



Adolescents' Problem Solving Ability in Mathematics and Medium of Instruction

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Background: Today's world considers English as a global language because there has never been a language so widely spread or spoken by so many people as English [1]. The main idea of English medium instruction (EMI) is to combine the conventional instruction of content-area subjects with foreign language-learning. Using a foreign language is certainly a major obstacle in problem solving in mathematics since it involves abstract thinking and mastery of mathematical terminology which make a high demand on language proficiency.

Objective: Objective of this present study was to explore the role of medium of instruction on problem solving ability in mathematics of adolescent boys.

Hypothesis: Students of Odia medium schools (mother tongue based instruction) would score more in problem solving ability test as compared to students of English medium schools.

Methods: The size of the sample was 120. Out of 120 boys, 60 boys from English medium schools and 60 boys from Odia medium schools within the age bracket of 14-15 yrs were purposively selected from various schools of Cuttack. Problem solving ability test developed by Roop Rekha Garg was used for data collection. A t-test was applied to know the significance of mean difference

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among English and Odia medium students with respect to their scores in mathematical problem solving ability test.

Results: Results reveal that there is a significant difference between students of English medium and students of Odia medium with regard to their scores in mathematical problem solving ability test.

Conclusion: Problem solving ability in mathematics is high among students studying in Odia medium schools as compared to the students of English medium schools.

Keywords: Problem solving; medium of instruction; language proficiency; abstract thinking; adolescents.

1. INTRODUCTION

The language used in the classroom dramatically affects children's opportunity and ability to learn. The language of learning is important because it is in this language that classroom discourse between the teacher and the learner is created. It is in the discourse that education essentially takes place. However, in order that meaningful learning takes place, the language of learning must not only be familiar to both the learner and the teacher, but also it should be the language in which textbooks and other teaching and learning materials are written. Mitchell (1998) viewed that interaction between teachers and learners is facilitated by a language known well enough by both of them [2]. Without the common language it would be difficult for teachers to engage their learners meaningfully. In learning teachers matter, and what they do in terms of instruction matters the most [3].

Mother tongue based education (MTB) is instruction in a child's first language, usually with a planned gradual transition to a second language or foreign language at a specified time in primary school. MTB education is especially beneficial in early childhood programs, preschool, and the early grades (up to grade 6), when children are learning to read and gaining new concepts [4]. The use of English as the medium of instruction among non-native speakers of the language is based on the theories of bilingualism and second language acquisition or learning. A person's success in acquiring knowledge, skills for problem solving and attitudes through the medium of a second language seem to depend largely on his or her proficiency in the second language [5].

A medium of instruction is the language used by a teacher to teach students. Simply put, it is a means of conveying information to students. Such a medium could be the official language in the country or it could be the native mother

tongue of the students. Deciding which language to use for instruction is important because it can affect the way the students learn. In multilingual education the language of instruction will not be just one language, it will also include two or more other languages. Vernacular language is a local language commonly spoken by a community. Vernacular medium schools are schools where the medium of education is local or native language.

Baker [6] proposes that there must be two threshold levels of language proficiency. Below the first threshold level, bilingualism may have a negative effect on the child's cognitive development. When the child reaches the second threshold level in the target language then the child may begin to benefit cognitively from the bilingualism. The language of learning should also enable learners to react to learning experiences both covertly and overtly. Since learning involves thinking and learning to think logically, the medium of instruction should enable learners to conceptualize in that language and should afford them the opportunity to receive and transmit information clearly.

The Russian Psychologist, Vygotsky [7], has made a significant contribution to the debate on language and cognition. Vygotsky argues that children's growth in thinking ability develops together with their linguistic competence and both are closely related to their social development. UNESCO [8] listed the importance of mother tongue based instruction in education by providing more scientific arguments. Use of mother tongue in schools not only enhances the cognitive development but also it has psychological value and it serves a very important role in shaping child's early perception.

The adoption of English as a medium of instruction may result in positive or negative educational outcomes. Using a foreign language is certainly a major obstacle in mathematics. The

mother tongue therefore, has a central role in education that demands cognitive development. One of the fundamental human cognitive process is problem solving. Problem solving is a cognitive process of the brain that searches a solution for a given problem [9]. Problem solving has two major domains: mathematical problem solving and personal problem solving where, in the second, some difficulty or barrier is encountered.

The present research is based on mathematical problem solving. Ausubul [10] defines problem solving as a form of discovery learning which bridges the gap between a learner's existing knowledge and a solution to a problem. Duffield [11] on defined problem solving as a goal directed behavior. Problem solving as a part of cognitive learning process makes use of previously learned knowledge and strategies.

Driscoll [12] defines instruction as "the deliberate arrangement of learning conditions to promote the attainment of some intended goal". In this definition, instruction is intentional arrangement of experiences, leading to learners acquiring particular capabilities. These capabilities can vary qualitatively in form, from simple recall of knowledge to cognitive strategies that allow a learner to find new problems within a field of study. For example, a teacher or trainer may wish to help learners' use a particular kind of computer software to solve a certain set of problems. The instructional designer will develop materials and activities that are intended to prepare the learners to use the software effectively. Every experience that is developed is focused toward one or more goals for learning. In addition to effective instruction, designers also wish to create instruction that is efficient (requiring the least time and cost necessary) and appealing.

Problem solving ability is related to the medium of instruction (varieties of instructions). Deciding which language of instruction is important because it can affect the way one student learns. It also affects the problem solving ability of the students. Students in mother tongue based instruction would have clarity regarding the various concepts of mathematics. Various researchers claim that understanding mathematics needs vernacular or native language to solve problems [13].

The cognitive view of learning can be described as a general agreed upon philosophical orientation. This means cognitive theorists share

basic notions about learning and memory. Most importantly, cognitive psychologists assume that mental processes exist, that they can be studied scientifically and that humans are active participants in their own acts of cognition [14]. Language is related to cognition. Cognition is the activity of knowing and processes through which knowledge is acquired and problems are solved.

Little research has examined the role of medium of instruction upon problem solving ability among adolescents. There may be a significant difference between the problems solving ability of student from both mediums (English & Vernacular) of instruction.

1.1 Objective

To study the role of medium of instruction on problem solving ability in mathematics among adolescent boys.

1.2 Hypothesis

Students of mother tongue based instruction (Odia medium) schools would score more in a problem solving ability test as compared to students of English medium schools.

2. METHODS OF STUDY

2.1 Sample

The size of the sample was 120. Out of 120 boys, 60 boys from English medium schools and 60 boys from Odia medium schools within the age bracket of 14-15 years were purposively selected from various schools of Cuttack.

2.2 Tool

2.2.1 Problem solving ability scale

The problem solving ability (PSA) scale developed by Dr. Roop Rekha Garg [15] was used for data collection. It was a 7 point scale. This scale was designed to measure the problem solving ability in mathematics among adolescents. This questionnaire consisted of 22 problems along with multiple acceptable answers (except item no 2 and 20 in which only one answer is 'correct'). Maximum score of this scale was 22. The entire questionnaire was based on mathematics. The split-half reliability of this test was .68. The validity coefficient of the present test has been calculated by correlating scores of

intelligence tests. This scale is highly valid with two group tests of intelligence developed by Mehta and Tondon, [16] with a correlation coefficient of .72 and .68 respectively.

2.3 Procedure

The problem solving ability (PSA) scale was used to assess the students' ability in mathematical problem solving. The instructions of this scale were clearly explained to the subjects and care was taken to ensure that they understood the scale. All subjects were asked to clarify their doubts before answering the questionnaire and instructed to give a tick mark beside the one which they think is correct among four options. They were asked to respond to each problem or question freely without any hesitation. This study was conducted in compliance with ethical principles.

3. RESULTS

3.1 T-test

DV: Problem Solving Ability in Mathematics (see Table 1).

The mean for students of mother tongue based instruction (Odia medium) school was 20.26 whereas the mean for students of English medium school was 18.56. SDs for Odia medium and English medium students were 1.52 and 2.11 respectively. A t-test was applied to analyze the significance of mean difference between problem solving ability among Odia and English medium students. The obtained t value = 5.05 with $df = 118$ was significant at .05 level of significance ($P = .04$). So, alternative hypothesis was accepted and there is a significant difference in mental health between the addicts involved in self-help group and the addicts not involved in self-help group. Similar results has been found by Nyagura [17] on mathematics attainment in Zimbabwean Primary Schools concluded that most grade seven pupils show very low ability to apply mathematical ideas to real life problems even in those involving practical concepts such as gain, loss, interest, discount, and sales tax, those story problems that require reading and comprehension of the language of textbooks and of instruction has failed the pupils.

Raborn [18] found that for substantial teaching and learning and correct concept and content discourse to occur in mathematics, the pupils' mother tongue is very important. Dube and

Cleghorn [19] viewed that pupils do not make mathematical progress because they do not understand what they are taught due to their inability to understand the language of instruction. The use of mother tongue according to Rose [20] reduces what she terms 'instructional dead time'. This is when teachers use English or a language which pupils do not understand and the whole mathematical lesson shows a mismatch between the child's mother tongue and the language of instruction resulting in school failure [21].

4. DISCUSSION

Results reveal that there is a significant difference between English and Odia medium students with regard to their scores in problem solving ability. Odia medium students are better in problem solving ability as compared to English medium students. Mother tongue based education is very important in development of cognitive development. The medium of instruction determines how our brain solves mathematical puzzles. Brain scans have revealed that Indians rely more on visual regions than English speakers when comparing numbers and doing sums. Our mother tongue influences the way problem-solving circuits in our brains develops.

Neural and behavioural research studies show that exposure to language in the first year of life influences the brain's neural circuitry even before infants speak their first word [22]. Understanding the underlying developmental pathways to mathematics from a brain perspective can help shape the design of teaching strategies [23]. As the learning process is influenced by the physical, social and cultural context of the learning task, the quality of interactions between the child and the significant others around him would be affected by the language of communication at home, in school and in the community. Studies have proven that the use of the mother tongue creates a sense of pride in having to use one's home language; thus, elevating the young child's self-esteem and eliminating his fears and inhibitions [24].

Piaget [25] viewed that cognitive development is the product of complex interaction between the maturation of the nervous system and that of language, and that this maturation depends on children's social and physical interactions with the world around them. People's interaction with

Table 1. Difference in problem solving ability in mathematics among students of mother tongue based instruction and the students of English based instruction

Groups	N	Mean	SD	t	df	P	Interpretation
Students of mother tongue based instruction (<i>Odia medium</i>)	60	20.26	1.52	5.05*	118	P<.05	Significant
Students of English based instruction (English Medium)	60	18.56	2.11				

*t value is significant at .05 level of significance,

Note: Odia is the mother tongue in Odisha

the environment produces certain patterns of neural activity that shape the circuits of the brain. Influences from the outside world are especially important early in life, during certain limited time intervals called critical periods. Mother tongue education during this critical period influences language acquisition and helps in problem solving.

In order to actively construct meaning, mathematical problem solving should be experience-oriented. [26] active means using two senses. One is acting on material things while the other means doing things in collaborative or group effort. This process leads to a critical frame of mind, where children must convey their ideas in their most proficient language. A number of studies in mathematical problem solving have shown that when the students are actively engaged in problem information, they are better able to understand and solve the problem [27]. Controlling one's own process of understanding may be done through free investigation and spontaneous effort. The teacher, therefore, provides a rich physical environment and encourages the child to experiment, but realizes the difference between physical knowledge which can be discovered and logico-mathematical knowledge which may have to be invented [26]. The process of investigation and invention of knowledge necessitates the use of a language where children may freely and spontaneously ask or answer questions or discuss observations with the teacher and with peers.

The literature states that mathematics achievement is generally not easy for students whose mother tongue is Odia and they are admitted in English medium schools. Learners in English medium schools face many difficulties because of the highly specialized mathematical terms with a variation of meanings from those used in every day speech [28]. Students in English medium schools whose mother tongue is Odia have to first struggle with the English language and thereafter with the mathematical

language and consequently they lag behind. The English medium student whose mother tongue is Odia usually focuses on both cognitive and linguistic tasks for learning new vocabulary, structures and to understand academic discourse [29].

Mathematics language does not only consist of ordinary English; rather it consists of symbols and highly specialized language. These symbols (>, ≠, ≤, ±, ¼, ×, ÷, Σ, χ, θ) and specialized language (e.g. hypotenuse, triangle, simultaneous equations, etc.) pose a problem to students' ability to interpret and conceptualize mathematical texts [30], especially word problems [31]. Thus, mathematical language becomes the second language challenge to those whose language differs from the medium of instruction. So, mathematics vocabulary, special syntactic structures, inferring mathematical meaning, and discourse patterns typical of written text all contribute to the difficulties many English medium students face when learning mathematics in English [28].

Mathematics plays a central role in scientific progress and development. When curriculum content is presented in an unfamiliar language, an enormous amount of time must be spent in teaching children to understand, speak, read and write a foreign language, something that is extremely difficult and wastes valuable years in the early grades that could be spent learning to read and learning academic concepts in Mother tongue. Moreover, children who cannot understand the languages used in the classroom are unable to demonstrate what they know, in asking questions and in participation.

In contrast, providing children with an opportunity to learn in a language they understand starting on the first day of school confers significant advantages for the education system, teachers, parents and students. A recent review of research reports on language and literacy concludes that becoming literate and fluent in one's first language is important for overall

language and cognitive development, as well as academic achievement [32]. Mastering a first language and core learning concepts promotes general cognitive development that is needed to learn a second language more easily and readily.

The aim of the study was only to know the role of medium of instruction on adolescents' problem solving ability in mathematics. So, attempts should be made to know the effect of other cognitive factors on adolescents' problem solving ability. A recommendation is made to conduct research for analyzing the role of medium of instruction in problem solving ability by investigating some more predictor variables like numerical ability, and information processing skills etc.

5. CONCLUSION

There is a significant difference in the achievement of the adolescents in mathematics when taught using the mother tongue as medium of instruction (Odia medium) compared to those adolescents who are taught in English as medium of instruction. It would be good practice for the curriculum implementers to enrich and enhance the newly implemented curriculum. It may be concluded that most basic concepts and literacy skills in mathematics can be taught best in the child's native language. Since the child's early years are the most absorbent, this study strongly recommends that the native language be used as language of instruction as early as kindergarten in order to establish a solid foundation not only in mathematics but also in other areas. Teachers and parents should use mother tongue as a medium of instruction while interacting with students with complex cognitive issues.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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