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An Analytical Study on Activity-Pedagogy for the Teaching and Learning of Mathematics at Secondary Level

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***ABSTRACT**: Mathematics is a method of inquiry known as postulational thinking or reasoning from carefully formulated definitions and assumptions, and deducing conclusions by the application of the most rigorous logic that man is capable of using. Mathematics is also a field for creative endeavour, constructing methods of proof and employing a high order of intuition and imagination. Mathematics curriculum has undergone various changes from time to time to fulfill the goals of Mathematical Education and to its social relevance. Mathematics is considered as a compulsory subject of general education. But when separate periods are allotted for learning and teaching mathematics, these Basics of Mathematics tend to be isolated from the real context and taught formally. The present study aims to compare the activity- pedagogy with the conventional method of teaching mathematics in terms of pupils'/teachers' behavioral changes and reactions. A questionnaire was developed by the investigator to compare the present activity-pedagogy approach with conventional approach in terms of pupils'/teachers' behavioral changes and reactions. Percentage analysis was used to interpret the items used in the questionnaire. It is concluded that, integrated activity pedagogy is welcomed by teachers. But it also creates some problems. Some have noted that all the areas do not lend themselves to integrated teaching. Many teachers feel that all the activities cannot be done. There was no time for doing all of them.*

*(**KEY WORDS**: Activity-pedagogy, Mathematics)*

Mathematics is a method of inquiry known as postulational thinking or reasoning from carefully formulated definitions and assumptions, and deducing conclusions by the application of the most rigorous logic that man is capable of using. Mathematics is also a field for creative endeavour, constructing methods of proof and employing a high order of intuition and imagination.

Mathematics is a body of ideas structured by logical reasoning. The facts, principles and methods developed in early Mesopotamia, Egypt and Greece play a central role in the learning of the subject even today. The sustaining social interest in mathematics is based on at least four major themes in its development;

i. The arithmetic of whole numbers and fractions for recording and ordering commerce and practical affairs;

ii. The ideas of Algebra, Geometry, Statistics and Calculus providing valuable models in the biological and physical world;

iii. Aesthetic qualities of mathematical structures embodied in art;

iv. The patterns of logical reasoning in mathematical proofs carried over in many other disciplines.

Bertrand Russell, the master of abstract mathematical thought, has also praised the beauty of Mathematics. Mathematics rightly viewed, possesses supreme beauty, a beauty cold and austere, like that of sculpture, without the gorgeous trappings of painting or music, yet sublimely pure, and capable of a stern perfection such as only the greatest art can show. The true spirit of delight, the exaltation, the sense of being more than man, which is the touch stone of the highest excellence, is to be found in Mathematics as surely as in poetry.

Mathematics expresses quantitative relations and spatial forms in carefully, purposefully, and often ingeniously designed compact symbolic language and express what in ordinary language would be unwieldy or ambiguous. Its language is precise, so precise that it is often confusing to people unaccustomed to its forms. NCF (2000) recommended that the study of Mathematics contributes in the development of precision, rational and analytical thinking, a positive attitude and aesthetic sense among students.

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I. NEED AND SIGNIFICANCE OF THE PROBLEM

Mathematics has also a content dimension which enters into different subject and situations – e.g. Number System, Fundamental Operations, other Mathematics Calculations, Algebraic Equations, Trigonometric Functions, Differential Equations, and Set Theory etc. These are the Basics of Mathematics. Kline (1964) mentions that the simple steps made in primitive civilization were promoted by purely practical needs.

Traditional civilizations also invented the four fundamental operations, out of their needs. These fundamental operations and other mathematical operations and skills enter most naturally in various physical, social, intellectual and aesthetic contexts. Many of the further developments in Mathematics too were triggered by practical challenges. But as the subject has crystallized, it is nurtured as a separate body of knowledge and continues to grow and get transmitted in its own right.

Mathematics is the key to opportunity, which is no longer just a language of science. It now contributes in direct and fundamental ways to Business, Finance, Health and Defence. But in another sense, Mathematics has no content of the type that one finds in History, Geography and Science. It consists of certain structures which can be imposed upon or drawn out of any life situation which permeates into the other subject fields too. It can be read in Dance, Music and Physical Education. The world of commerce cannot run without Mathematics. Science and Technology cannot thrive without it.

Mathematics curriculum has undergone various changes from time to time to fulfill the goals of Mathematical Education and to its social relevance. Mathematics is considered as a compulsory subject of general education. But when separate periods are allotted for learning and teaching mathematics, these Basics of Mathematics tend to be isolated from the real context and taught formally. At its best, it may be the abstraction of the highest order. But only the minority of students reaches this level. As far as the majority in this system is concerned, the process involves sheer rote memorization, repeated drill, examination orientation, threat of punishment etc. Observation of hundreds of classroom situations in the ordinary school show that, on the whole, the focus on skills and mechanical repetition seems to predominate. In many schools, even the skills are not actually developed by the pupils or drawn out of mathematical problem reading, analyzing, creative hypotheses formulation and testing them by using the relevant data. An artificial problem - very much unlike the problem that one faces in real life – is presented before the pupil, which might include mathematical components too. The teacher 'explains' the problem and 'how to do it' and get the answer. Most pupils do not really seize the problem. The teacher artificially 'motivates' the pupils to 'do the sum', and tries to show 'how to do it'. When the pupil does not grasp it, teacher himself does it for the pupil and the pupils copy the steps in their notebook. Occasionally we do find innovating and resourceful teachers who can introduce mathematical problems close to our conditions.

Problems can be especially appealing when they spring from the environment in which students live. But in the ordinary classrooms this phenomenon is getting less and less. Most pupils wait for the teacher or his 'deputy' to work out the problem on the blackboard and then copy the steps and the answers in their notebooks. When this happens, School Mathematics gets isolated not only from its practical context, but also from the true world of joyful mathematics. This would turn the young minds wrestling with mathematical problems to a veritable hell of drudgery, routine and mechanization.

Focused drill on the Basics is emphasized by many essentialist teachers. But even that does not effectively happen. The majority of pupils in school have no Mastery of Mathematics. The problem becomes more difficult because the cumulative backwardness of the children in mathematics increases as the child proceeds through schools. A large percentage of pupils fail in SSLC for want of the 10 mark minimum in each Mathematics paper. To remedy that, several attempts have been made at the high school itself, without making much improvement. The recent attempt to improve quality from primary education upwards through *creative activity pedagogy*, did make primary education more joyful, but many critics argued that these approaches did not give adequate importance to the *Basics of Mathematics*.

RESEARCH QUESTIONS

Is the teaching of mathematics in the typical Kerala classroom uniform, mechanical and rigid?

OBJECTIVE

To compare the activity- pedagogy with the conventional method of teaching mathematics in terms of pupils'/teachers' behavioral changes and reactions

METHOD

The text books prescribed for mathematics prepared by the SCERT, Kerala were intensely analyzed from the point of view of the references made to the creative / problem solving approaches, conceptual understanding mode, mathematical connections, chances of divergent thinking, innovative methods / strategies to pose problems, challenging / puzzling situations to develop the ultimate goal to mathematics education.

TOOL

This analysis helped the investigator to frame a questionnaire to compare the present activity-pedagogy approach with conventional approach in terms of pupils'/teachers' behavioral changes and reactions

STATISTICAL TECHNIQUES USED

Percentage analysis was used to interpret the items used in the questionnaire

ANALYSIS AND INTERPRETATION

Analysis of Data Regarding Teachers' Responses of Comparison of Present Approaches in Terms of Pupils'/Teachers' Behavioral Changes and Reactions

The questionnaire for teachers with 26 items is used to collect data of teachers' responses of comparison of present approaches in terms of pupils'/teachers' behavioral changes and reactions. Some open ended questions are included to get the free comments about the present activity-pedagogy in the teaching and learning of mathematics. The respondents are requested to judge whether in the new approach, the particular behavior is achieved 'More', 'Less' or whether it is 'Same' (as before). In interpreting the responses to a question of this kind, numerical weightages resulting in reducing the three-point judgement to one numerical score would nullify the qualitative advantages implied in 'more' and 'less' judgement. Hence the table presents M (More), L(Less) and S (Same).The qualitative insights can be got directly from inspection of the table, with M (where present approach has resulted in increase) and L (where it has decreased). The discussion is based on the percentages are given in Table1.

Table1

Comparison of present approach with conventional approach in terms of pupils' / teachers' behavioral changes and reactions M= (Present) is More, L= Less, S= Same

	Dimension of behaviour	N=122			
		M		L	
		N	%	N	%
	Pupils' behaviour				
1	Awareness about basics at each grade level	25	20.5	93	76.2
2	Ability to link mathematics with real life	100	81.9	5	4.1
3	Ability to apply mathematics with other subjects	48	39.3	54	44.3
4	Attitude towards word problems	41	33.6	62	50.8
5	Translates verbal problems into symbolic forms and vice versa	68	55.7	26	21.3
6	Understanding about mathematical symbols and its origin	69	56.6	30	24.6
7	Procedural knowledge	110	90.2	8	6.6
8	Handwriting	9	7.4	94	77.1
9	Logical reasoning in problem solving	100	81.9	10	8.2
10	Represent verbal problems through pictures, diagrams etc.	116	95.1	2	1.6
11	Method of writing answers in the note book	10	8.2	110	90.2
12	Ability to visualize mathematical concepts	116	95.1	2	1.6
13	Content knowledge in gradation	20	16.4	95	77.9
14	Participation in group activity	107	87.7	2	1.6
	Teachers' behaviour				
15	Teacher's workload	118	96.7	2	1.6
16	Innovative adaptations in teaching	95	77.9	9	7.3
17	Preparation of teaching aids	116	95.1	3	2.5
18	Preparing them to meet in a competitive world	52	42.6	57	46.7
19	Help from handbook	115	94.3	5	4.1
20	Amount of curricular content	60	49.2	51	41.8
21	Inviting multiple contexts to represent a problem	54	44.3	60	49.2
22	Use of black board	41	33.6	75	61.2
23	Teacher pupil interactions and pupil- pupil interactions	118	96.7	4	3
24	Integration of curricular content with real life contexts	96	78.7	10	8.2

Analysis of pupils' behaviour

The first fourteen aspects are taken in pupils' behavior to compare present approach with conventional approach. The discussion is based on the ranks calculated from percentages

In the case of **"awareness about basics at each grade level**", the present approach does not contribute much in enhancing the awareness about the basics. The data shows that 76 % of teachers state that when compared to present approach, conventional approach was more responsive in enhancing the basic knowledge in mathematics when analyzed on students' perspectives.

Regarding the "**ability to link mathematics with real life**" when analyzed on students' perspectives, 81.9% of teachers state that the present approach was more effective when compared to the conventional approach.

Considering the "**pupils' ability in applying mathematics with other subjects** when taken from students' perspectives, 44.3% of teachers state that the present approach does not provide a holistic nature in the teaching learning process.

To the aspect "**attitude towards word problems**", when viewed from pupils' behavior, the data reveal that the conventional approach is more responsive in developing positive attitude towards word problems.(50.8)

Students' **ability to translate verbal statements in to symbolic forms and vice-versa**" when analyzed in students' perspectives show that for 55.7% of teachers, the present approach is more effective in

developing the students' competency to convert verbal statements into mathematical form and vice-versa when compared to the conventional approach.

For the dimension "**pupils' understanding about mathematical symbols and its origin**", 56.6% of teachers recorded that, the present approach contributes much to the pupils' understanding about mathematical symbols and its origin when compared with conventional approach.

"**Procedural knowledge regarding the formation of mathematical principles**" when analyzed on students' perspectives, it was found that the present approach is more conducive in building procedure knowledge in the formation of mathematical concepts, principles and formulae. The data shows that 90.2% of teachers opine that the students possess more procedural knowledge through the present approach when compared to the conventional approach.

While analyzing **"pupils' handwriting**" as one of the dimensions of pupils' behaviour, illegibility and neatness in handwriting is more in the present approach as reported by 77.1% of teachers.

Considering "**logical reasoning in problem solving**" in the dimension of pupils' behaviour, the present approach is more constructive in developing the ability of logical reasoning in problem solving when compared to the conventional approach in the teaching and learning of mathematics as perceived by 81.9% of teachers.

For the aspect "**diagrammatic representation of verbal problems**" 95.1% of teachers states that the approach contribute a wide range of opportunities to represent the verbal problems through pictures, graphs, diagrams etc when compared with conventional approach in teaching mathematics.

Considering the dimension "**systematic way of writing answers to problems in notebooks**" under pupils' perspective, 90.2% of teachers reported that the present approach is less responsive in keeping notes in a systematic way than the conventional approach.

Regarding the "**ability to visualize mathematical concepts meaningfully**" as pupils' perspectives, 95.1% of teachers states that the present approach contributes a lot in developing ability to visualize mathematical concepts meaningfully when compared with the conventional approach.

Taking into account "**pupils' content knowledge in sequential manner**" in the context of pupils' behaviour, 77.9% of teachers states that the present approach does not impart content knowledge in sequential way when compared with the conventional approach in teaching mathematics.

To the aspect "**Participation in group activity**" in the context of pupil' , the majority of teachers rated as 'more' in the present approach. The data shows that 87.7% of teachers reported that when compared to conventional approach, the present approach is more productive in pupils' participation in group activity when analyzed on students' perspectives.

The responses obtained from the 14 aspects pertaining to pupils' behaviour in the present activity-based approach were checked and tabulated, the hierarchical order of percentages accordingly under two categories "More" and "Less" and are given in the Table2 and Table3 respectively.

Table2 : Percentage of teacher's responses as "More" in the present activity-pedagogy approach (Pupil behavior)

Sl. No.	Item no.	Statement	%
1	10	diagrammatic representation of verbal problems	95.1%
2	12	ability to visualize mathematical concepts meaningfully	95.1%
3	7	Procedural knowledge regarding the formation of mathematical principles	90.2%
4	14	Participation in group activity	87.7%
5	2	ability to link mathematics with real life	81.9%
6	9	logical reasoning in problem solving	81.9%
7	6	pupils' understanding about mathematical symbols and its origin	56.6%
8	5	ability to translate verbal statements in to symbolic forms and vice-versa	55.7%

Table 2 illustrates the preferences of eight aspects recorded as "More" in terms of pupils' behavior in the activity- pedagogy approach. The diagrammatic representation is given as Bar Diagram.

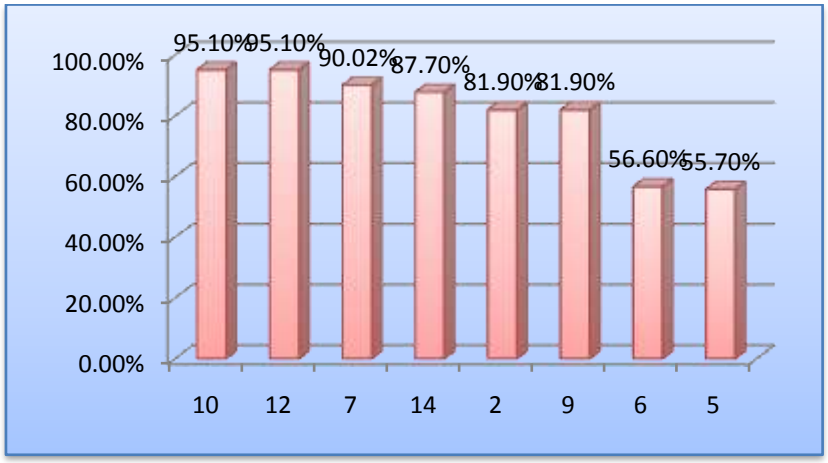

Figure: 1showing the percentage of **teacher's responses as "More" in the present activity-pedagogy approach**

The teachers pointed out that in the present approach, Diagrammatic Representation Of Verbal Problems, Ability To Visualize Mathematical Concepts Meaningfully, Procedural Knowledge Regarding The Formation Of Mathematical Principles And Participation In Group Activity have high preferences (above 90%). The medium preferences go to Participation In Group Activity, Ability To Link Mathematics With Real Life, Logical Reasoning In Problem Solving (between 80% and 90%). The least preferences are: Pupils' Understanding about Mathematical Symbols and Its Origin, Ability to Translate Verbal Statements in to Symbolic Forms and vice-versa (below 60%).

Table 3: Percentage of teacher's responses as "Less" in the present activity-pedagogy approach (Pupil behavior)

Sl No.	item no.	Statement	Percentage
1.	11	Systematic way of writing answers to problems in notebooks	90.2%
2.	13	Pupils' content knowledge in sequential manner	77.9%
3.	8	Pupils' handwriting	77.1%
4.	1	Awareness about basics at each grade level	76.2%
5.	4	Attitude towards word problems	50.8%
6.	3	Pupils' ability in applying mathematics with other subjects	44.3%

The table 3 illustrates the preferences of six aspects recorded as "Less" in terms of pupils' behaviour in the activity- pedagogy approach. The diagrammatic representation is given as Bar Diagram.

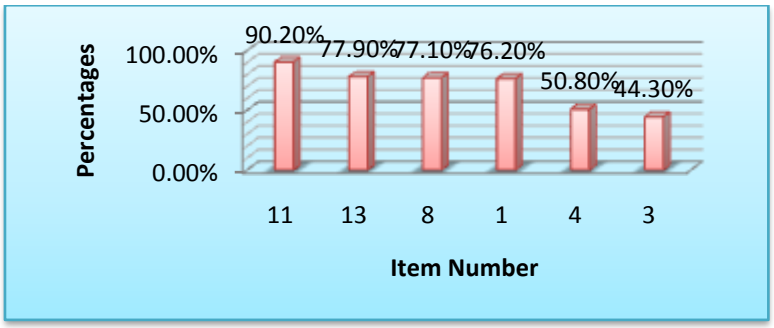

Figure 2: showing the percentage of **teacher's responses as "Less" in the present activity-pedagogy approach**

In the present activity pedagogy, the teachers pointed out The Lack of Systematic Presentation of Answers to Problems in Notebooks (above 90.2%). Pupils' Content Knowledge in Sequential Manner, Pupils' Handwriting, Awareness about Basics at Each Grade Level, is also decreased in the present system (average 75%). Attitude towards Word Problems, Pupils' Ability in Applying Mathematics with Other Subjects are also decreasing.

II. DISCUSSION

In order to maximize the potentialities in the present activity-pedagogy approach, the less preferred aspects in terms of pupils' behavior such as "Systematic Way Of Writing Answers To Problems In Notebooks, Pupils' Content Knowledge In Sequential Manner, Pupils' Handwriting, And Awareness About Basics At Each Grade Level, Attitude Towards Word Problems, Pupils' Ability In Applying Mathematics With Other Subjects" need to be highly attended and treated.

Analysis of teacher's behavior

Ten aspects from teacher behavior are taken in to consideration to compare the present activity pedagogy with conventional approach in teaching and learning of mathematics. The discussion is based on the rank calculated from percentages

In the case of **"Teacher's workload**", the present approach does contribute much in enhancing the awareness about the basics. The data shows that 96.7 % of teachers state that when compared to present approach, conventional approach was more responsive in increasing the workload of teachers when analyzed on teachers' perspectives.

Regarding the **"Innovative adaptations in teaching**" when analyzed on teachers' perspectives, 77.9% of teachers state that the present approach was more effective when compared to the conventional approach.

"**Preparation of teaching aids**" when analyzed on teachers' perspectives, it was found that the present approach is more constructive in preparing teaching-learning aids in building procedure knowledge for the formation of mathematical concepts, principles and formulae. The data shows that 95.1% of teachers opine that teachers have to prepare a lot of teaching aids to transact curriculum in the present approach when compared to the conventional approach.

"Preparing students to meet a competitive world" when analyzed on teachers' perspectives, it was found that the conventional approach is more meaningful in preparing pupils to meet in a competent world. The data shows that 46.7% of teachers opine that in the present system, less preference is given to prepare the pupils to meet in today's highly competent world.

Regarding the **"Help from handbook"** when analyzed on teachers' perspectives, 94.3% of teachers state that, in the present approach teachers seek more help from handbooks when compared to the conventional approach.

With respect to **"Amount of curricular content" "** when analyzed on teachers' perspectives, 49.2% of teachers state that the present approach put forward more curricular content when compared to the conventional approach.

In the case of **"Inviting multiple contexts to represent a problem"** as teachers' dimension, the present approach does not contribute much in inviting multiple contexts to represent a problem. About 49.2% of the teachers opine that there are less preferences to invite multiple contexts to the representation of a problem.

"Use of black board" when analyzed on teachers' perspectives, it was found that the conventional approach is more effective in the skill of using blackboard when compared to the present approach. The data show that, about 61.2% the present approach does not give importance to black board work.

Regarding **"Teacher pupil interactions and pupil- pupil interactions",** 96.7% of teachers reported positively that, the present approach contributes much in the classroom interaction pattern such as teacher-pupil interaction and pupil – pupil interaction.

With regard to the **"Integration of curricular content with real life contexts"** when analyzed on teachers' perspectives, 78.7% teachers reported that in the present approach there are more provisions for integrating curricular content with real life contexts.

The responses obtained from the 10 aspects pertaining to teachers' behavior in the present activity-based approach were checked and tabulated, the hierarchical order of percentages accordingly under two categories "More" and "Less" and are given in the Table 5 and Table 6 respectively.

Table 5: Percentage of teachers' responses as "More" in the present activity-pedagogy approach (teacher behaviour)

ItemNo.	Teacher's behavior	Score	%
15	Teacher's workload	118	96.7%
23	Teacher pupil interactions and pupil- pupil interactions	118	96.7%
17	Preparation of teaching aids	116	95.1%
9	Help from handbook	115	94.3%
4	Integration of curricular content with real life contexts	96	78.7%
6	Innovative adaptations in teaching	95	77.9%
20	Amount of curricular content	60	49.2%

Teachers' behaviour is more in the present approaches for the aspects, Teacher's workload, Teacher pupil interactions and pupil- pupil interactions, Preparation of teaching aids, Help from handbook are above 90%. Integration of curricular content with real life contexts, Innovative adaptations in teaching have got in between 70% and 80%. Amount of curricular content is least preferred item.

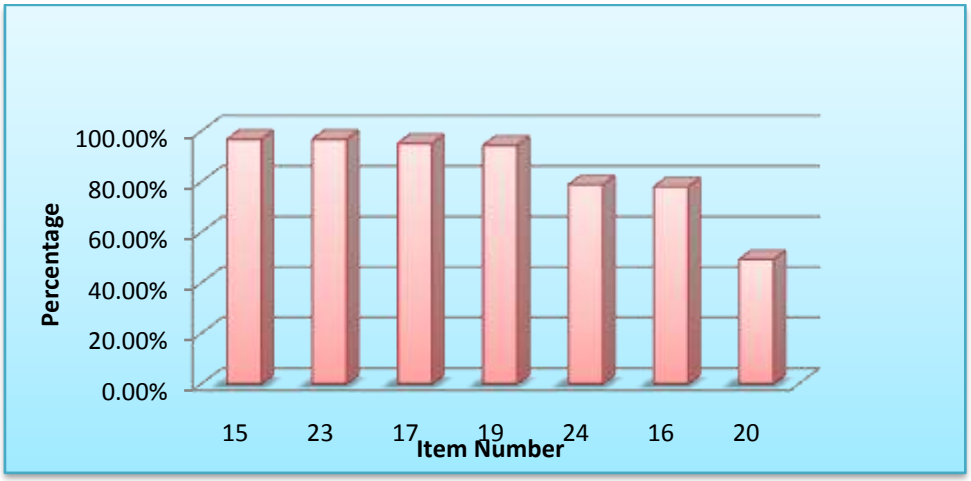

Figure 3: Percentage of teachers' responses as "More" in the present activity-pedagogy approach (teacher behaviour)

Table 6 Percentage of teachers' responses as "Less" in the present activity-pedagogy approach(teacher behaviour)

Item no.	Teacher's behavior	Score	Percentage
22	Use of black board	75	61.2%
21	Inviting multiple contexts to represent a problem	60	49.2%
18	Preparing them to meet a competitive world	57	46.7%

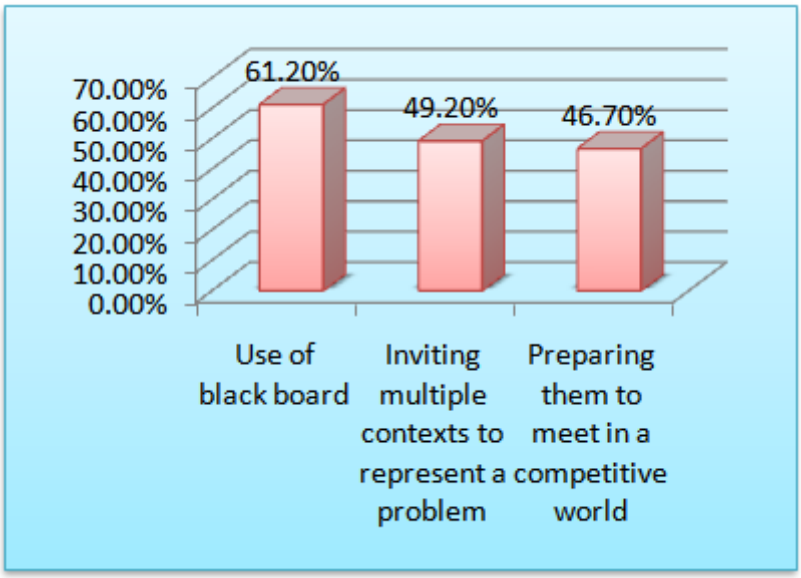

Figure 4 Percentage of teachers' responses as "Less" in the present activity-pedagogy approach (teacher behaviour

Regarding teachers' behaviour, "Use of black board" got high percentage which was rated as 'Less" in the present approach. The two aspects "Preparing them to meet in a competitive world" & "Inviting Multiple Contexts to Represent a Problem" got an average of 47%. This further shows that there should need high treatment on these less rated aspects of teacher behaviour in the present system.

III. ANALYSIS OF OPEN RESPONSES

The questionnaire gave some open items (items 25 & 26) at the end inviting teachers to offer their free comments about the merits and demerits of the scheme as perceived by the parents, the public, and teachers in general and the respondent himself. The responses were coded and analyzed. A few insights could be got which did not arise from the quantitative analysis of the responses. Even a point made out by analyzing the check mark responses of the teachers or parents tends to get a live form when it comes as free responses from the teacher .A few important points are presented below:

On the positive side , pupils coming joyfully to school, study with interest, self-motivation, expressive capacity, creativity, responsiveness, self-confidence, freedom from fear of the teacher or of the school setting as such featured in the free responses of teacher. One teacher who has had considerable experience with the old approach also wrote that, when a teacher puts a question, many pupils are not able to come up with their ideas. Now, the pupils have much to say.

On the contrary, it is very difficult to control the class. Many teachers have pointed out that the text book does not give any clear idea of the curriculum objective especially in Mathematics. The result is that the standard in mathematics is becoming very low. Pupils commit plenty of errors while doing problems. They suggest that the text book should contain more worked out exercises. Some teachers suggested that the Hand book should give clear idea of learning experience. The errors in hand writing and spelling cause anxiety in the minds of parents about the future of their children. Some parents are said to have complained to teachers about their inability to help their children with their home work. Such statements have two interpretations. One is about the old type homework where specific written work of a convergent nature is given, about which they know what to do or get help from someone who knows. The other type is about the new project type home work which appears unfamiliar to them, or at least as something which they do not associate with education as they understand it.

The close relation between school, home and the community was noted with satisfaction by some. A few teachers have pointed out that this approach has helped to generate new ideas and creativity not only in pupils but also in teachers. Many teachers expressed the problem of workload of teacher, especially in maintaining many records about evaluation. A few teachers admitted that the teachers' workload is more, but the joy of seeing the children do new things is a worthwhile reward that they get.

IV. CONCLUSION

Integrated approach is welcomed by teachers in the primary teachers. But it also creates some problems. Some have noted that all the areas do not lend themselves to integrated teaching. Many teachers feel that all the activities cannot be done. There was no time for doing all of them.

It is very difficult to form an idea about the percentage of teachers who answered the open response questions and the percentage that are genuinely for it or oppose it. Out of the 122 who answered the check list part of the questionnaire satisfactorily, only about one-third have attempted to answer the open responses and even much smaller have answered it fully and with conviction. Many have left the open questions blank or given fragmentary answers. A smaller number, which may be estimated to be about 10% of the sample have unequivocally supported it, but some of the have added the difficulty they have faced on aspects like evaluation in multiple dimensions of integrated pedagogy.

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