EFA retained 13 factors with the first accounting for 15.56% of the variability and a total of 62.39% of the variance for the entire set of variables. Initially, to examine the strength of relationship among the items, the Kaiser Meyer Olkin (KMO) and Bartlett's test were used. The KMO measure of sampling adequacy was 0.78, above the commonly recommended value of 0.5 by [17]. The Bartlett's test of sphericity was also significant with $x^2 = 3510.253$ ($p < 0.0001$). The communalities of the 47 items ranged between 0.56 and 0.72, confirming that each item shared some common variance with other items. The Test gave the indication that factor analysis was suitable for the data. As recommended by [18,19], a factor loading cut-off point of 0.40 was used as the inclusion criterion for factor interpretation. Based on these, the seven scales were further retained, namely:

i. Confidence in Mathematics (CM)
ii. Value of using computer for learning mathematics (VCLM)
iii. Confidence with Computer (CC)
iv. Interest in using computer for learning mathematics (ICLM)
v. Mathematics Anxiety (MA)
vi. Anxiety in using computer for learning mathematics (ACLM)
vii. Computer Anxiety (CA).

Table 2. Factor Loadings for the Items

	Rotated Component Matrix[a]							
	Component							
Item Code	Items	CM	CC	MA	CA	VCLM	ICLM	ACLM
CM2	Mathematics is not difficult for me	.870						
CM4	I study mathematics more willingly than any other subject	.782						
CM3	I am confident that I understand concepts in mathematics	.663						
CM1	I have a lot of self-confidence when it comes to mathematics	.640						
CM5	I have avoided mathematics because it is difficult for me	.541						
CM6	When I have difficulties with mathematics, I know I can handle them	.508						
CC10	I am more confident in using computer to do my school work		.794					
CC13	I am always very excited about using computers.		.772					
CC8	I can master any computer program needed for school		.680					
CC9	I have less trouble learning how to use a computer than I do learning other subjects.		.568					
CC11	Using a computer is very frustrating		.544					
MA19	Working mathematics is very frustrating			.723				
MA15	I feel nervous when working mathematics.			.688				
MA16	I do not have a mathematical mind.			.649				
MA21	I wish that mathematics was not an important subject			.595				
MA20	I am always excited to take mathematics test.			.535				
MA17	I worry about making mistakes when solving problems in mathematics			.521				
CA27	I feel tense whenever working on a computer				.677			
CA24	I worry about making mistakes on the computer				.650			
CA25	I have avoided computers because they are unfamiliar and somewhat intimidating to me				.577			
CA22	Working with a computer makes me nervous				.545			
CA23	I wish that I could be as calm as others appear to be when they are using computers				.498			
VCLM32	Computers can be useful instructional aids in almost all subject areas.					.749		
VCLM33	Computers help to incorporate new teaching and learning methods					.654		
VCLM31	Computing power makes it easier to explore mathematical ideas.					.630		
VCLM29	Having computer skills helps one get better mathematics related jobs.					.576		
ICLM40	I learn swiftly mathematics topics when computer is use.						.720	
ICLM39	I regularly use computer in mathematics to help me solve mathematics problems.						.672	
ICLM41	I can learn many concepts in mathematics when a computer is use						.660	
ICLM34	I like using computer for learning mathematics.						.590	
ICLM38	I feel motivated learning mathematics when computer is use.						.538	
ACLM43	Working mathematics with a computer makes me feel tense and uncomfortable							.685
ACLM47	Working with a computer makes me feel tense and uncomfortable							.670
ACLM44	I know computers are important but I don't feel I need to use them to learn mathematics.							.624
ACLM46	I get a sinking feeling when I think of trying to use computer to learn mathematics.							.588
	Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.							

NOTE: The item codes in the first column of Table 2 represent the item numbers and the corresponding scales they are measuring. For example, CM2 is item number 2 which is measuring Confidence in Mathematics; CC13 is the 13th item which is measuring Confidence in Computer, etc.

From Table 2, it is seen that out of the initial 47 items, 35 are loaded onto the seven scales based on the strength of the loads. 6 items (CM2, CM4, CM3, CM1, CM5 and CM6) are loaded onto the Confidence in Mathematics scale. This scale measures the confidence level of teacher trainees towards mathematics. The second scale, Confidence with Computer had 5 items (CC10, CC13, CC8, CC9 and CC11) loading onto it. It measures teacher trainees' confidence level in working with computer. The third scale, Mathematics Anxiety had 6 items (MA19, MA15, MA16, MA21, MA20 and MA17). These items measure the anxiety level of teacher trainees. The Computer Anxiety, Value of using computer for learning mathematics, Interest in using computer for learning mathematics, and Anxiety in using computer for learning mathematics scales each had 5 (CA27, CA24, CA25, CA22 and CA23), 4 (VCLM32, VCLM33, VCLM31 and VCLM29), 5 (ICLM40, ICLM39, ICLM41, ICLM34 and ICLM38), and 4 (ACLM43, ACLM47, ACLM44 and ACLM46) items loads respectively.

3.4. Reliability Analysis of the Instrument

According to [20], the term reliability generally refers to the consistency of a measure. Reliability analysis on the seven scales was performed and their corresponding Chronbach's coefficient alpha recorded. Chronbach's coefficient alpha estimates the consistency of items included in a questionnaire. Values range from 0 to 1, with higher values (> .7) indicating greater reliability [19].

Table 3. Reliability Analysis

Scales	Number of Items	Chronbach's coefficient alpha
Confidence in Mathematics (CM)	6	.854
Confidence with Computer (CC)	5	.762
Mathematics Anxiety (MA)	6	.891
Computer Anxiety (CA)	5	.786
Value of using Computer for Learning Mathematics (VCLM)	4	.735
Interest in Uuing Computer for Learning Mathematics (ICLM)	5	.880
Anxiety in using Computer for Learning Mathematics (ACLM)	4	.751
Total	35	.933

From Table 3, the Cronbach's alpha for the seven scales ranged from .735 to .880 with a total of 0.933, which indicates a high level of internal consistency for our scales.

4. Summary and Conclusions

The aim of the study was to develop and validate an instrument suitable to measure attitudes towards the use of computer in learning mathematics (ATCLM). Review of literature reveal that most instruments developed are mostly centered on attitudes towards mathematics or computer with very little work on the use of computers in learning mathematics. A total of 214 (132 = males: 82 = females) teacher trainees participated in the study. Factor Analysis (FA) performed on an initial 47 items relating to the use of computer in learning mathematics retained 13 factors with the first accounting for 15.56% of the variability and a total of 62.39% of the variance for the entire set of variables. A factor loading cut-off point of 0.40 was used as the inclusion criterion for factor interpretation and the initial 47 items were reduced to 35. These 35 items loaded on to 7 factors (scales) namely: Confidence in Mathematics (CM), Confidence with Computer (CC), Mathematics Anxiety (MA), Computer Anxiety (CA), Value of using Computer for Learning Mathematics (VCLM), Interest in using Computer for Learning Mathematics (ICLM), and Anxiety in using Computer for Learning Mathematics (ACLM). Cronbach's alpha values for the 7 scales ranged from .735 to .880 with a total of 0.933, which indicates a high level of internal consistency for the scales.

Based on the above results, the instrument (ATCLM) was developed (See appendix) and will be a good tool to be used by researchers in determining the attitudes of students towards the use of computers in learning mathematics.

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