Problem Based Learning (PBL): Using Reading Comprehension to Solve Mathematical Word Problem at Junior Secondary School Level

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Abstract: **- Statistically speaking, Nigerian students perform much better in English language than they do in Mathematics (WAEC 2014-2016). While many studies (Anderson 2001, Savery 2006, Puri 2014) have identified various reasons for this disparity in performance, and have suggested ways and strategies to address each problem, Problem-Based Learning (PBL) has not been explored within the Nigerian context as an instructional strategy to help students overcome this challenge. This paper is designed to look at how PBL as an instructional strategy can be used to transfer students' problem-solving skills in reading comprehension to mathematical word problem-solving. Summative outcome of the analyses indicates that well designed and facilitated PBL instruction enhances students' academic skills transfer across the content areas including solving mathematical word problems. Problem-Based Learning is a curriculum development and instructional approach that simultaneously develops problem-solving strategies, disciplinary knowledge bases and skills. It places students in the active role of problem-solvers confronting sometimes ill-structured problems that mirror real-world situations.**

Key words: **Problem based learning, reading comprehension, Solve, mathematical word problem**

I. INTRODUCTION

The development of problem-based learning emerged out of the medical field when Neurologist Howard S. Barrows noticed that medical students were bored in class and were dropping out of the programme. His investigation revealed that students were leaving the programme because they complained about not having opportunities to transfer theory to practice; i.e. there were no opportunities for them to apply what they had in classes to their real life practical work experiences two years later (Walker, Leary, Hmelo-Silver, & Ertmer (Eds.) 2015).

Rather than continuing the practice of lecturing and more lectures that drove students out of the programme, Barrows (1980) decided to put students in small groups and present them with actual patient medical problems to solve. He also required them to search and use whatever resources they considered relevant to help them solve the problem (Andrew Walker, Heather Leary, Cindy Hmelo-Silver, Peggy A. Ertmer (Eds.) 2015). Problem-Based Learning (PBL) can be traced back to what Cavanaugh (1997) described as Discovery-Based Learning of the 1960s (Cavanaugh1997).

Based on its successes in the medical, sciences and humanities, the application of PBL approaches has now spread far beyond medical education. (Walker, Leary, Hmelo-Silver, & Ertmer (2015). Today, PBL is used at all levels from elementary school to adult education, in disciplines ranging across the humanities and sciences, and in both academic and corporate settings (P.1).

Despite its high acclaim and widespread application in teaching and learning, "PBL does not have a store of transferable techniques or methods like cooperative learning" (Rhem1998, P.2). Its strengths are derived from its structure which provides students opportunity to learn through contextualized problem sets and situations. Contextualization brings real life authenticity to the problem and give students a sense of ownership of the problem, empowering them to explore possible solutions to the problem with confidence. Problem-Based Learning (PBL) is a learning strategy that embodies most of the principles that improve knowledge acquisition, cooperating, prompt feedback, team work and accountability.

II. THEORETICAL FRAMEWORK

Constructivism is a view of learning based on the belief that knowledge is not a thing that can be simply given by the teacher at the front of the classroom to students in their desks, but it is believed that knowledge is constructed by learning through an active mental process of development, learners are the builders and creators of meaning and knowledge. Piaget (1977) Kelly (1991) and Fosnot (1989) opines constructivism by reference to four principles: learning is an important way, depends on what we already know, new ideas occur as we adopt and change over old ideas, learning involves inventing ideas rather than mechanically accumulating facts and meaningful learning occurs through rethinking old ideas and coming to new conclusion about new ideas which conflict with our ideas. A productive classroom, the teacher provides students with experiences that allow them to hypothesize, predict, manipulate objects, pose questions, research, investigate, imagine and invent, but the teacher's role is to facilitate this process. Also Piaget (1977) asserts that learning occurs by an active construction of meaning, rather than by passive recipience and he further explains that when

we as learner, encounter an experience or a situation that conflicts with our current way of thinking, a state of disequilibrium or imbalance is created. He was of opinion that we alter our thinking to restore equilibrium or balance to arrive at this making sense of the new information is very vital by association with what we already know by attempting to assimilate it into our existing knowledge, and this can be done by accommodating the new information to our old way of thinking by restructuring over present knowledge to a higher level of thinking.

In the same vein Kelly's theory of personal constructs (Kelly, 1991) proposes that we see the world through mental constructs or patterns which we create and develops different ways of constructing or understanding the world based on our experiences. Every individual in the world encounter a new experience, we attempt or try to fit these patterns or experiences into the new experience.

Constructivist ideas were not widely valued due to the perception that children's play was seen as aimless and of little importance. Jean Piaget did not agree with these traditional views. To him, he saw play as an important and necessary part of the student's cognitive development and provided scientific evidence for his views. Today constructivist theories are influential throughout much of the informal learning sector. Formalization of the theory of constructivism is generally attributed to Jean Piaget, who articulated mechanism by which knowledge is internalized by learners. He suggested that through process of accommodation and assimilation, individuals construct new knowledge from their experiences (Duckworth, 2006). It is important to note that constructivism is not a particular pedagogy, constructivism is a theory describing how learning happens, regardless to understand are using their experiences to understand instructions for a particular direction.

The student-centeredness of a constructivist classroom is clearly apparent in a reader response approach and recognizing the significance of the unique experiences that each individual brings to the reading of a selection of literature, the leader in a response centred approach seeks to explore the transaction between the student and the text to promote or extract a meaningful response (Roseblatt, 1978), Devries (2002) explains that in most pedagogies based on constructivism, the teacher's role is not only with the students while they are completing activities wondering aloud and posing questions to the students for promotion of reasoning.

III. WHAT IS PROBLEM-BASED LEARNING (PBL)?

Going by its name, it is self-defining. Savery, (2006) defines PBL as "an instructional and curricular learner-centered approach that empowers the learner to conduct research, integrate theory and practice and apply knowledge and skills to develop a viable solution to a defined problem" (P. 44). It does not require a singular paradigm or solution to the problem; it engenders innovation and encourages exploration in the contexts of teaching and learning. This provides the platform for independent application of prior knowledge and construction of new knowledge to current problem. Proponents of PBL believe that students develops methods for constructing new conceptual knowledge (Roh, 2003). It is further argued that the existing traditional ways of teaching in Nigeria's classrooms are not only teacher-oriented, but are driven by use of one-dimensional, ready-made approach. This approach presents the singular (Usually teacher's) knowledge to students who are considered 'empty vessels' (Freirean concept) and assumed to have no knowledge base on the subject matter. Decades of research and users of PBL (Kelly 1999)have debunked this erroneous assumption.

IV. ADVANTAGES OF PROBLEM BASED LEARNING (PBL)

Despite, the many acknowledged advantages of PBL, there are some drawbacks. The most prominent complaint is that PBL is time consuming due to its complex structure. It requires a lot more time to design and implement in a classroom setting than the traditional 'stand and deliver approach.'

However, its advantages outweigh the disadvantage. For example, Clark, Clough & Berg (2000) believe that with well-phrased questions, PBL teacher can guide students to see discrepancies in their thinking and consider alternatives without telling them exactly what to do (P. 42). Some of PBL's advantages are described from different, sometimes discipline-based perspectives. While some describe them as characteristics (Judy Kay, 2002), others simply call them advantages (Torp Sage, 2002). Mome of the advantages are listed below.

- It offers an environment for positive problem-solving without restricting students' ideas to the confined of one school of thought (The teachers')
- Learning is done in context
- Students are more motivated to learn
- It promotes higher order thinking (Meta cognition)
- It allows for self-regulated learning
- It encourages collaborative work
- It engenders recognition and application of prior learning
- It uses integrated learning
- It gives students ownership of the problem
- It helps develop debating and negotiating skills
- It teaches and uses critical/analytical thinking skills
- It is based on Problem-solving

V. STRUCTURE OF PROBLEM BASED LEARNING (PBL)

Torp L. and Sage S. (2002) explain problem-based as a teaching strategy that leads students to learn and encourages them to develop critical thinking and problem-solving skills that they can carry for life. As an instructional strategy that

searches for solution to life's problems, a well-designed PBL has a fairly complex structure.

1. Problem based – It begins with presentation of a real life problem
2. Problem – Solving approach: It supports the application of problem-solving skills required to navigate real life..
3. Student-Centered –It guides students to take responsibility for their own learning as independent problem-resolvers.
4. Self –directed learning: Students develop research skills and become self-reliant.
5. Reflection: It concludes with group discussion designed to reflect on the learning process and transfer of new knowledge.

VI. WHY ADOPT PROBLEM BASED LEARNING IN MATHEMATICS?

Recognizing PBL as an innovative approach to teaching and learning, Puri (2014) cautions that "what happens inside schools has a deep and lasting effect on the mind-sets that children develop toward lifelong learning. A teacher affects eternity and one can never tell when his influence stops" (P.???). She suggests that it is better that the teacher make learning as interesting as game, and the classroom a joyful learning environment.

One of the primary goals of using constructivist teaching strategy is that students learn how to learn by giving them the training to take initiative for their own learning experiences. According to Audrey Gray (2002) opines features of constructive classroom.

- Learner are actively participated
- Democratic environment is created
- Student-centred and interaction centre for all
- Teachers stands as facilitators in a process of learning in which students are ought to be responsible and independable in their duties and work.

The Indonesian Modular ??? of 2006 states that the objective of teaching and learning Mathematics in secondary schools is to understand mathematical concepts, describe the connection between concepts and apply concepts or algorithms in problem-solving as flexible, accurate, efficient, and exact as possible (MoE of Indonesia, 2006). Similarly, the Principle Standard of School Mathematics (NCTM, 2000) which is??? states that the purpose of learning Mathematics is to develop and deepen understanding of mathematical concepts and relationships as they create, compare, and use various comprehensions. The Principle Standard of School Mathematics (NCTM 2000) seems to be establishing a central role of comprehension as a required learning skill in solving mathematical problems. This would be especially applicable to mathematical word problems which require reading and comprehending the problem in order to solve it. Consequently, this paper argues that (understanding) comprehension is an integral part of daily real life problem solving.

Daily life problems are numerous, multi-dimensional, complex and inter-woven. This makes for a compelling argument that comprehension of problems and problem-solving skills are transferable between learning fields as well as between life situations. This paper therefore, pursues this premise by studying how students who have good comprehension skills can transfer same to reading and mathematical word problems. The basic principle of PBL is that clear comprehension of the problem sets the path for solving it using previously acquired problem solving skills.

Building on Puri's (2014) position that learning that happens in schools not only has deep and lasting effect on students, but helps them develop lifelong skills supports the transference of reading comprehension skills to better comprehension of mathematical word problems. Problem-Based Learning (PBL) has the potential to increase students' understanding of the problem; this in turn increases their chances of successfully solving the problem, especially in mathematical word problems.

Studies show that students are said to understand when they are able to construct meaning from instructional messages, including oral, written, and graphic communication presented to them during teaching (Anderson, 2001).This comprehension happens when incoming (new)information connects to their existing (prior) knowledge in their cognitive structure. For example, students will understand the concepts of fraction addition if it is connected to the concept of integer addition. Underscoring this theory, Hiebert & Carpenter (1992) note that mathematical ideas, procedures or facts are understood if they are parts of an internal network of concepts which already exist in the cognitive structure of the student.

A 2013 pilot research conducted in Indonesia showed that students' achievement in mathematical problem-solving in Public Junior Secondary schools increased to67% (Minarni, 2013) after PBL was adopted as the instructional strategy for. Prior to this, it was reported that Indonesian eight grade students' achievement in problem solving was very low - under 400 from 600 (TIMMS evaluation (Mullis, et al., 2011). The breakdown showed that students scored only get 19% in solving geometry problems, while theinternational average was 32%; they scored 8% in solving algebraic problems while the international average was 18%. After implementing problem-based learning teaching approach, the students' mathematical problem-solving scores rose to 67 % (Minarni, 2013).

While this paper is not claiming that PBL is the sole reason for the increased scores, its multi-dimensionality is believed to have compensated for the conventional teacher-centered approach, poor leaning materials, and lack of student engagement (Ronis, 2008).

It seems that there is a connection between mathematical understanding and mathematical comprehension. On the other hand, mathematical understanding is very important in studying Mathematics since it will be ease solving mathematical problem, even it will sharpen problem solving. Now, problem solving is the important thing the student must be mustered (Lee & Tan, 2004; Ronis,2008) since almost every work field needs this skill. No doubt, teacher should teach the student such that the student has the opportunity in solving mathematical problems as well as mathematical understanding and comprehension.

So, it is emerge that teachers need to know and implement learning approach that can support and facilitate students' mathematical comprehension and mathematical comprehension. Furthermore, the writer suggest that principle standard for school Mathematics (NCTM, 2000) should be grasped by using learning approach which facilitate the students to solve various problems since by working in

One of teaching learning approach that should be implementing in the school is Problem-based learning (PBL). PBL, the problem is the central of learning activity. The students are encouraged and facilitated to be actively engaging in solving problems. Using previous knowledge and experience, they try to sharpen their mathematical skills by solving real, challenging, open-ended, and contextual problems. From this kind of learning, it can be hoped that the students be motivated and Interested to try to be a problem solver.

Puri (2014) proposed some ideas to create joyful in learning in classroom, they are let the students:

1. Enjoy learning as well as they enjoy games
2. Create songs and rhythm when learning something new
3. Decide on the topic they want to study for that week and then as "experts" they will teach the next week
4. Create things such as make a newspapers and magazines, brochures, stories, picture books, posters, PowerPoint presentations, interviews, oral histories, models, diagrams, blueprints and floor plans, plays and role-plays, mock trials, photographs, paintings, songs, surveys, graphs, documentary videos,
5. Show off students work, for example hang it at the wall
6. Get outside cause it is delightful for a student to sit under a tree and read or for a class to sit in a circle on the grass and talk
7. Read good book; allow books beyond the texts simply for the sake of student enjoyment.

Methodology, the research was conducted based on interview and observation in one school. The instrument consists of some questions about students' comprehension and mastery achievement in Mathematics. For the purpose of measuring students reading comprehension ability to solve mathematical word problem, the researchers have designed Essay test. The test formulation was designed based on aspects of reading worded Mathematics and resolving the worded sentence Mathematics into mathematical equation involving equation to be solved.

VII. PROCEDURE OF ANALYTIC MARKING SCHEME FOR READING COMPREHENSION MATHEMATICS TESTS (RCMT)

- Understand the problem by drafting
- Knowing relevant concept to apply in solving the problem
- Complete working that give correct answer
- Showing an aspect of mathematical understanding based on the comprehension
- Using incorrect procedure that bring wrong answer

Data obtained is analyze descriptively based on the four aspect mentioned above included test sentence (worded) problems on Mathematics.

Let us consider the short sentence mathematical word problem below

Problem 1: The sum of the age of a mother and a daughter is 44yrs. Three years ago the product of their ages was 192. How old is the daughter now?

Problem 2: A number of two digits is increased by 9. When the digits are reversed, the sum of the digits is 5, find the number

Problem 3: The sum of the ages of two brothers is 22years. Six years ago, the product of their ages was 21 years, find the age of the elder brother

It is believed that Word sentences Mathematics is more difficult than equation Mathematics. The reason of this believes, is that words sentences Mathematics requires adequate interpretation and understanding of the mathematical word problem. It means indebt understanding and interpretation are needed before a good student can resolve the problem into equation to be solved.

Examples are shown below

Problem 1 solution

Step I Let mother age be x

Step II Let daughter age be y

But remember that sum means addition

So x+y = 44 _____ (1)

Translation of word problem

3 year ago, means

Mother age would be x-3

Daughter age would be y-3

Solving of The Problem

Product of their ages = (x-3) (y-3) = 192

Expanding => xy – 3x -3y + 9 =192

xy – 3x - 3y + 192-9

xy - 3x - 3y = 183 _____ (ii)

From equation (1) x = 44-y

(44-y) y-3 (44-y) -3y = 183

$44y-y^2$ -132 + 3y-3y =183

44y-y2 -132 =183

$44y-y^2 = 315$

$- y^2 + 44y = 315$

Multiply through by – 1

y^2 44y = -315

Using completing squares method

y^2 44y + $(-22)^2$ = -315 + $(-22)^2$

$(y-22)^2$ = -315 + 484

$(y-22)^2 = -315 + 484$

$(y-22)^2 = 169$

Squares both sides

$y - 22 = \sqrt{169}$

y - 22 = 13

y = 13+22, y = 35

Mother's age = 35

For the daughter's age

From equation (1) x+y = 44

x + 35 = 44

x = 9

Mother's age = 35 yrs

Daughter age = 9 yrs

Problem II

Let the number be

10x + y+9 = 10y + x

Inter changed = 10y + x

10x - x + y -10y + 9 = 0

9x – 9y + 9 = 0

9x – 9y = - 9

x – y = -1 _____ (i)

Reversed of the digits number

= x + y = 5 _____ (ii)

From equation (i) x = - 1 + y

From equation (ii) – 1 +y + y = 5

-1 + 2y = 5

2y = 5 + 1

y = 6/2

y = 3

For x = -1 + y

x = -1 + 3

x= 2

The numbers are

2, 3

Checked 10x+y+9 = 10y+x

10 x 2+3 + 9 = 10 x 3 + 2

20 + 3 + 9 = 30 + 2

32 = 32

Problem III

Let the ages of the two brothers be

x and y

Sum of their ages gives 22

So, x + y = 22 call it equation _____ (i)

6 years ago, means

Second brother would be

x – 6, and first Brother y – 6

Product of their ages = (n-6) (y-6) = 21

Expanding the equation

xy - 6x -6y + 36 = 21

xy – 6x -6y = 15 _____ (ii)

From equation n+y = 22

x = 22-y _____ (iii)

y (22-y) – 6 (22-6) -6y = -15

$22y –y^2 – 132 + = 15$

$22y – y^2 - 132 = - 15$

$22Y - y^2 = -15 + 132$

$22y - y^2 = 117$

$-y^2 + 22y = 117$

$y^2 - 22y = -117$

Using completing square root

$y2 - 22y + (-11) = -117 + (-11)^2$

$(y-11)^2 = - 117 + 121$

$(y-11)^2 = 4$

Square both sides

$(y - 11) = \pm\sqrt{4}$

$y - 11 \pm 2$

$y = 2 + 11, y = 13$

From equation (i)

$x + y = 22$

$x + 13 = 22$

$x = 9$

First brother age = 13 yrs

Second brother age = 9 yrs

VIII. CONCLUSION

The objective of teaching and learning Mathematics in primary and secondary school is to understand mathematical concepts and describe the connection into our daily life activities, but today the result is the reversed. This paper is aimed toward students' engagement in learning which shows very low performance in the area of Word Sentence Mathematics. Based on the essay test, it was found that performance of the students was insignificant showing that Word Problem (in terms of reading comprehension is small in solving Mathematics). On this note, it is clear that when students are allowed to search information for themselves, it gives them indebt understanding of the problem than the classroom teaching when the teacher dominate the class in term of learning.

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