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SIMULATION APPROACH OF DEVELOPING THE CONCEPT OF SIMULTANEOUS EQUATIONS TO SECONDARY SCHOOL STUDENTS

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ABSTRACT: *This paper raised observations concerning the identified gap between the way secondary school teachers teach word problems involving simultaneous equations and best practices in mathematics teaching. The method of teaching the topic by teachers using the algorithm approach with the methods of substitution and elimination was found to be insufficient, and may not allow students to excel. Alternative approach of simulation was used on type A and type B word problems leading to simultaneous equations. The three stages of cognitive development of the learner which are categorised as the enactive, the iconic and the symbolic were presented with specific examples. Based on the conclusions of the paper the simulation approach of teaching word problems leading to simultaneous equations was recommended to secondary school teachers*.

KEYWORDS: Simulation Approach, Simultaneous Equations, Secondary School Students

INTRODUCTION

Mathematics is generally believed to be the bedrock of Science. It is also true that mathematics is a tool for everyday activities of man. The importance of the subject is acknowledged in the policy of government of the Federal Republic of Nigeria where mathematics is stated as a core subject which all primary and secondary school pupils and students must offer nationwide. It is also the policy of government that prospective candidates for admission into the tertiary institutions to read science or science related courses must have obtained a credit level pass in mathematics prior to admission. Furthermore, students' admission into Federal universities had been fixed for science and Arts in the ratio of 60 to 40 in government national policy (FRN, 2004). Earlier, a general poor performance of pupils at the Federal common entrance examination for the placement of candidates into Federal Government Colleges had triggered public outcry nationwide; because many pupils could not secure admission and parents would neither understand a newly introduced 'modern' mathematics into the primary school curriculum nor help their children at home to do better in the new mathematics. The outcry prompted government to summon mathematicians and mathematics educators for conference in Benin on 6th and 7th January, 1978 (Ohuche, 1978). This was also the era when modern and traditional mathematics curricula were going on simultaneously in secondary schools, leading to confusion of a sort in the system and untold poor performance among students at the West African Senior School Certificate Examinations (WASSCE).

Major decisions at the Benin Conference include: the production of mathematics curricula for schools; the teaching of the curricula by competent teachers who are capable of securing the interest of learners in the subject. In particular, seven objectives were stated for teaching mathematics at the secondary school level on page 4 of the original manuscript. They are:

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- To generate interest in mathematics and to provide a solid foundation for everyday living;
- To develop computational skills;
- To foster the desire and ability to be accurate to a degree relevant to the problem at hand;
- To develop precise, logical and abstract thinking;
- To develop ability to recognise problems and to solve them with related mathematical knowledge;
- To provide necessary mathematical background for further education;
- To stimulate creativity (FME, 1977:4).

The outcome of the Benin conference led to preparation of curricula for schools at the levels of primary, junior secondary and senior secondary levels (FME, 1979; 1982; 1985). The curricula had also been revised (FME, 2006, 2007a, 2007b and 2007c). The Mathematical Association of Nigeria (MAN) and other scholars had prepared textbooks to match various levels of the curricula. It is therefore expected that students' achievement will be enhanced significantly but this has not happened.

The Problem

The results of school examinations at the West African Senior School Certificate Examinations (WASSCE) particularly after the 2007 review of mathematics curricular are still not good enough. In particular students still find the learning of algebra abstract, while many teachers still find it difficult to make algebra real. This has been highlighted by Chief examiners and by general observations at school examination marking centres that candidates had problems with 'word problems leading to simultaneous equations'. Majority of candidates at the WASSCE exhibited varying degrees of frustration when solving word problems because they need to transform the word problems into linear or quadratic equations prior to application of algorithms and most of them could not do the required transformation. Furthermore, observations had been made that some candidates who were able to recall clues to the solution of simultaneous equation problems when they are presented in the model form: $ax + by + c = 0$ or $ax^2 + bx + c = 0$ where a, b, c are constants; were unable to take off when the same problems are presented as word problems. The teachers' mechanical approach of presenting students with equations in the iconic form, followed by helping them to apply related algorithm is just not sufficient. In a topic of this nature, there is the need for students to be guided from the enactive (action-based or concrete stage), through the iconic (use of icons or image –based i.e. the pictorial stage) to the symbolic otherwise called abstract stage (Awodeyi, 2001; Brachier, 2009; Culatta, 2012).

Purpose of this Paper

The general purpose of this paper is to present a peer reviewed work on simulation approach of teaching the concept of simultaneous equations to teachers through journal publication, for wider accessibility and inputs. Specifically, the paper intends to present to teachers at the secondary school level an approach of teaching word problems involving simultaneous equations using simulation approach. The approach was first presented at the workshop of the Mathematical Association of Nigeria (MAN) during her 49th National Annual Conference at Abuja, 2nd- 7th September, 2012.

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Concepts Clarification of Key Terms:

Simulation and Simulation Technique of Teaching

Simulation is described as a model of a set of problems or events that can be used to teach someone how to do something, or the process of making such a model (Cambridge Advanced Lerner's Dictionary). It has also been described as something that is made to look, feel, or behave like something else especially so that it can be studied or used to train people (Merriam-Webster's Online Dictionary, 2012). Empirical study has indicated that simulation-games environment when used constructively enhanced students' achievement in mathematics and also encouraged positive attitude among students towards mathematics (Akinsola and Animashahun, 2008). However, the present study is not about simulation-games environment but it is about simulating simultaneous equation problems by taking students through appropriate stages of problem solving in the topic.

Simultaneous Equations in Word Problems

In the Nigerian Mathematics Curricula for JSS and SSS, simultaneous equations exist in two major types. The first type is the one in which its two equations are linear in two unknowns x and y i.e. in the form $ax_1 + by_1 = c_1$ and $ax_2 + by_2 = c_2$ where a, b, c ϵ R. The second type has one of its equations in the linear form while the other is in quadratic form i.e. $ax_1+bx_2+c_1=0$ and $ax_1^2+bx_2+c_2=0$ where a, b, c ER (FME, 2006 and 2007). The problems involving simultaneous equations of both types are stated in textbooks either in the symbolic form or in word problem (Kalejaiye, 2010). When the problems are in symbolic forms, the substitution method and the elimination method are employed to find the unknown values. This is achieved by the use of related algorithm. Unfortunately, learners usually have the initial challenge of transforming word problems into the symbolic before going through algorithm. This is where the teacher has to do something extra such as employing the simulation technique. With this, students should easily recall knowledge, or as they encounter increasingly difficult problems, they can fall back on experience at the enactive, iconic or symbolic stages of the development of the concept of simultaneous equations.

Application of simulation and simulation technique to word problem involving simultaneous equations

Illustrations:

Type A: Simultaneous Linear equations.

Question 1:

A buyer pays ₦1,750 for 7 cups and 8 plates. He also pays ₦1,700 for 8 cups and 7 plates. Find the cost of a plate and a cup.

Activities:

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The Simulation: The teacher calls out two students to act shopping.

C

P

7c + 8p = 1750 .....(i)
8c + 7p = 1700 .....(ii)

Figure 1.

Simulation activities:

1. A shopkeeper and a buyer may be assumed among the class members. The class interacts with the word problem.
2. A table is prepared on a chart or displayed by a power point with cells open, to be filled with facts from the word problem.
3. The symbols C and P (or any other letters from the alphabet) may be used for cup (C) and plate (P) respectively as in Table 1 below.

Table 1: Showing Interpretation of the Word Problem into Tabular Form

Purchase	Cups	Plates	Cost (N)	Reasoning/equations
1st	7	8	1750	7C + 8P= 1750
2nd	8	7	1700	8C + 7P= 1700

Algorithm:

7C + 8P = 1750----------(i)
8C + 7P = 1700----------(ii)
(i) x 8: 56C + 64P = 14000---------(iii)
(ii) x 7: 56C + 49P =11900---------(iv)
(iii)- (iv): 15P =2100 or P=N140
Substitute for P =140 in (i): 7C = 1750- 8(140);
7C = 1750- 1120 or 630
C = 630/7 or 90

Answer: The cost of a plate is N140 and the cost of a cup is N90.

Example 2:

1. A woman's age and her son's add to 45 years. Five years ago, the woman was 6 times as old as her son. How old was the woman when the son was born?

(Ans: 25 years)

Simulation activities:

1. A student could be made to act the mother while another act son. The entire class (the actors inclusive) interact with the word problem (**enactive stage**).
2. A table could be prepared on display charts or projected from power point etc, with the cells open to be filled with symbols like in example 1 above. Icons which the teacher may find appropriate to further aid understanding may be used (**iconic stage**).

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3. The symbols W and S (or other letters such as X and Y) may be selected to stand for woman and son respectively as in Table 2 (Symbolic stage).

Table 2*: Showing the interpretation of the word problem in symbolic form*

Time	Age of woman	Age of son	Reasoning	Equations
Present	W	S	W+S=45	W+S=45.....(i)
5 years ago	W-S	S- 5	(W-5)= 6(S-5)	W-6S=25....(ii)

Display the resulting equations for further discussion among students and solve as convenient using the elimination or substitution method.

Algorithm:

W+ S = 45 --------(i)
W- 6S = -25 ------(ii)

(i)- (ii) 7S = 70; and S=70/7 or 10.
Use S=10 in (i): W= 45 – 10 = 35.
The first conclusion that can be made is that the woman is 35years when the son is 10years. We can proceed from this point to determine the age of the woman when the son was born. The figures below will help the majority of students to comprehend the required result.

Demonstrations/Deduction:
Some demonstration on the part of the teacher will help the student to determine and clarify the age of the mother when the son was born.

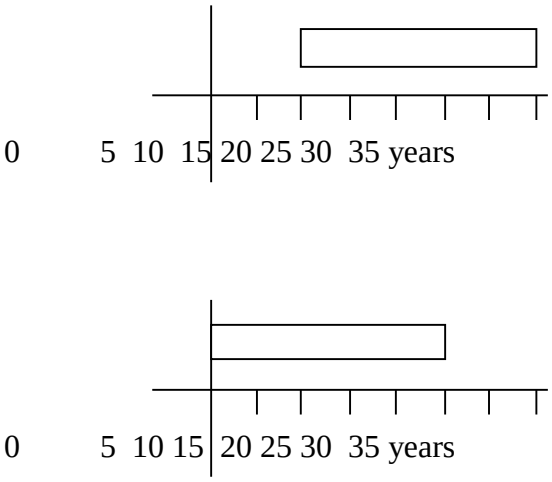

Figure 2.

Type B: One linear and one quadratic e.g. comparison of ages of two persons

Example 1:
A girl is 6 years younger than her brother. The product of their ages is 135. Find their ages.

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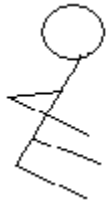
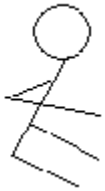
Activities:
The Simulation: The teacher calls out two students from the class to act as siblings.



Girl
x



Boy
x + 6

Figure 3.

Simulation activities:
1. Two siblings may be assumed from members of the class. The class would then interact with the given problem.
2. A table of readings is prepared on a chart for display or a power point projector is employed. Icons which may be found suitable by the teacher could also be adopted to reinforce learning.
3. The symbol X may be assumed as the age of the girl and Y the age of her senior brother in the word problem. It also follows that the age of the girl's senior brother is X+ 6. This is put clearer on the table.

Table 3: Showing interpretation of the word problem into symbols and equations

	Girl	Brother	Product of ages	Equation
Age	X X	Y X+ 6	XY X(X+6)	XY= 135 Y= X+ 6

The equations are assembled as indicated below and the algorithm employed.

Algorithm:

$XY= 135$---------- (i)
$Y = X+ 6$ ---------- (ii)

Use (ii) in (i): $X(X+ 6) = 135$ ----------(iii) also ($XY = X(X+6)$)

$X^2 + 6X = 135$
$X^2 + 6X -135 = 0$
$X^2 + 15X- 9X– 135 = 0$
$X(X+15) – 9(X+15) = 0$
$(X +15) (X-9) =0$

Deductions: It is either $X+15 = 0$ to give $X = - 15$ or $X- 9 = 0$ to give $X = +9$.
The age of a person could not have been a negative value. Hence, the age of the girl is 9 and her senior brother is 15 (i.e. 9+6).

Example 2:
A father is 3 times as old as his son. 8 years ago, the product of their ages was 112. Find their present ages.

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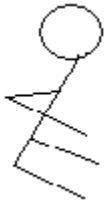
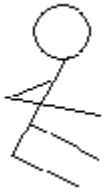
Activities:
The simulation:



Father



son

Figure 4.

Present ages: **x** years **y** years

Simulation Activities:
1. Let two members of the class act father and son. Then the class should be allowed to interact or digest the word problem.
2. The teacher would guide the students to assemble their thoughts or interpretation correctly on a table for clarity.
3. The symbol X may be adopted for son and Y for father.

Table 4: Showing the interpretation of the word problem into the symbolic form

Variables	Son	Father	Product	Equations
Present age	X	Y		Y=3X
8 yrs ago	X-8	Y-8	(X-8) (Y-8)	(X-8)(Y-8) = 112

The equations are assembled as shown below to determine the values of X and Y.

Algorithm:
Assemble the equations and apply the algorithm as solved below:

$Y = 3X$ ---------- (i)
$(X-8)(Y-8) = 112$ ---- (ii)

Use (i) in (ii): $(X-8)(3X-8) = 112$ (Y is eliminated)
$3X^2-8X-24X+64=112$
$3X^2-32X-48 = 0$
$3X^2 - 36X + 4X - 48 = 0$ (refer to text on factorisation of quadratic expressions)
$3X(X-12) + 4(X-12) = 0$
$(X-12)(3X+4) = 0$
Either $X - 12 = 0$ or $3X + 4 = 0$
$X = 12$ or $-4/3$ (a negative value is not suitable for the age of a person).
If $X = 12$ then $Y = 3(12)$ or 36.

Deductions:
The present ages of son and father are 12 and 36 respectively.

Exercise: to do in class and at home.
1. The sum of two numbers is 19. Their difference is 5. Find the numbers

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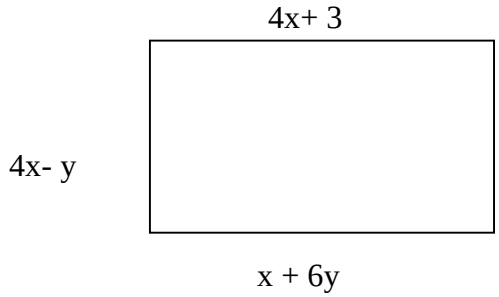
Answer: 12, 7

2. A father is 25 yrs older than his son. The sum of their ages is 53 years. Find their ages. (Answer: 39, 14)

3. The sum of two numbers is 17. The difference between twice the larger number and three times the smaller is 4. Find the numbers. (Ans:11, 6)

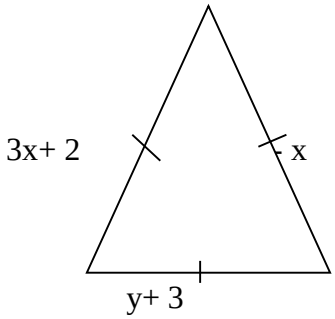
4. A newspaper and a magazine cost N55 together. The newspaper costs N35 less than the magazine. Find the cost of each. (Ans: N10, N45)5. Dupe's age and Olu's age add up to 25 years. Eight years ago, Dupe was twice as old as Olu. How old are they now? (Ans: 14 yrs, 11 yrs)

6. The sides of a rectangle shown below are given in cm.



Find x and y and the area of the rectangle. (Ans: x= 3, y= 2; 150cm^2)

7. The sides of the equilateral triangle shown below are given in cm.

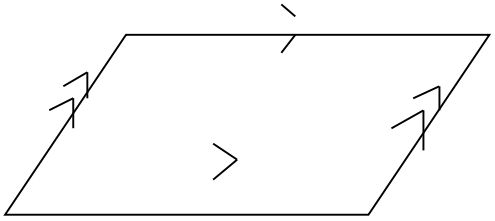


Find x and y and the perimeter of the triangle. (Ans: x= 2, y= 5; 24cm.)

8. The sum of the digits of a two-digit number is 10. The result of subtracting twice the units digit from three times the tens digit is 15. Find the number. (Ans: 73)

9. The sum of the digits of a two-digit number is 12. If the digits are interchanged, the number is increased by 36. Find the number. (Ans: 48)

10. The sides of a parallelogram in the figure are given in cm. Find X and Y, and the perimeter of the parallelogram.



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(Macrae, M. F., Kalejaiye, A. O., Chima, Z. I., Garba, G. U., Channon, J. B., Smith, A. M., and Head, H. C. (2005:129)

CONCLUSION

The teaching of simultaneous equations involving word problems to secondary school students(age 15 and 16) using the simulation technique was discussed in this paper. The word problems were categorized into types A and B for each discussion. Type A involves two linear equations in two unknowns while type B involves two equations in which one is linear and the other quadratic. The paper pointed out that teachers generally place priority on the use of algorithms mainly while teaching the topic to the neglect of the processes of transforming word problems into equations in symbolic form prior to algorithm.

The problem was observed to have existed for a long time among teachers on teh yearly teaching practice in the faculty of education. Practicing teachers in the schools too, who are expected to mentor those on teaching practice also have the same challenge. A further look through the textbooks used in the schools also placed emphasis on the use of algorithm involving methods of substitution and elimination. This is the gap which the present paper has attempted to fill. The use of simulation technique was discussed in details. Readers/teachers are taken through three stages of solution which learners should be exposed to while solving word problems leading to simultaneous equations at the secondary school level. The stages are the enactive, the iconic and the symbolic.

RECOMMENDATIONS

The following recommendations are made based on the conclusions of this paper:
-The teaching of word problems involving simultaneous equations using simulation technique is recommended for use by secondary school teachers.
-Teachers may find it worthwhile to compare this approach with existing approaches with the view of finding out if a significant difference is obtained between achievements of students who are taught simultaneous equations using various approaches.

REFERENCES

Akinsola, M. K. & Animashahun, I. A. (2008). The Effeccts of Simulation-Games Environment on Students' Achievement in and Attitude to Mathematics in Secondary Schools. Retrieved 28th October, 2016 at http://www.researchgate.net/profile/mojeed.

Awodeyi, A. F. (2001). The Enactive, Iconic and Symbolic Stages of Presenting Addition and Subtraction of Fractions to Learners. Nigerian Journal of Science and Science Education (NJSSE) 7 (2), 23-36.

Brachier, D. T. (2009). Teaching Secondary and Middle School Mathematics. Retrieved 15th September, 2016 at http://www.google.com.ng

Culatta, R. (2002). Constructivist Theory (Jerome Bruner): Instruction Design. Retrieved January 2012 from http://www.instructonaldesign.org/theories/constructivist/html

Channon, J. B., Smit, A. M., Head, H. C., Kalejaiye, A. O., & Macrae, M. F. (1997). *New General Mathematics for West Africa (Revised)*. Academy Press: Nigeria.

ISSN 2054-6351 (print), ISSN 2054-636X (online)

Federal Ministry of Education (FME), (1977). A Report of Mathematics Conference Held in Benin at the University of Benin, Nigeria: 6th & 7th January.

Federal Ministry of Education (FME), (1979). *National Curriculum for Primary Schools (Mathematics).* Lagos: Government Press.

Federal Ministry of Education (FME), (1982). *National Curriculum for Junior Secondary Schools (Mathematics) Vol 1*. Lagos: Government Press.

Federal Ministry of Education (FME), (1985). *National Curriculum for Senior Secondary Schools (Mathematics) Vol 5*. Lagos: Government Press.

Federal Ministry of Education (FME), (2006). *9-Year Basic Education Curriculum (Mathematics) for Primary Schools 1-3*. Nigeria Educational Research and Development Council (NERDC) Press: Abuja.

Federal Ministry of Education (FME), (2007a). *9-Year Basic Education Curriculum (Mathematics) for Primary Schools 3-6*. NERDC Press: Abuja.

Federal Ministry of Education (FME), (2007b). *9-Year Basic Education Curriculum (Mathematics) for Junior Secondary Schools 1-3*. NERDC Press: Abuja.

Federal Ministry of Education (FME), (2007c). *9-Year Basic Education Curriculum (Mathematics) for Senior Secondary Schools 1-3.* NERDC Press: Abuja.

Ohuche, R. O. (1978). Change in Mathematics Education Since the Late 1950s- Ideas and Realisation in Nigeria. *Educational Studies in Mathematics Vol 9*, pp.271-281.

Simulation. (2012). In Merriam-Webster.com. Retrieved June 1, 2012, from http://www.merriam-webster.com/dictionary/simulation.

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