Approval Sheet

Thesis entitled **'Design intervention through experience-based pedagogy to decode process of learning in primary school children'** is approved for the degree of Doctor of Philosophy.

Examiners

Sky (SATYAKI ROY)

Jairam Bhanda

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Chairman

Date: 27-05-2019

Place: Mumbai

Design intervention through experience-based pedagogy to decode process of learning in primary school children

Submitted in partial fulfilment of the requirements for the degree of

Doctor of Philosophy

by

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(2018)

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Declaration

I declare that this written submission represents my ideas in my own words and where others' ideas have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or falsified any ideas/data/fact/source in my submission. I understand that my violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus been cited or from whom proper permission has not been taken when needed.

Poornima Sajive Nair

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Dedicated to my son

Akshar Nair

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ABSTRACT

"Education has produced a vast population able to read but unable to distinguish what is worth reading" –G M Trevelyan

This work seeks to decode the manner in which children from marginalised societies learn. This thesis establishes the mode in which children in primary schools in particular internalise misconceptions. It further establishes that experience-based pedagogy is not an effective method to enable learning with understanding among the children of the marginalised section of society (lower economic stratum).

NCERT is framing and proposing to introduce Experiential Activities across the Education Boards as a national initiative. Several schools in the city are replacing existing curriculum by Experience based learning on the directive of NCERT. Previous attempts to set up schools based on experiential learning have not gained impetus and schools based on the philosophy of experiential learning have opted to change the mode to formal systems. Experience based pedagogy is based on personal experiences or learning 'by doing'. Experience based pedagogy has been effective in schools globally and is an established mode of communication for conceptual understanding by educators. It is considered an effective tool for learning with understanding among primary school children.

The underlying methodology is in three parts (1) initial correlational study, in which a phenomenon is observed and studied. (2) intermediate study using Phenomenography to establish the occurrence of the phenomenon in other geographic areas of the country, and (3) specific study, which entails studying 20 school children for 18 weeks, and finally, a focussed study on 3 students who dropped out of the group of 20 children.

The hypothesis is based on two main theoretical concepts. The first concept is based on that of Kolb's experiential learning theory. This theory advocates the feedback mechanism and looping between reflection, analysis and observation. This process goes on until conceptual understanding is achieved.

Another major theoretical basis is the Mediated Learning theory, which poses a major challenge in a classroom as the class consists of children with varied cognitive abilities.

The challenge in this research is in formulating problems to test conceptual understanding in children. The questions have to be dynamic. Following questions are based on the answers the children have given to the previous question. The mode of answers given by children not being predictable, the pre-structured questions do not work at times, posing challenges to the testing process. Questions are developed from literature studies based on classroom studies by Paul

Cobb (Cobb P & Steffie 1983.) and others. This research gives a deeper understanding of the issues prevalent in learning with understanding, amongst children of the lower economic stratum of the society.

The last part of this research goes on to co-relate the parental expectation and student learning. The mode of learning is observed and analysed by co-relational comparisons.

One of the main challenges facing the development of the model is addressing not only teaching-learning-understanding issues, but other aspects of learning such as social, cultural and lifestyle patterns in personal experiences. By doing this, the generalisation of the study increases to a wider range of children and necessitates re-looking into the intervention of Design in designing curriculum for schools that cater to children from lower economic stratum of the society.

The larger purpose of this inquiry is to align the curriculum makers, enforcers and educators to the mode of learning in children living in slums, as this study inquires into the ontological nature of experience-based pedagogy and learning through experience-based pedagogy.

The principles of Design-based Research are applied with a focus on 'classroom' and 'out of classroom' design studies to probe 'learning with understanding by children from municipal schools, in a particular mathematics domain. This is an attempt to explicate the relationship between Design research using experiential activities and conceptual understanding, if it exists. The research elucidates the crucial structure of experiential activities for understanding children's endeavour in learning mathematical concepts and rational experiential activities that are a pragmatic approach to problem solving to ease the cognitive load of making a decision. The main limitations to present design-studies in the classroom are accentuated.

The design research methodology to study the children's understanding of mathematical concepts is described. The socio-economic factors affecting the children while participating in the experiential activities are documented and analysed.

The children abstain from school for long periods and cannot cope up with the spiralling curriculum (Bruner). The learning trajectories are mapped and it is deduced from classroom studies that the learning takes place in an undesirable manner. On inquiry, it is found that Children belonging to the marginalised section (lower economic stratum) of the society have difficulty in learning. Some experience-based activities are conducive to learning in some children, but all activities are not readily accepted by children and do not increase knowledge in children. The students respond to formalised learning. Children like to be controlled by the

teachers and like formal schooling. These findings led to the discovery that attaining social status is the driving force behind the effort to educate and be educated.

The findings led to the emergence of a probable theory of how children learn in school, by investigating how children learn, misinterpret and internalise concepts. The study inquires, if there are other factors affecting their learning.

The research generated a probable theory of learning called Disoriented learning. The learner is lost in a maze of self-generated, misunderstood or assumed concepts. The orientation of the learning trajectory is away from the expected goal of learning. At any point, the student may redirect learning towards the expected goal. If the learner is unable to re-orient towards the expected goal, he/she lives with misconceptions. At every point in learning, the children tested directed their learning away from the goal (object of learning). The learning thus, was on a different plane. The students assumed that they have learnt the concept.

The factors leading to Disoriented learning are found to be multiple. Learners /students learn from peers who lack conceptual understanding. Students have ambiguity of the concept in real life. They cannot connect experiences of real life to concepts. Subject teachers have inefficiency and lack of in-depth knowledge of the subject. Students Lack motivation to study. Student's Emotional state, their Caste, Social status and Social Activities affect learning and cause them to learn in a disoriented manner. Social media (movies, Television) has a great impact on children; they sometimes are influenced by the character roles played in movies. Children work as substitutes for the working parent, Single parents working and taking care of children cannot monitor the academics of the child. The society dictates the expectations from schools, and the modality of teaching. The society (parents and community) instils the "right" and "wrong" mode of teaching by the teachers in school, and that influences the children's attitude towards schooling/education. Economic compulsions (children working to complement the income of the family), Illness, Food and Nutrition are some of the other factors that dictate the attitude of children towards education.

Findings are corroborated by taking up the Topic of 'Area and Perimeter' of a Rectangle and observing how children fail to understand the concept and develop misconceptions. Grading akin to Van Haile system is designed and tested in this research. For communicating the concept of area, tangrams are used.

To achieve the expected knowledge or pre-requisite to the Goal the learner must have conceptual understanding of all topics covered in the previous years. In case there are 'gaps' or

misconceptions that require to be rectified; those errors are indicated by a scale called “Root Stability” in the year ending grades. For example, if the learner does not have the third prerequisite to learn the topic of ‘Area’, it is indicated in the final grades of the student. Root Stability will indicate the remedial work required to reinforce prerequisite no3, root3, or r-3.

As a remedial measure, it is essential that the student bridges the gap between the pre-requisites and the expected learning objective. Currently only the ‘right answers’ are represented in the grading. The misconceptions are not represented in the grading system. In case the student does not have a misconception and the answer shows that there is a lacuna, then the bridge course has to determine if the error due to lack of understanding or a careless mistake.

The research study concludes with the finding that a unified curriculum is not conducive to learning among children belonging to the marginalised section of the society. Misconceptions in children occur during collaborative and peer learnings. The misconceptions over time are compounded and internalised. This research recommends a bridge course to be introduced in schools in order to help children who have no or insufficient pre-requisites to the topic of instruction in higher classes.

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Chapter I: Introduction

Classroom instruction has always been the focal point of research in education systems because of its purpose-oriented instruction. This is the most time tested and successful live group-teaching exercise that deeply affects how each individual learns and applies concepts, especially in subjects such as mathematics with abstract concepts (in primary class).

In the United States it was observed in 2012, in the iteration of PISA, the international test administered by the OECD, students in the United States ranked thirty-sixth out of sixty-five countries in math performance. Out of thirty-four OECD members, they ranked twenty-seventh. 70 percent of students attending colleges require remedial math courses which only one in ten successfully passes. Jo Boaler (Boaler, 2015), gives three reasons for the phenomenon of American math education being ineffective:

1) Classroom learning is too passive as the teachers lecture in class. Active interaction between students and teachers doesn't happen.
2) Instruction doesn't encourage understanding and critical thought, leaning instead on memorisation and repetition by rote learning.
3) The contexts in which content is taught don't reflect the way math is used in everyday life. Jo Boaler gives the example of a problem in the textbook: "A pizza is divided into fifths for five friends at a party. Three of the friends eat their slices, but then four more friends arrive. What fractions should the remaining two slices be divided into?". This situation of dividing food does not exist in real life as it is not critical.

This approach of classroom communication leaves students ill prepared to use what they've learned in new situations, as such it leads to both failure in assessments and widespread aversion to mathematics. Boaler draws attention to the issues beyond students scoring low in assessments. If the phenomenon continues, it is a threat to the global competitiveness (of the students representing the country in global math challenges). Jo Boaler cites the research conducted by Julie Gainsburg from Cal State (Northridge), which concludes that "the traditional K-12 mathematics curriculum, with its focus on performing computational manipulations, is unlikely to prepare students for the problem-solving demands of the high-tech workplace."

Keith Devlin (2015) has highlighted communication with the focus on Language ability, and how better use of this innate talent can be made. He put forth a new theory of language development that language evolved in two stages, highlighting the fact that ability to think mathematically came around from the same symbol-manipulating ability that was so crucial to

the emergence of true language. Despite this, people can't do math as well as they can speak. Keith Devlin is of the opinion that we can do math as we can speak but we are unable to recognise when we're using mathematical reasoning.

Studies by Paul Cobb *(Cobb, 2010)* established that class room instruction is not effective in communicating concepts to children and for classroom instruction to be effective, it is important to understand the process of learning in children. The classroom instructor must be able to effectively communicate content of the syllabus and concepts of the topic in the syllabus to children so that children can have conceptual understanding and be able to connect the content to solving problems in unfamiliar or real-life situations. Application of conceptual understanding in solving problems would help students to develop metacognitive abilities and use thought processes.

In order to study thought and reflective processes in children, Robert Sternberg's study of meta-cognition is reviewed in this research. Children live in a society and are largely exposed to social norms according to Robert Sternberg. This theory paved the way to inquire if socio cultural-economic parameters affect learning in children and this research studies in depth the influence of the socio-economic status and the effect of Design Intervention based on Experience-based Pedagogy on learning. It is therefore also important to inquire if socio cultural-economic parameters are incidental in determining the modalities in learning amongst children.

It is established by ELT (Kolb, 1984) that learning with Experience-based activities would be conducive to learning with conceptual understanding. Examining learning in children would help a researcher to check the effectiveness of Experience based pedagogy for conceptual understanding in school. The necessity of decoding learning in children would hold a direction to design effective intermediaries.

1.1 Motivation

The Idea for this research emerged from a comment made by Akshar a student of class 8, that most of the students in his class believe that the area and perimeter of a rectangle are interdependent on each other. Subsequently on interviewing the same group of Class 8 children (60 children), it was found that they had developed misconceptions about Area and Perimeter of a Rectangle.

On quizzing random people, I met, on the road, in offices, in schools, I discovered that professionals and as well as non-professionals in society had internalised misconceptions even in primary school. All people who were quizzed had fear of mathematics. The fear of mathematics in people and children meant there was a deeper issue to learning which could impact society in a broader sense. These observations motivated and directed me towards the start of the research. In the pre survey analysis and from the Educational consultants India limited (EdCIL) survey in 21 major states of the country in 2008-10 years ago to assess the drop-out rates at primary and upper primary levels. This researcher has found that there are socio-economic reasons for the increase in the dropout rates.

There is reason to believe from the pre-survey that caste and social status also plays a major role in the increasing drop rates in school. After one or more years of schooling.

The data that collected through the DS-4 schedule shows that the dropout rate at the primary stage has risen compared to 2009-10 in all states. This clearly gives an indicator that there are other factors causing dropout rates in schools. The entire study is out of the scope of this research so the research aims at finding out how children learn and how can children be motivated to attend class. In the initial studies it was found that subjects had the fear of learning (mathematics) and fear of failing. Increasing Dropout rates in municipal schools is recorded by the government and this dropout rate had increased in 2013. Social pressure (peers doing well) is another factor that motivated me to look into this aspect. The student is always compared with their peers. The constant comparison of marks demotivates a student. All these factors were incidental to motivate the research to conduct the study.

1.2 Aims and Objectives:

The Objective of this research is to decode how children learn, by observing if misconceptions are internalised and then harboured lifelong. The inquiry examines the inability of the students to understand concepts from classroom instruction and if classroom instruction is insufficient to communicate concepts and create conceptual understanding amongst children. The study seeks to inquire how misconceptions are internalised and further, to find out if experience-based pedagogy would be conducive to learn with understanding. The study examines if parental aspiration, views and the economic status of the family are incidental in learning amongst children.

It is found from earlier studies (prior to taking up the research inquiry) that Mathematics is the most dreaded subject by school children above Grade 5. Personal Knowledge and Acquired

Knowledge of people was examined in the research. This is in tune with Robert Sternberg's theory of triarchic Intelligence. It indicated that the misconceptions are latent and there is a possibility that they could be transferred to children while interacting/mentoring (if such situations arose). Before the study commenced it was essential to understand the previous works on education. The next chapter examines the stalwarts and researchers who have proposed theories of learning, Experiential Learning, Mediated Learning and Triarchic Theory of Learning will be taken up for review. ELT proposes that active experimentation by the learner and since play is an integral part of a childhood, it is assumed that intermediaries designed would assist a child to understand concept and relate to real life problem solving by visualisation. The design of intermediaries entails design intervention in a classroom.

1.3 Significance of the study

Jo Boaler (Boaler, 2015) praises the Common Core State Standards for their inclusion of mathematical practices such as problem solving, sense making, perseverance, and reasoning. These "ways of being mathematical" are of critical importance for students trying to become successful in math. In one chapter, she voices that it is impossible to know exactly which mathematical methods will be most helpful in the future, therefore it is important that schools develop flexible thinkers who can draw from a variety of mathematical principles in solving problems. The major significance is that the study is planned as an attempt to understand how children in marginalised sections learn with 'understanding'. The significance of this study in observing the classroom instruction to children would pave the way to curriculum development[1] and a strategy to implement the curriculum and a 'bridge course'[2] for dropouts as well as children to develop conceptual understanding of the previous years. The study would be significant to academicians and stakeholders concerning Educational practices/methods and learning achieved by children belonging to the marginalised section of the society. To establish the area and theory pertaining to the study. Study of literature would give a perspective to the past and current theories in practice.

[1] For the appropriate board and the bridge course for children who lack conceptual understanding. The curriculum for the bridge course may be developed according to the needs of the students. This may be used for slow learners as well but addressing such children is out of the scope of this research.

[2] Bridge course is discussed in detail later in chapterV

Chapter II: Literature Review

The Literature reviewed was in five areas

First	:	literature review from the Indian thinkers was visited.
Second	:	literature review of the western philosophy and views were explored.
Third	:	Philosophies on which schools are based on - reviewed.
Fourth	:	Literature on the qualitative methodologies was reviewed.
Fifth	:	Government policies and surveys on education in India reviewed.

Literature review was narrowed down to Cognitivist theories as they pertain to the current formal education system prevalent in the country.

1) literature review from the Indian thinkers.

Views of education by western philosophers and theorists is compared with that of Indian thinkers. Design research Action research and the significance of Design research is reviewed to understand if these methods can be used in this research. An attempt is made to understand if literature on 'learning' in Primary school children in India exists.

Indian thinkers and educators set up schools based on experiential learning. Students attending the experiential school had the freedom to experiment and develop one self.

Lord Thomas Babington Macaulay brought the 'modern school system' (present school system as it is today) and the English Language to India in the 1830s. He introduced the curriculum in India that was confined to "modern" subjects such as science and mathematics. Core subjects like metaphysics and philosophy were considered unnecessary. Teaching was confined to classrooms resulting in the loss of link with nature. Close relationship between the teacher and the student was broken. The NCERT[3] has redeveloped the curriculum on the lines of the Old

[3] ***In India, the curriculum is designed by the NCERT and teachers are trained to teach the curriculum. Specific contents in the prescribed syllabus have to be completed in the allotted period set by the curriculum developers. The curriculum is not designed to be domain specific. In a country where there are different values and cultures, the same curriculum is followed.***

British system of education. In order to decrease dropout rates in school the NCERT reduced the content in the syllabus. The examples incorporate Indian nomenclature. The scenarios used in the syllabus are related to India. When the curriculum is made relevant to cater vast suburban and rural population, the essence of the academic objective gets clouded.

Views of Indian thinkers on the philosophy of education is reviewed. Indian thinkers reviewed are J Krishnamurti, Mohandas Karamchand Gandhi, Rabindranath Tagore, Gijjubhai Gadecha, and Lokmanaya Tilak.

The Indian thinkers advocated learning by experience and value education. The learners had to learn from experiences in life. J.K, Gandhiji and Tagore were exposed to education in the West; they had concerns about the education system in India. They set up schools in India according to their philosophical views.

In the Indian context, J Krishnamurti (Krishnamoorthy, Education and the significance of life, 1953) (Krishnamoorthy j. , 1978) (essays of JK September 1970) had concerns about education. His concerns were freedom and discipline, comparison and competition, learning through the senses, scientific temper, joy and creativity. The function of education, he said, is "to bring about a mind that will not only act in the immediate but go beyond a mind that is extraordinarily alive, not with knowledge, not with experience, but alive". "More important than making the child technologically proficient is the creation of the right climate in the school for the child to develop fully as a complete human being". This means giving him "the opportunity to flower in goodness, so that he is rightly related to people, things and ideas, to the whole of life" (Gandhiji, 1937) (Montessori, 1986) (Montessori, The Absorbent Mind, 1995) Essay September 1970). Education is essentially the art of learning, not only from books, but also from the whole movement of life. Learning about the nature of the intellect, its dominance, its activities, its vast capacities and its destructive power. Learning it not from a book but from the observation of the world about ourselves without theories, prejudices and values (Letters to the Schools). "Likewise, people who are experiencing, and therefore teaching, are the only real teachers, and they too will create their own technique". (Education and the Significance of Life, p.21, 48). This Ideology was used in setting up schools. The schools had chalked out a curriculum to develop children holistically. The curriculum included meditation, sports, academics and skill development. The schools set up by J Krishnamurthy[4] slowly switched to

[4] Fondly called JK he set up Rishi valley school in Andhra Pradesh currently following ICSE curriculum.

ICSE syllabus reducing the skills in class 9 and 10. They emphasise on class 10 board exams as any other school in the state.

Mohandas Karamchand Gandhi, believed that children should learn from their own experience and set up schools in 1937 to facilitate this. He did not isolate skill, knowledge and the main aim was to make a self-sustaining community, from his experiments at Tolstoy Farm, Sabarmati and Sewagram Ashrams. Learning in their mother tongue was the focus as it is easier to understand in one's own mother tongue. Sewagram educational experiment as conceived by Mahatma Gandhi. Mahatma Gandhi believed that children between 7 years to 14 years of age should have a basic education. Children should stay at home with parents and true education is that which draws out and stimulates the spiritual, intellectual and physical faculties of children. The aim of education is not 'literacy' but development of personality. Gandhiji believed that interaction of parents with children was important for the overall development of the child. He believed that children should not get extra privileges and that all round education is drawing out the best in the child's body, mind and spirit. Gandhiji believed that the optimum number of children in any class should be 25 but not more than 30. The program "basic national education" of 1937 was planned as the initial preparation of children in India as a step to develop the society and towards nation building. Every aspect of life, social, economic, political, cultural, should be based on truth and on non-violence. The whole of general education up to "matriculation" standard should be treated as one integrated unit. Pupils should learn in their Mother tongue. Schooling should be for seven or eight years beginning at the age of seven. Course should include the practice of a useful productive handicraft which would enable the schools to be self-supporting. (To majority of teachers such ideas were unheard and provoked many questions with much criticism. In order to answer to these doubts Gandhiji wrote his seminal article in '*Harijan'* on 31st July 1937).

Gijjubhai Gadecha School based on Maria Montessori is established in Gujarat. The medium of education in this school is Gujarati and is the mother tongue of students attending the school. The focus of this school is learning by experience. The school has primary section after which the children are absorbed in the mainstream schooling. This school is being run by a trust that funds the school. Children are given one meal in school and learn through playing. The teachers are friendly to the children and take care of them. The children in this school are very happy and learn from first principles.

Rabindranath Tagore believed in creativity as the trigger to education. Vishwa Bharati, his brainchild, integrated art, performative practices, music and craft studies that created

opportunities for invigorating and sustaining the manifold facets of the human personality. This was the initial intent of teaching and learning. (Vishwa Bharati Later incorporated several departments and grew into an autonomous university).

His educational philosophy has evolved from his hatred towards 'school' and his love of nature. He did not have a problem with discipline towards children. He advocated that learning should discovery based and exploratory. School should be enjoyable (Sunanda Chopra; Philosophical and sociological foundations of education: 2014). Tagore believed that the teacher must be a mentor and a student throughout life. "He who fails as a learner fails as a teacher". Along with Gandhiji and Tagore, social reformists like Lokamanya Tilak, Baba Sahib Ambedkar worked for educational reforms especially towards for socially oppressed students.

Schools set up by JK and Tagore on experiential learning and holistic learning have ceased to exist and have streamlined to accepted curriculum set by NCERT and deviant from the philosophical principle of the great thinkers. This study of thinkers and the social reformists later directed the inquiry towards people in the other backward castes. The children, who took part in this study, are from the other backward castes and lower socio-economic stratum of society, studying in the state board schools.

2) literature review of the western philosophy, theories and views on education

Several thinkers and philosophers in the west developed theories of learning. Rousseau (1712-1778) says "I hate books" based on this he felt ready-made material as in books should not be used to educate a child. Guiding the child to learn by experience-based activities is the key to educate a child. Encouraging the Process of self-discovery in children as opposed to formal education is the mode of imparting education in children. The thought of John Dewy was similar wherein he believed that formalised teaching-learning methodology is not effective in children. Dewey believed that education should be pragmatic. He also believed that barriers of caste, creed, religion, nationality, language have separated man from man and fragmented society. He believed education can bring together unity of nations and humans. Like Gandhiji he believes that school should be like a large home.

Stages in education according to Dewey were: (1) Play period from 4 to 8 years of age (2) Period of spontaneous attention 8years to 12 years (3) Period of reflective attention 12 year onwards. Dewey's view of curriculum is not merely books but holistic education based on experience.

Jean Piaget was the pioneer in conducting cognitive experiments on children. Cognitive abilities of children develop according to the child's ability to observe understand and repeat. Several Western theorists advocate 'learning by doing' Cognitive tests as a measure segregate differently abled child. In the present-day schooling, the tests/exams that measure cognitive abilities differentiate children within a group in class. This method of measuring learning in schools causes damage in schools. The chapter revisits and reviews the theorists whose philosophy is incidental to the research.

2.4 Literature Review pertaining to the Government machinery and curriculum developers:

In the NCERT draft, the policy makers have not included the theories of learning in professional education programmes (in teacher training) and informal education programs. The education programme relies mainly on the teachers who are supposed to deliver the content effectively and that learning will occur in children. it is crucial to examine children

Examining Learning in Children: Learning in children is complex to decode as they employ different skills to develop a learning style. Literature pertaining to learning styles, cognitive development and mediation needs to be reviewed. It is essential to grade students as it is important to determine the learning that has occurred. The classification of the geometric learning gives an understanding of an efficient grading system that can encompass misconceptions in a learner. The literature review consists of established information that is pertaining to learning.

2.5 Examining "learning" according to learning models:

Alan Roger's (2003) work provides a deep understanding of task-conscious or acquisition learning. It also proved information regarding learning-conscious or formalized learning. Learning as a product: Psychology textbooks decades back have defined Learning as a change in behaviour. This definition does not address the issue if a person needs to perform for learning to have happened, in other words, the measure of learning. Change in behaviour can occur not necessarily by learning. Merriam and Caffarella in 1991questioned, "if change would include potential for change". Not all changes in behaviour from an experience involve learning (Ref: study with maids [domestic helps] and their children). Experience used in some way helps an individual to learn. Change in behaviour may result because of conditioning. This change caused by the experience may not generate new knowledge. The depth or nature of the changes involved is likely to be different.

2.6 Meaning of learning:

Säljö in 1979 carried out a research in which he asked a number of adult students what the meaning of learning was to them. He categorized their responses in to five major classifications

Learning is 'acquiring information' or 'knowing a lot'. (quantitative increase in knowledge)

Learning is storing information that can be reproduced (memorising)

Learning as - acquiring facts, skills, and methods that can be retained and used as necessary (acquisition).

Learning involves relating parts of the subject matter to each other and to the real world- (making sense or abstracting meaning).

Learning as interpreting and understanding reality in a different way. Learning involves comprehending the world by reinterpreting knowledge (quoted in Ramsden 1992: 26).

According to Paul Ramsden, it is evident that perception of learning from the first three above classifications are simple and that perception of learning from classifications 4 and 5 are qualitatively different from the others and look to the 'internal' or personal aspect of learning. Learning is viewed as "something one goes through to understand the real world". Truths can be imparted, procedures can be inculcated, and while inculcation is a gradual process, imparting is relatively sudden. It is only logical to enquire, "At what moment someone appraised of a truth, but not at what moment someone acquired a skill" (Ryle 1949:58). Gilbert Ryle (1949) has differentiated between 'knowing *that*' and 'knowing *how'.* The first two points of the classification above mostly involve 'knowing that'. The third point - with 'knowing that' there is a value attached on 'knowing how'. This system of categories is hierarchical – each higher conception implies all the rest beneath it. Students who conceive of learning as understanding reality are also able to see it as increasing their knowledge (Ramsden 1992: 27). In the five classifications made by Säljö, it can be seen that learning appears to be a process. Learning could be perceived as 'a process by which behaviour changes as a result of experience' (Maples and Webster 1980 quoted in Merriam and Caffarella 1991: 124).

In the area of Informal Learning, review, and discussions or resolutions pertaining to what extent people are conscious of what is going on. Monitoring Informal learning is the key to understand the progress of the learner.

If they are aware that they are learning, then does it have any meaning to them? Do people attach meaning to learning? This inquiry is very crucial to the research as the groups studied

were asked what learning meant to them and their mode of learning and indicated their aspiration with regards to education for their children.

Alan Rogers (2003) based on the theory of language learning (Krashen 1982), has concluded that there exist two approaches: (a) task-conscious or acquisition learning and (b) learning-conscious or formalized learning. 'Acquisition learning' is an ongoing activity in an individual. It is 'concrete, immediate and confined to a specific activity; it is not concerned with general principles' (Rogers 2003: 18). This learning is from routine jobs and from the challenges faced or otherwise in the day-to-day activities, also referred to as 'unconsciousness or 'implicit'. Rogers (2003: 21), recommends implicit learning as having a consciousness of the task. The learner may be aware of the task but not be conscious of learning. Formalised learning is 'educative learning' rather than the accumulation of experience. There is a consciousness of learning. Through the process that enables learning by guiding the learner. 'Learning itself is the task. What formalized learning does is to make learning more conscious in order to enhance it' (Rogers 2003: 27). School learning and learning from adults at home is a mix of informal and formal learning. Students examined in this research were doing routine jobs at home and attending formal school in the day. Literature pertaining to this situation is helpful to understand how the children in this context learn and if the activities they perform on a day to day basis influence their learning in a formal environment.

Events occur continuously as real-life experiences. Incidental learning occurs through unconscious activity. Conscious modes of learning include learning in school or where education is imparted and experiential activities with the focus still on the task. When an individual learns something in a more systematic way, not interacting with teachers or formal institutions, individual indulges in purposeful activities. The other end of the spectrum of learning is the self-directed learning projects. There are of course no clear boundaries between the categories. (Rogers 2003: 41-2). This distinction has been made in different ways, discussed by Kurt Lewin, Chris Aryris, Donald Schön and Michael Polanyi. It is inevitable but to visit the domain of learning theories after going through the process of learning.

It is noteworthy to understand how theorists perceive 'how or why' change occurs.

There are several theories but three broad classifications according to Merriam and Caffarella (1991) are taken up and the more recent social learning theory is compared and contrasted:

(a) the behaviourist theory of learning,

(b) Cognitive theory of Learning

(c) Humanistic theory of Learning

(d) Social / Situational theory of Learning.

Table 2.2.3: classifucation of theorists (Merriam S. C., 1991, 1998)

	Behaviourist	Cognitivist	Humanist	Social/situational
Theorists	• Thorndike, • Pavlov, • Watson, • Hull, • Tolman, • Skinner	• Koffka, • Kohler, • Lewin, • Piaget, • Bruner, • Gagne, • Sternberg • Ruven Feurestine	• Maslow, • Rogers	• Bandura, • Salomon • Lave and Wagner
Learning process	Change in behaviour	Internal mental process insight, information processing, memory, perception	A personal act to fulfil potential.	Interaction /observation in social contexts. Movement: periphery to centre of community of practice
Focus of Learning	Stimuli in external environment	Internal cognitive structuring	Affective and cognitive needs	Relationship between people and environment.
Purpose in Learning	Produce behavioural change in desired direction	Develop capacity and skills to learn better	Become self-actualised, autonomous	Participation in communities of practice and utilisation of resources
Educator's duty	Arranges environment to evoke a proper response	Structures content of learning activity	Enables the development of a person	Works to establish communities of practice in which conversation and participation can occur.

There are other classifications of the learning theories as theories overlap one another, the four theories that are addressed herein are very broad categories. Table 2.2.3 gives the classification by Merriam and Caffarella (1991). The table is important as it provides an overview to position the research domain. The table gives a clear idea of social/ situational theories that may not be

applicable to some of the groups studied herein. Children from marginalised society are exposed to the culture of that society.

The table gives/draws the comparison between theorists. The four theories can be compared and contrasted as in the table below. (Merriam and Caffarella 1991: 138). The distinctions between various modes of learning and theories of learning provides varied views.

2.7 Triarchic Theory of Intelligence:

All people engage in metacognitive activities every day. Metacognition has been associated with intelligence and helps people to be 'successful learners' (Borkowski, Carr, & Pressley, 1987; Sternberg, 1984, 1986a, 1986b). 'Metacognition' refers to higher order thinking involving active control over cognitive processes involved in learning. 'Planning how to approach a given task, monitoring, and evaluating progress toward the completion of the given task are activities that are metacognitive in nature. Metacognitive activity if analysed would help to teach or guide students to apply cognitive resources effectively. In an Observation in earlier studies, students have knowledge yet they face difficulty in understanding concepts in mathematics. It is difficult to classify this knowledge as cognitive or metacognitive knowledge.

Flavell (1979) acknowledges that metacognitive knowledge may not be different from cognitive knowledge. The technique in which the information is used determines the distinction. Metacognition is considered "thinking about thinking".

Cognitive strategies assist a student to achieve a particular issue (like understanding a particular concept of mathematics). Metacognitive strategies assist if the particular task is achieved (trying self-evaluate the understanding of the particular concept). Fig 2.9 gives the overview of his theory.[5]

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[55] Source for fig 2.2.4
https://www.google.co.in/imgres?imgurl=http://study.com/cimages/videopreview/screen_shot_2015-06-08_at_10.54.24_am_110795.png&imgrefurl=http://study.com/academy/lesson/sternbergs-triarchic-theory-of-intelligence.html&h=716&w=1274&tbnid=2toafMMr4_PhfM:&vet=1&tbnh=118&tbnw=211&docid=ZWHbO43jM8wBdM&usg=

Metacognitive experiences often occur when cognitions fail, such as the recognition that one did not understand the concept. Such a situation triggers metacognitive processes as the learner attempts to rectify the situation (Roberts & Erdos, 1993).

Metacognitive experiences involve the use of metacognitive strategies or metacognitive regulation (Brown, 1987). Metacognitive strategies are sequential processes that one uses to control cognitive activities, and to ensure that a cognitive goal is met for example understanding a mathematical concept. These processes help to regulate observe and direct the execution of learning.

These processes consist of planning and monitoring cognitive activities, as well as checking the outcomes of those activities. On reading a concept in a mathematics text, students may question one-self about the concepts discussed in the textbook. Cognitive goal is to understand the concept read in the textbook. Self-questioning is a metacognitive activity which is the ability to understand the monitoring strategy. When the student finds it is not possible to answer self-generated questions, or does not understand the material discussed, then must decide what needs to be done to make sure to meet the cognitive goal of understanding the concept. The student may decide to re-read the paragraph with the goal of being able to answer the questions generated. If, after re-reading through the text student can now answer the questions, student may determine that he/she understands the material. Thus, the metacognitive strategy of self-questioning is used to ensure that the cognitive goal of comprehension is met.

Metacognition or the ability to control one's cognitive processes called as self-regulation has been suggested to connect to intelligence (Borkowski et al., 1987; Brown, 1987; Sternberg, 1984, 1986a, 1986b). In the “Triarchic theory of Intelligence” Sternberg (fig 2.2.4) refers to executive processes as "metacomponents". Metacomponents receive feedback from cognitive components and control them as well. According to Sternberg metacomponents determine how a task is "Figured" out and made sure it is done correctly (Sternberg, 1986 p24). Sternberg also supports that the ability to allocate cognitive resources is central to intelligence. Intelligence is one of the most complexes talked about concepts within the field of psychology. Sternberg's theory calls for the integration of intelligence and creativity. According to Robert Sternberg's theory, three basic mental processes underlie all intelligent behaviour.

The three basic mental processes

(a) Metacomponents: the executive processes that we use to solve problems, plan what to do, make decisions, and evaluate outcomes. Example: If one plans to read a book; - that involves metacomponents.

(b) Performance components: carry out the directions of the metacomponents. It is performance components that allow us to store information in short-term memory compare two concepts, compare solutions to the task, etc. Example: When one grabs a book off the shelf and actually reads it, that act involves performance components

(c) Knowledge-acquisition components: are what we use to learn and store new information. In other words, metacomponents tell us what to do, performance components actually do it, and knowledge-acquisition components make sure we learn things along the way. Example: If you learn new vocabulary words while reading, that act involves knowledge-acquisition components. What is viewed as intelligent in one culture might not be viewed as intelligent in another culture. Basic mental processes are the same across different cultures .

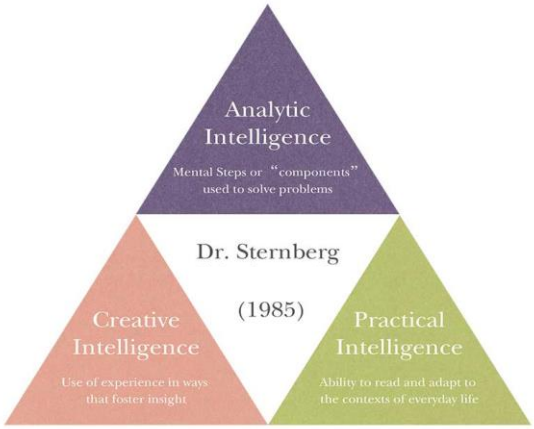

fig 2.9 : Triarchic theory of intellegence

Three Parts of Intelligence: According to Sternberg, intelligence cannot be defined by tests. Rather, intelligence should be defined in terms of how you perform in your everyday world. Sternberg refers to what he calls successful intelligence. People who are 'successfully intelligent' are able to define and achieve their own idea of success within their culture. People who are 'successfully intelligent' are skilled at adapting to and modifying their environment to fit their needs. "One's intelligence is highly dependent upon the culture that one lives in, an individual that is considered intelligent in one culture might not be considered intelligent in another. There are three components of successful intelligence: analytical, creative, and practical intelligence". It is not enough to possess the three components but one must know when and how to use these components in order to be effective. This theory is very incidental to the research as children are examined for how they understand (study), learn, recall and apply knowledge to situations both in real life and in school. This theory of intelligence was revisited several times to relate to the children in this research.

Instruction Design by taking into consideration the metacognition and cognitive processes: Students engage in metacognitive regulation when confronted with a cognitive task

that requires vigorous attempts. Students with greater metacognitive abilities are successful. Students with lesser metacognitive abilities can learn to control the cognitive activities if appropriate instruction programs are designed. Cognitive Strategy Instruction (CSI) is an instructional approach, which emphasizes the development of thinking skills and processes as a means to enhance learning. The objective of CSI is to enable all students to become strategic, self-reliant, flexible, and productive in their learning endeavours (Scheid, 1993). The basis of CSI is on the assumption that there are identifiable cognitive strategies, previously believed to be utilised by only the best and the brightest students, which can be taught to most students (Halpern, 1996). Use of these strategies has been associated with successful learning. (Borkowski, Carr, & Pressley, 1987; Garner,1990).

It is essential to study the CSI as an instructional approach to design the questionnaire to be administered to the students examined in this research. Metacognition enables students to benefit from instruction (Kurtz et al 1989; Van Zile-Tamsen, 1996) and influences the use and maintenance of cognitive strategies. While there are several approaches to metacognitive instruction, the most effective involve providing the learner with both knowledge of cognitive processes and strategies (to be used as metacognitive knowledge), and experience or practice in using both cognitive and metacognitive strategies and evaluating the outcomes of their efforts (develops metacognitive regulation). Simply providing knowledge without experience or vice versa does not seem to be sufficient for the development of metacognitive control (Livingston, 1996).

The study of metacognition has provided educational psychologists with insight about the cognitive processes involved in learning, and the factors that differentiate successful students from their less successful peers. It also holds several implications for instructional interventions, such as teaching students how to be more aware of their learning processes and products as well as how to regulate those processes for more effective learning.

2.8 Instructional Theory:

Instructional Theory by Gagne: Since 1899 the need for an instructional theory was recognised. "You make a great, a very great mistake, if you think that psychology, being a science of the mind's laws, is something from which you can deduce definite programmes and schemes and methods of instruction for immediate schoolroom use" (James, 1899/1958. p. 23). Educators evaded the need for an instructional theory before Gagne proposed the instructional theory in 1960. The major focus was on:

a) Sequence and content concerns from within a framework of reference of a curriculum theory and

b) Application of learning theory, particularly applications within a frame of reference of a programmed instruction.

Gagne came up with four landmark propositions which became an integral part of the instructional theory.

1) Learning goals categorised as to learning outcome or knowledge type;

2) Acquisition of different outcome categories requires different internal processes;

3) Learning outcomes can be represented in a predictable prerequisite relationship;

4) Acquisition of different outcome categories requires identifiably different instructional processes.

Instructional Theory proposed by Gagne takes into account the curriculum design taking considering the learner, knowledge of the learner and the experience of the learner.

Theory of instruction by Bruner: Bruner (1968) proposed a theory of instruction that would encompass the four points as:

(1) Experiences that would create motivation to learn.

(2) Optimal structures of knowledge for learning.

(3) Optimal sequences of and

(4) Nature of rewards and punishments.

These four propositions of the instruction theory by Bruner indicate a strong view of a “teaching-cantered” view of instruction.

Gorden parallel to Bruner, defined instructional theory as "a set of statements, based on replicable research, which would permit one to predict how particular changes in the educational environment (classroom setting) would affect pupil learning." Gordon differentiated the terms "instruction" and "teaching" clarifying that teaching "refers primarily to the human interaction between teacher and pupil" (Gordon, p. 3).

Gagne’s perspective was from “applied Science”. He viewed learning in a realistic environment. Gagne and Bolles opined that "the learning tasks that have been most intensively studied by psychologists in a theoretical framework but not in the real life situations. Instructional theory has be used effectively to develop the curriculum in schools for example Stephan and Akyuz (2012) and Lehrer et al. (2001) both sought to develop a *domain-specific*

instructional theory. Stephan and Akyuz (2012) framed their study as a case of supporting the development of middle-grades students' reasoning about integers. Lehrer et al. (2001) framed their study as a case of supporting elementary students learning in particular mathematical and science domains.

2.9 Kolb's experiential learning theory:

Four stages in learning that are proposed by Kolb are represented by figures 2.2.6.1 1 and 2.2.6.2 1[6] The learner according to this theory touches all the bases

1. Concrete experience: being involved in a new experience
2. Reflective observation: watching others or developing observations about one's own experience
3. Abstract conceptualisation: creating theories to explain observations
4. Active experimentation: using theories to solve problems, make decisions.

Kolb (1974) views learning as an integrated process with each stage being mutually supportive of and feeding into the next. It is possible to enter the cycle at any stage and follow it through its logical sequence. Effective learning occurs when a learner is able to execute all four stages of the model. Therefore, no one stage of the cycle is an effective as a learning procedure on its own. Critical review of the learning cycle is taken up to determine if the children in this research were amongst the type of learners that are mentioned by Kolb. If so, then curriculum can be built around the theory and assessment criteria could be setup however, if the children do not exhibit the tenets of this theory then the investigation could be made to find out the mode of learning.

Learning Style: Kolb's learning theory (1974) sets out four distinct learning styles, which are based on a four-stage learning cycle. Kolb explains that people adopt different learning styles. Several factors influence the preferred style of the learner. The preference of a learning style is the product of two pairs of variables, or two separate 'choices'. Kolb presented the preferences as lines of axis, each with 'conflicting' modes at either end: A typical presentation of Kolb's two continuums is that the east-west axis is termed as the Processing Continuum, (how we approach

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[6] ***Source for figs 2.2.6.1 and fig 2.2.6.2 http://www.simplypsychology.org/learning-kolb.html*** (20-8-09)

a task), and the north-south axis termed as the Perception Continuum (our emotional response, or how we think or feel)

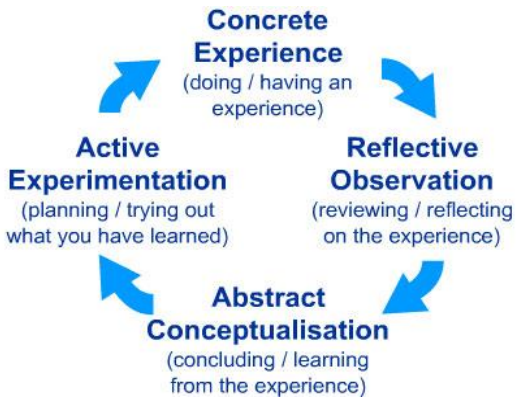

figure 2.2.6.1

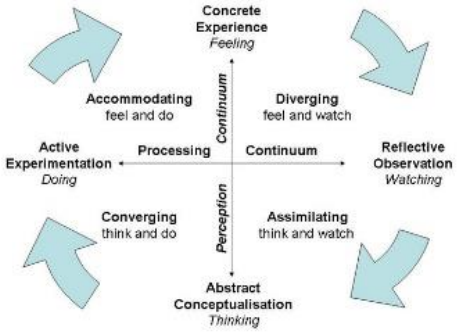

figure 2.2.6.2.

Educational Implications of Kolb's theory: Teachers can critically evaluate students using Kolb's (1984) learning stages/cycle and develop effective, appropriate learning opportunities. If educators design and carry out activities that will offer each learner the chance to engage in the manner that suits them best. Younger children must be assisted in school to identify the best style that will help them learn more effectively through the experiential learning cycle. Ideally, activities and teaching material should be developed in ways that draw on abilities from each stage of the experiential learning cycle and take the students through the whole process in sequence.

Effective learning according to Kolb takes place when a person progresses through a cycle of four stages:

(1) Of having a concrete experience followed by

(2) Observation of and reflection on that experience which leads to

(3) The formation of abstract concepts (analysis) and generalisations (conclusions) which are then

(4) Used to test hypothesis in future situations, resulting in new experiences.

Definition of Experiential Learning: Beard and Wilson explained 'Experiential Learning". 'Experiential Learning is the sense-making process of active engagement between the inner world of the person and the outer world of the environment'. Traditional learning with the

teacher or trainer without deeper involvement is an ineffective form of learning. Creating a meaningful learning experience by involving the learner would be effective, long lasting form of learning. This enables a student to unleash some effective powerful constituents of learning. Experiential learning thus offers techniques that help learners make sense of their experiences as well as methods to develop and practice new positive behaviours. It helps the developers, educations and trainers to focus on the design of new ideas and explore ways to improve professional practice and ethical responsibility through self-monitoring and feedback techniques.

Beard and Wilson further define experiential learning as "the insight gained through conscious or unconscious internalisation of our own observed experiences which builds upon our past experiences or knowledge." Experiential learning[7] is the best possible method to learn a concept and remember it

2.10 Mediated Learning Experience (MLE):

A basic assumption of MLE theory is that individuals learn by way of two main modalities Direct exposure to stimuli and Mediated learning Experience.

Direct exposure is characterised by unmediated encounters of individuals with stimuli in the environment. The Stimuli (S) to the Organism (O, learner) represent the direct exposure. In MLE interaction, on the other hand, learning takes place by means of an experienced adult, usually the parent, who interposes between the child and the world of stimuli. The mediator (H) modifies the stimulus in various ways and presents it to the child (O) so that it can be registered efficiently. The mediator presents stimuli to the children by modifying their frequency, order, intensity, and context, by arousing in the children curiosity, vigilance, and perceptual acuity, and by trying to improve and/or create in the child the cognitive functions required for temporal, spatial, and cause-effect relationships –Ruven Feuerstein (2010).

[7] (Rudolf Steiner's Pedagogy of Imagination: A Phenomenological case study *by Thomas William Nielsen, PhD* A paper to complement a presentation given at the first International Conference on Imagination in Education, 16-19 July, Vancouver, Canada, BC).

2.11 Theory of Motivation:

He'd presented his pyramid in a paper, "A theory of Human Motivation" published in *Psychological Review*. The hierarchy as it seemed to him when it was published in 1943. Maslow's original theory of needs (fig 2.8.1). He added a *self-transcendence*. At the apex of the pyramid (Fig 2.8.2) both figures in Appendix 1) in his later years.

Nichol Braford was convinced that the most serious problems facing humanity aren't technical: Although engineering our way out of trouble *is* possible, it can't happen until we transcend ourselves, seeing beyond our own individual well-being to the needs of us all. This is what the final stage of Maslow's pyramid is about.

Having met the basic needs at the bottom of the pyramid, then having worked on our emotional needs in its middle and worked at achieving our potential, Maslow felt we needed to transcend thoughts of ourselves as islands. We had to see ourselves as part of the broader universe to develop the common priorities that can allow humankind to survive as a species.

Maslow saw techniques — mindfulness, flow — as the modality by which individuals can successfully bring about broader perspective that comes with self-transcendence. His work is vitally important tool if we hope to continue as a living species.

fig2.8.1 theory of needs 1

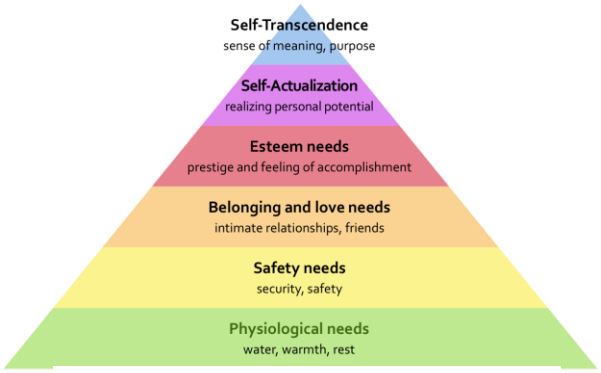

fig2.8.2 revised theory of needs 1

Abraham Maslow offered the definition of transcendence to the very highest and most inclusive or holistic levels of human consciousness, behaving and relating, as ends rather than means, to oneself, to significant others, to human beings in general, to other species, to nature, and to the cosmos. (1971, p. 269)

This theory is reviewed and studied in depth as it is important to understand the category of students being studied in this research.

2.12 2.13. Van-Hieli system of Geometric learning:

Since the grading pattern in this study is based on the previous concepts, and akin to the Van-Hieli System of Geometric thinking it is critical to review it. The Van Hieli system has classified learners in 5 levels Level 0 (Visualisation-shape recognition), level 1 (Analysis), level 2 (informal deduction), level 4 (deduction), level 5 (rigor). This method of classifying learners has taken into account only what children can do. To go to the next stage the previous stages have to be complete.

Literature Review covers the instructional, cognitive and the experiential theories. Literature Review looks into the system of education that prevailed in India before the British rule. The influence of the western education system and the theoretical framework of the instruction were researched in depth in this research.

3) Review of the Philosophies on which schools are based

The ‘Gurukul system” formed the basis of the ancient system of education in India. In the Gurukul system, anyone who wished to study went to a teacher's (Guru) house and requested to be ‘taught’. If the ‘guru’ accepted a student, the student would then stay at the guru's place. The student would acquire knowledge from the ‘guru’ while helping the guru in all his daily chores and activities at home. This created a strong learning bond between the teacher and the student. The Guru used to teach the student everything about running a house. The teachings encompassed subjects, which included a wide array of topics from Sanskrit to the Holy Scriptures and from mathematics to metaphysics. The student stayed as long as the student wished or until the guru felt that he had taught everything that he could teach. In the Gurkul, the gurus taught lessons that were closely linked to nature, life and not just confined to memorising information. Ms. Sanyukta Keshalkan (IASAR USA:2013) explains about music education in ancient India where traditionally a student stayed in the teacher’s house and acquired the musical knowledge and skill along with acquiring ethical concept of living in society. In the Gurukul the gurus taught the student based on their ability to grasp information, understand and apply concepts. The gurus believed that higher order thinking capabilities are limited to the individual student. This system of education instilled values in students by

constantly living with the Guru and learning from the 'Guru' or teacher. The mind-set of a large population used to be the same and they believed that the teacher is the ultimate power and has to 'teach' the student. This gave scope for a student to apply knowledge acquired from Guru and reflect on the concepts learnt. The student's capacity to understand was of utmost importance.

Education in India is intricately tied with caste system. Ghanshyam Shah through his book "Caste and Democratic Politics in India" explores caste and politics in India with focus on not only decision-making in institutional functioning, resource distribution and change. The groups still facing discrimination due to caste. They continue to have low literacy rates and high dropout rates. It is important to inquire if this discrimination has any effect on their learning with understanding. It is important to determine how children learn and decoding learning would help designing an effective curriculum and educational policy.

Students attending schools in the present system of education in India are observed to have an innate fear for mathematics due to which most children drop out of school. In municipal schools of Mumbai, two or three children in a class of forty are able to do extremely well and obtain a first class in the exam conducted by the state board. Children who 'pass' the board exams lack conceptual understanding in mathematics and applied sciences. In this research misconceptions developed by the children in mathematics (research inquiry is limited to only concepts in Area and Perimeter of a Rectangle) are studied and the mode of learning is determined.

4) Literature on the qualitative methodologies

a) Phenomenography: The Concepts of Phenomenographie Research Marton (1986) has stated that methods in his original work were "developed out of some commonsense considerations about learning and teaching" (p. 40) and lacked a clear conceptual basis. Marton (1979) has characterised his approach as introspective method, in which people were asked to report their mental processes while carrying out an experimental task. According to Marton, had was popular in educational and psychological research during the 1960s and 1970s. In an earlier study Marton (1970) obtained introspective reports in experimental research on human memory, although then he had acknowledged that his participants might simply have drawn inferences from their own behaviour (p. 76). In the 1970, academic bodies through a debate questioned the validity of introspective evidence within cognitive and social psychology (Evans, 1980; Nisbett & Wilson, 1977; Pylyshyn, 1973). The research by Morton and his colleagues was disparaged from the paradigm of

psychological research as being an essentially descriptive enterprise (Marton, 1986). The research bore similarities to qualitative approaches to social-science research being developed during the 1970s. They searched for arguments to legitimise their approach by examining the stand taken by other approaches. Marion (1978) suggested that conventional research on student learning adopted a "first-order" or "from-the-outside" perspective that sought to describe the learner and the learner's world in broadly the same terms. He described his approach as a "second-order" or "from-the-inside" perspective that sought to describe the world as the learner experienced it. He drew parallels to Kant's distinction between a thing in itself (or noumenon) and a thing as it appeared (or phenomenon): whereas traditional research had adopted an observational or "noumenal" approach, he had adopted an experiential or "phenomenal" approach (*Richardson* Marton& Svensson, 1979). Subsequently, Marton (1981) labelled this approach "phenomenography."

b) Study of Action Research: Action Research is one of the methods to conduct research in the field of education. It is an interactive method to collect information to explore topics of teaching, curriculum development and student behaviour in the classroom. This method offers reflection in classroom. In areas where development is continuously desired, this method is beneficial. Paul Cobb(2016), (two views of culture and their implications for mathematics teaching and learning) discuss the cultural participation orientation which is key to instruction in urban class room setting. Prior to this Paul Cobb and other deduced from Action research how classroom instruction be designed. Action research is reviewed, as the subjects in this research need constant monitoring to find out how they learn. This also gives a concrete platform to establish curriculum for school dropouts and ‘failures’ in a class. The fundamental aim of action research is ‘to improve practice rather than to produce knowledge. The production and initialisation of knowledge is subordinate to and conditioned by, this aim’. Sagor (2005:4) sets out a straightforward four-stage model of action research:

Stage 1: Clarify vision and targets.

Stage 2: Articulate appropriate theory.

Stage 3: Implement action and collect data.

Stage 4: Reflect on the data and plan informed action (Cohen, 2013, p. 353).

Paul cobb:

Step1: classroom research

Step 2: One –to-one teaching

Step 3: Experiment design for classroom based on step2

"Teaching experiment methodology" (Cobb & Steffe, 1983; Steffe, 1983). Under this scaffold, a one-to-one teaching experiment focuses on understanding how children learn rather than a change in the mode of teaching. Addressing these one on one teaching sessions, the classroom instruction was planned. The need for classroom teaching experiments arose when analysis of traditional instruction within the same (socio-constructivist) research program, produced only negative advice for the teachers; advice of the type: "Don't do this, don't do that."

To create more productive classroom environments, the researchers had to take the responsibility for the design of the instruction of a classroom for an extended period.

In doing so, the one-on-one teaching experiment methodology was expanded to classroom teaching experiments.

The focus on understanding is a prime fundamental and important characteristic of design research[8]. In this respect, the distinction Bruner (1994) makes a between research that aims at (statistical) explanation, and research that aims at 'understanding'is noteworthy. This distinction is used to reiterate that the goal of design research is very different from research along the lines of an experimental or quasi-experimental research design. Different goals imply different methods and different forms of justification. The NCTM Research Advisory Committee (1996) that observes "a shift in norms of justification" in mathematics education research, towards research; that has as its goal to provide *an empirically grounded theory on how the intervention works*. Socio Economic stratum is a common thread among the people in the entire country and the world at large. Terezinha Nunes (Street Math Vs School Math), in a study on Brazilian children observe that contain and indicates the economic divide in the society. Taking into the consideration of this reality, groups of this economic and social divide, in India are examined.

[8] Design Research provides a designer as a researcher to iterate process and test. The design research provides scope for in-depth analysis and understanding of a situation. In 1973 Horst Rittel tried to define 'design theory' while concentrating on Design methods. The other methods are DBR (design Based research) which create solutions known as 'interventions' which are put to use to test and then iterated which are re-tested. This is widely used in education research and learning sciences. Therefor this research uses the principles of 'design research'

The gaps in background study observed is that the educating children of marginalised society from India is not addressed. Focus on the marginalised section of society paved the way to chapter III which is the design the research study.

c) Classroom Design Study: An important goal when conducting a classroom design study is to produce "humble theory" (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003) this would provide useful guidance as they attempt to support students learning in other settings. It is therefore critical when preparing for a design study to place it in a larger theoretical context by framing it as a paradigmatic case of a broader class of phenomena. In this research it is proposed that classroom design study is conducted for a specific time while covering the topic of Area and perimeter. The line of conducting would be akin to Paul Cobb and others.

The Gaps in literature survey are

- Experience based pedagogy within the purview of ELT, is **not structured** with respect to the academic system prevalent in the country.
- **Not much theory / understanding** on the effectiveness of the experience-based activities, and impact on learners in primary schools.
- Experience based activities are **not used in schools** to communicate and facilitate conceptual understanding.
- There is no **recorded database** of experiential activities for a teacher to facilitate class room instruction.

5) Review of Government policies and surveys on education in India

From the national census taken by Educational consultants India limited (EdCIL)[9] on behalf of Ministry of Human Resource Development (MHRD) a sample survey was conducted in

[9] Educational consultants India limited (EdCIL) on behalf of Ministry of Human Resource Development (MHRD) conducted a sample survey in 21 major states of the country in 2008-10 years ago to assess the drop-out rates at primary and upper primary levels. In this survey, a of total 99,226 households in all the states and union territories of India were studied during February – May 2009. The government census has shown that there were 190,582,581 children in age group 6-13 years and out of these 8,150,617 were schoolchildren who were 'out of' school. At the national level among the children who were out of school, 74.89% were those who never went to school and 25.11% were those who had dropped out from school after one or more years of schooling. The data that was

21 major states of the country in 2008 (that is 10 years ago). Based on the conclusions from the survey, dropout rates were found to be greater in the lower economic strata but the reasons for the increasing drop out percentages were not documented. This study of the census is of importance to understand if the children have dropped out of school due to lack of interest, lack of understanding, ineffective classroom instruction or other socio-economic factors. The education system in India currently has four boards Viz: ICSE (*The Indian Certificate of Secondary Education)*, CBSE (Central Board of Secondary Education), SSC (Secondary School Leaving Certificate) and other international boards (IB, IGCSE, A Levels).

Literature review was narrowed down to Cognitivist theories as they pertain to the current formal education system prevalent in the country.

This concludes the literature review.

6) Gaps in existing research from literature review

Gaps in literature review

- Experience based pedagogy within the purview of ELT, is **not structured** with respect to the academic system prevalent in the country.
- **Not much theory / understanding** on the effectiveness of the experience-based activities, and impact on learners in primary schools.
- Experience based activities are **not used in schools** to communicate and facilitate conceptual understanding.
- There is no **recorded database** of experiential activities for a teacher to facilitate class room instruction.

collected in the 2009 survey through the DS-4 schedule to provide estimates of dropout, repetition and promotion rates for the year 2008-09 and 2009-10, was rechecked through survey for assessment of dropout rates at elementary level in 21 states during January 2013 and 4,154 schools (2,401 primary and 1,753 upper primary) were covered from these 21 states. It was seen that he dropout rate at the primary stage had risen compared to 2009-10 in all states.

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Chapter III: Framework of Research Design

It is of prime importance to initially create a conceptual and theoretical framework of enquiry. From the literature review and the studying the theories the frame work is conceptualised. Since the research focusses on decoding learning amongst children, classroom research and observation are adopted. The classroom instruction revolves around the mode of instruction and the mode of communication. The framework for the research is built on the hypothesis.

3.0 Task Identification for the research study

Akshar a student from class 8 had pointed out that students in his class had a misconception on Area and perimeter of a rectangle. He had mentioned that students have a misconception on the interdependency of area and perimeter. To verify this statement students were examined and it was seen all except one student out of 85 had internalized this misconception. It was also found that most subjects did not have conceptual understanding on the Topic of Area and Perimeter of a rectangle. At this juncture the topic of Area and Perimeter of a rectangle was taken up as the topic of inquiry.

3.1 Methodology: Studies conducted are as follows:

This research is a qualitative study. Tenets of 'Design research' are employed in this research. A questionnaire is deployed and data is collected. From the data obtained, design intervention and its execution by way of action research in classroom is undertaken. Through iterations deeper understanding of the 'learning' amongst children is revealed (Cobb, 2010). The iterations are small and the effects of the iterations are documented. On observing small changes that affect the situation, the changes are documented. The design research is unique and diverse from other approaches and methodologies.

The characteristics of Design Studies that investigate students' learning are:

1) The intermediaries were designed to support and enhance learning to improve the quality of instruction. This addresses the problems that arise in using intermediaries that are designed based on the curriculum.
2) The methodology is interventional; the activities designed focus on the curriculum.
3) The activities target concepts and skill development.

4) The intermediaries designed for the activities give the flexibilities to explore other possible solutions that do not limit the thinking to one solution.

Since design research methodology is interventional, the investigations are directed to improve, and develop the students or teachers. The effect of intervention on both the instructors and the learners can be studied.

The design research refrains from the teaching-learning practices of formal schools. The process of creating the modes of learning provides inputs with substantial control in comparison with naturistic investigations along with the other forms of aids that are pivotal to class room communication (teaching) / practices.

The other feature is that design encompasses both the theoretical and pragmatic domains. The prime objective of a design study is to develop a theory that has a postulation of both processes of Learning and the modality of assisting that learning.

These theories are self-effacing and focus on either students' attitude and thinking towards mathematical reasoning in the classroom or teachers' development of the forms of instructional practice as a method to enhance professional development in the particular field.

Since Design Research is iterative, at any stage the study can be abandoned. The study focuses on the subjects (teachers and students). The response is very individualistic and may be divergent. In such cases it may be negating the hypothesis and the hypothesis may be revisited. The iterative processes help improve the design to positively enable the students to learn and enable the teachers to improve educational practices.

The design of intermediaries is iterated in this study as a part of Design Research. This is done to better/improve the understanding of concepts and to investigate the mode of learning.

The last step of design research is generalisability. In this study the curriculum in schools of class 7 is revisited and the intermediaries are specific to the syllabus for a particular age group. It is assumed that thereafter generalisability can be achieved.

3.2 Pre-test towards Hypothesis building:

After identification of the task it was important to examine other schools and check if similar situations existed therefore a pre-test was conducted in schools to find out if children in primary schools have internalised misconceptions on the topic of Area and

Perimeter of a rectangle. This Pre-test was to observe children schooling in CBSE board[10]. CBSE is considered to be the board that has a unified curriculum and the content delivery is common across all schools.

The consensus among the academicians is that the CBSE curriculum addresses the fundamentals in any subject. The teachers teaching in these schools are professionally qualified graduates. The curriculum is revised and redeveloped regularly once every five years. The CBSE curriculum is uniform across the country.

These facts about efficacy the curriculum and the teachers being qualified, indicates that students studying the CBSE syllabus do not internalise misconceptions and the teachers teach students in a manner that the students learn with conceptual understanding.

This is the justification of choosing the CBSE schools for doing a pre-test. Tests on Area and Perimeter were administered in two schools.

1) One CBSE school (School 'A') was the control sample as they had high achievers where class 12 results were a '100% pass'. This prompted an initial study on the schoolchildren of class 7 and their conceptual understanding of the topic Area and Perimeter of a rectangle.
2) The other CBSE school, (school 'B') studied, was 35 Kilometres away from School 'A'. Seventh and Eighth graders, (13-year-old children) from both schools had high achievers.
3) Among children from the lower economic strata of the society a preliminary test was conducted on the children of domestic help.

School 'A' had more children from the marginalised section of the society (lower Socio-economic group) compared to school 'B'. Irrespective of this socio-economic divide, only two children from school B had conceptual understanding of Area and Perimeter of a rectangle. They had a conceptual understanding of other topics in mathematics.

The outcome from mode of questioning by means of questionnaire indicated that children had misconceptions in the concept of Area and Perimeter of a rectangle. Among the high achievers, it was wrong assumption that led to misconception which was rectified and no longer stayed as a misconception once they were exposed to the concept in detail by a

[10] However, the draft policy of NCERT has not been revised for the last 15 years.

professional instructor out of school. The High achievers did not take a liking to Experience Based pedagogy and understood concepts by rote learning or visual thinking. At this point of pre-Hypothesis building[11], it became evident from the pre-tests conducted that children attending SSC board schools had internalised misconceptions in mathematics. The study is based on children attending State board (SSC). The children who are a part of this research and are attending Municipal schools are from the marginalised section (lower socio-economic strata) of the society.

3.3 Hypothesis and Research Questions:

Prior to framing the Hypothesis and the conceptual framework of inquiry, it is assumed that Experiential Learning activities in SSC board schools will create conscious learning from daily activities and experience. This Hypothesis is made based on the fact that education policy makers have changed the textbooks of SSC board curriculum and are trying to incorporate experiential education in schools. The views of education policy makers regarding primary school education are:

- Formalised learning prevalent as learning in SSC board schools is not conducive to the students developing abilities in thinking, visualisation and understanding abstract concepts.
- Experiential learning activities will enable students of SSC board schools to reflect, recall and relate concepts.
- Experiential Learning Activities will enable students to successfully attempt formalised testing at the end of the year and will reduce failure rate in school.

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[11] Since both schools had high achievers, they had access to professionals outside of their school and home for help in understanding the concepts dealt with in class. The math teachers in both schools were individuals who were specialised in the subject they were teaching and had skill in teaching the subject. The children worked and solved problems in a theoretical framework.

During the initial phase of testing, to determine if misconceptions exist amongst children in the lower economic strata of the society, a preliminary test was conducted on the children of domestic help. One such example was the reaction of a maid's child, "I have never coloured until today. I hate colouring; it is waste of time". They had a strong sense of 'right' and 'wrong'. It is observed during initial studies, that in the marginalised section of the society (domestic help); children harbour misconceptions and build new knowledge on the previously internalised misconceptions.

- School dropout rate will reduce with the introduction of experiential learning activities.

The premise, on which the research commenced, is based on assuming that the curriculum in SSC board school has to be based on 'hands-on-experience'. Activities designed for students related to their syllabus in the curriculum. (John Dewey and Kolb proved that experiential education is effective in conceptual understanding as in Literature Review chapter II).

The Hypothesis would be based on the gaps from the literature survey based on ELT and findings from the action research (Cobb, 2010). Major gap in the literature review is that no study on municipal school of Mumbai are undertaken using the tenets of ELT.

Hypothesis: Experience based activities develop conceptual understanding.

The Hypothesis is based on the following points

Experience based activities can motivate children to attend school and prevent dropout rate in school.

Experiential Activities can be planned and designed.

Experience based activities can generate interest in children for developing conceptual understanding.

It can motivate children to attend school and prevent dropout rate in school.

Experiential Activities can be designed according to the needs of the content in the syllabus using simple materials.

During the course of study, an attempt is made to answer several research questions after addressing the Hypothesis.

Experience based activities can generate interest in children for developing conceptual understanding.

Research Questions:

- Will attending experiential learning sessions enable children from municipal schools to **develop cognitive and metacognitive strategies** to link experience to formal school problems?
- Would children attending municipal schools **be motivated to attend** formal school after attending out of school (Saturday school) experiential sessions?

Sub questions:

- Would children attending municipal schools be motivated to attend formal school after attending out of school (Saturday school) experiential sessions?
- Should the curriculum facilitate experience-based pedagogy inclusive of life experience-art-craft, linked to academics with mediation, to be effective with children from an economically underprivileged background?

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3.4 Framework and Design of research study:

Conceptual and theoretical framework is built on the Hypothesis. To aid the development of a framework of Inquiry, Research problems are listed along with the probable implications that need to be addressed.

The concept of experience-based activities to be administered will be the basis of the conceptual inquiry.

The theoretical framework rests on the experiential learning theory and mediated learning theory.

The data collection and validation is based on 'Action research-classroom research' (Cobb, 2010) and 'design research' (Krippendorff, 2007).

.The table3.4 is the framework to develop the basis of the research and interpret from the observed outcomes.

The theories for classroom instruction and the design of intermediaries would be based on Experiential Learning Theory (ELT) within the purview of ELT. Mediated Learning theory and would form the basis on which the mode of classroom communication and communication amongst the groups would be. In the study the students need to be graded. To grade the students in a class room, the Van Hieli system of geometric understanding is revisited to attempt and develop a unique grading system would be attempted as the current grading system does not address the misconceptions.

The research focusses on inquiring if similarities in the misconceptions in mathematics existed among different groups of people living in different geographic areas of India. Considering the endeavour to decode learning among children, it is essential to determine learning in people who have attended formal school, the people and children in society. The research is planned in stages. This research study proposes to correlate the following by interpretation.

- socio-economic factors,
- collaborative learning and
- economic factors

These factors are at the start of the research and assumed to be the cause of school children internalising misconceptions. These factors also determine the modality in which they learn. In order to interpret people and their understanding of mathematical concepts, throughout the study, the topic and the questions were not changed.

The questions asked to all subjects in the research on Mathematical concepts are proposed to be the same irrespective of the subjects of varied age and diverse demographics. The acquired knowledge would be examined only on one topic and would be constant across all subjects. The questions planned were centred on the social and economic factors that influenced the groups. Unplanned Questions (Paul Cobb and other) had to be asked in order to have a deeper understanding of the knowledge of the 'subjects' (people in the groups) on area and perimeter of a rectangle and its pre-requisites.

School dropout rate amongst the marginalised section of society is recorded to be the highest and is increasing according to the Government Census and therefore this section of society is chosen for observation. All Groups studied in the research, are from the marginalised section (lower Socio-Economic stratum) of the society.

The framework in this research would create uniformity in testing and understanding the 'subjects'. The framework would help decode how they learn 'with understanding'. The modes they employ to understand a topic would be easily identifiable.

Prior to the study, it is important to understand the following:

- Modality of learning amongst School Children by decoding learning and the factors affecting the learning
- Factors affecting Conceptual understanding[12] amongst schoolchildren to ascertain if the factors are a national phenomenon.
- Other factors affecting conceptual understanding among schoolchildren.

Use of Action Research in this study (Paul Cobb and others) has established how macro-socio-culture has an effect on mathematics learning. The classroom observation used by Paul Cobb and others, is used in the current inquiry as a mode of understanding how children grasp concepts.

This method uses planned questions in the first phase. As the children answer the questions, the answers are studied by the researcher. If the answers given are different

[12] The school dropout rate in India is a national issue, the teachers from three municipal schools were of the opinion that students "don't understand" and "don't study" and they drop out of school due to their inability to cope with "studies". Government provides subsidies to students from the lower economic strata of the society. The preliminary interaction with students gave pointers that students found mathematics "tough", "teachers did not teach well", "tuition teachers had too many students".

from the expected answers, the children are asked to explain their answers and their responses are studied.

The responses and reasons given by children for the unusual answers is important and is to be understood as they hold the key to the misconceptions of a learner. Through the class room session or the individual sessions, more questions are posed. The questions sometimes fall out of the purview of the standard planned questions.

While studying the problems encountered by children in School, it is observed that quantitative analysis would not further lead to the understanding of the phenomenon of why and how children study and understand concepts.

The framework gives an outline within which the research study must function. The framework enables the design of elaborate plans to study the groups and the area of enquiry is finalised. Since the Pre-test towards Hypothesis building was based on Area and Perimeter of a rectangle, the research proposes that this topic of inquiry would be common to all subjects.

3.5. Objectives of the stages of the Research Design:

Stage I- Initial Study: The objective of the initial inquiry is to find out if people have internalised misconceptions. The research would be carried on to the next stage based on the indicators obtained in the initial study. This initial study was conducted on random subjects (samples). The groups in the initial study would include school dropouts, domestic help, children of the domestic help, teachers, people on the street. This initial inquiry would determine the range of people who probably have internalised misconceptions. Range of subjects would vary; with people who have attended a formal school and people who have not attended formal school.

The subjects were observed randomly: (randomised sample selection). This kind of selection enables researchers to find out if there is an occurrence of a phenomenon.

School dropouts and children of lower economic stratum: The objective of this study is to find out if/how school dropouts have internalised misconceptions and determine if and how they apply conceptual knowledge acquired from formal school to real life situations. The study documents the response of the children when attempting to answer questions on Area and Perimeter of a Rectangle.

Observing Teachers: Teachers from Music school, Steiner school, SSC Board School and KV (CBSE) are observed as a part of the research. The objective of observing teachers

is a part of classroom design study to find out the effectiveness of curricular content delivery.

People who have attended formal school: Randomised samples were quizzed on the topic of Area and Perimeter of a rectangle. The objective of this study is to determine if people who have attended formal school internalise misconceptions and carry these misconceptions and harbour them into adulthood.

Stage II- Intermediate Study based on Phenomenography: Based on the indicators obtained in the above study, the objective of this second stage of research, is to inquire if the phenomenon observed locally is a national phenomenon. To determine if people in other geographic areas harbour similar or the same misconceptions. It was also important to establish if the section of people from marginalised group, had any influence on their children's choice/education. Therefore, the study was conducted on groups of people from various geographic areas of the country.

Groups of people (Farmers, vegetable vendors, shopkeepers, bamboo workers, migrant workers) professing different professions are observed while solving problems related to Area and Perimeter of a rectangle.

Parental aspirations amongst them would be documented. Several small groups of people

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The focus is on Using Experience based Pedagogy for students to achieve conceptual understanding and develop metacognitive abilities. Table 3.3.1 below would direct the research towards the validation of the hypothesis and building of hypothesis by answering the research questions.

The NCERT in an attempt to increase the efficacy of teacher teaching, revises the curriculum as required and regularly, text books are revised regularly to incorporate local examples that most children can relate to. They organise training camps for school teachers. Teacher training is studied by attending training of music teachers by trinity school of music with Mili Mehta Music Foundation, Poushya (waldorf school), secondaray data of KV. school teachers' workshop and Balwadi teacher training camp; but this is out of the scope of this work. Hence will not be reported in the study.

Sunanda Chopra in her book has essays on educationists and their philosophies on education. She clearly categorises the philosophies the pros and cons of systems. In the book Philosophical and Sociological foundations of education. (2014). She designs training material and has experience working with NGO's. she is well aware of the problems in the system. M N Srinivas has written several books on caste and social changes. In the book Social change in Modern India (2016) he has documented the casts population page 104.

from different parts of the country were proposed to be observed during the time they engaged in their profession. Their demographic details would be recorded. The members of the groups to be observed, would be predominantly landowners.

The marginalised group of people who would be subjects of interest to this research study are from the scheduled caste and scheduled tribe. In the past, they have been 'oppressed' and at present, they enjoy privileges bestowed by the Constitution.

Questionnaires that would be administered to this group would inquire about people's aspiration, their views on education, how they educate their children, their personal knowledge, skill acquisition and how they solve problems. This inquiry would cover groups belonging to various pockets from North to South of the country.

This section of society was proposed to be observed, as their children attend school in state run schools and the dropout rates in state run schools is increasing every year according to the national census. These randomised groups of people across the country were chosen to be studied, as they represent a group within the purview of phenomenography.

Proposing the study of people in pockets across the country: Subjects would be mapped according to their geographic area. The phenomenon occurring in groups of a similar stratum of society irrespective of the geographic location would be mapped. Parental expectation for mode of educating their ward and their reaction to experience based activities was proposed to be documented. The study would be then focussed on one specific group in Maharashtra.

Fig 3.1.a

After the inquiry, the data was scrutinised to check if there is any commonality between the responses of subjects. Ference Marton[2] had documented studies of learning based on Phenomenography in 2014. My research is based on the study of phenomenography as mentioned by Ference Marton. Prior to the research, the scheduled tribe of Karnataka called 'Medar' who have migrated to Mumbai, were observed over 7 years. They earn their livelihood by working with bamboo. Domestic help in Mumbai are proposed to be studied. They attend household work in middle, upper middle class and affluent families and are influenced by what they see in their work environment. The objective of this study would give an indicator if there are parental influences on the transfer of knowledge to their children

which in turn would create misconceptions amongst children or if there are other factors from their work environment that affect their judgements with regards to educating their wards.

The domestic help would be observed in depth and their responses are documented while attempting to solve the questions on Area and perimeter of a rectangle in addition to the topics of ratio & proportion, and simple interest. Children of domestic help would be observed while solving the problem of Area and Perimeter of a rectangle.

If the groups studied in the research harbour misconceptions and similar aspirations, then their responses would validate that the occurrence of a phenomenon observed locally exists in other regions of the country and hence validates the methodology. ***It is important to find out how children learn concepts and how misconceptions manifest in them lifelong.***

It is important to find out if there is any effect of socio-cultural and economic conditions or any other dominating factors of the parents influencing learning.

Stage III- Final focussed studies on specific subjects: Study would be narrowed down to twenty schoolchildren in an out of school setting. Children from three schools that would be chosen, would be observed in detail to understand their conceptual understanding of Area and Perimeter of a rectangle. The out of school observation would be based on ELT. Finally, a few underperformers would be studied in depth to understand how they learn. This concludes the study (One municipal school where the study concludes).

The stage III study is proposed based on the assumption that children in the pre-hypothesis study exhibited internalised misconceptions.

The results would be verified by observing other children attending session in an out of school setting. The result obtained would be co-related to the groups in the initial studies to determine the extent of misconceptions amongst them. Focussed study would determine the mode of learning among children who have internalised misconceptions.

To study the mode of learning, it is proposed and planned that individual students would be tested and would be shadowed. Questions asked are planned but for personalised inquiry the questions are not planned; however, the questions would be centred on the topic of area and perimeter of a rectangle. Based on the action and response of the students the questions would

be framed instantaneously. This proposed research design is expected to yield rich data on the meaning of actions and how children learn.

In addition to the hypothesis, research would inquire into the 'meaning of education' to the subjects of the similar socio-economic stratum of the society. The research also aims to inquire into the aspect of how children in this stratum learn. This would clearly indicate the process of learning and harbouring misconceptions. Irrespective of the geographic region, the factors were constant.

It is proposed that some factors would be constant throughout the study. The factors which are constant throughout the study.

- Topic of study (area and perimeter of a rectangle- questions were designed and same questions were asked throughout the study)
- Social and economic status of the subjects

Keeping the factors constant throughout the study helps in structuring the study and giving clarity in the research. The research initially would be exploratory in nature, then Action Research based and finally interpretative. In the action research- class room study, it is planned that the questions posed would be initially planned, in a progressive manner, to tackle concepts, but if the students respond in an unpredictable manner, new questions would be asked in order to probe the understanding and learning in students.

Proposed line of questioning the subjects: It is evident that data would be collected from various subjects. The data is collected to find out the depth of knowledge each subject has. If the subject is able to respond effectively, only then the degree of difficulty of the problem would be increased. Ineffective response is probed. The relationship between the misconception and the understanding is proposed to be established with data collection and interpretation. Intermediaries would be designed according to the tenets of Design Research, and then tried and tested to probe learning with understanding. The test is proposed to be repeated after a few months to find out the effectiveness of the intermediaries.

The limitations of the school, teachers, staff and the infrastructure are well documented by the Department of Education of Maharashtra. To teach up to grade ten, a teacher needs to be qualified up to grade twelve or higher. They then undergo a diploma in teacher training offered by the government. Since these limitations are known, the focus is to find out how children learn if they are introduced to experiential learning. The assumption is that designing experiential activities for children and connecting these activities to their

real life would give them a better conceptual understanding of the domain that is chosen to be studied.

To conclude the study is proposed to be conducted in three stages the initial, intermediate and final studies and their objectives are as follows.

1) **Stage I: The Initial Study:** Built upon the premise that misconceptions in mathematics exists among people as they internalise them due to certain factors. The factors causing the misconceptions need to be documented to decode the mode of learning.
2) **Stage II: The Intermediate Study**: it is important to inquire if the phenomenon observed locally is a national phenomenon; if people in other geographic areas exhibit the similar or same misconceptions. Phenomenography was used to inquire about people's aspiration, their views on education, how they educate their children, their personal knowledge, skill acquisition and how they solve problems. Ference Marton[13] who had documented studies of learning based on Phenomenography in 2014 bases the mode of conducting this research on the study**.** The phenomenon occurring in groups from similar strata of society irrespective of the geographic location, is mapped. Parental expectation for the mode of educating their ward and reaction to experience based activities was documented.
3) **Stage III: The Final focussed studies:** The broad aspect of the study is proposed to be narrowed down to focus on specific students representing the groups that were observed in the initial study. The modality of conducting the focussed studies is proposed as follows:

    (a) Study would be narrowed down to a group of schoolchildren in an out of school setting. Children from three schools would be studied on the conceptual understanding of Area and Perimeter of a rectangle.
    (b) Three students from the out of school settings would be observed in their school settings and studied in depth in their school setting by shadowing. This would conclude the study (The study would conclude in one municipal school).
    (c) The results would be verified by observing other children attending session in an out of school setting. This result obtained would be co-related to the groups

[13] Ference Martons study on the 'necessary conditions of learning is based on the variation theory to validate Phenomenography as a methodology to research.

in the initial studies to find out the mode of learning among children who have internalised misconceptions.

In the school chosen, the teachers were happy to co-operate as they could rest for a few months when the researchers were taking the class with the help of another teacher. They were happy to use the intermediaries as it was easy to explain concepts. In this study, (Lave and Wagner[14]) community learning is not considered, as the focus was on the school setting and what they learnt outside of home and community. This research will observe the aspirations of society if any. The research aims at finding out if children are being schooled and the type of schools they attend. The pattern of learning would be observed to see if the factors/influences on learning in children. This study is proposed to be conducted during a personal interview with the 'subjects'. Chapter IV will inquire into the initial and intermediate studies.

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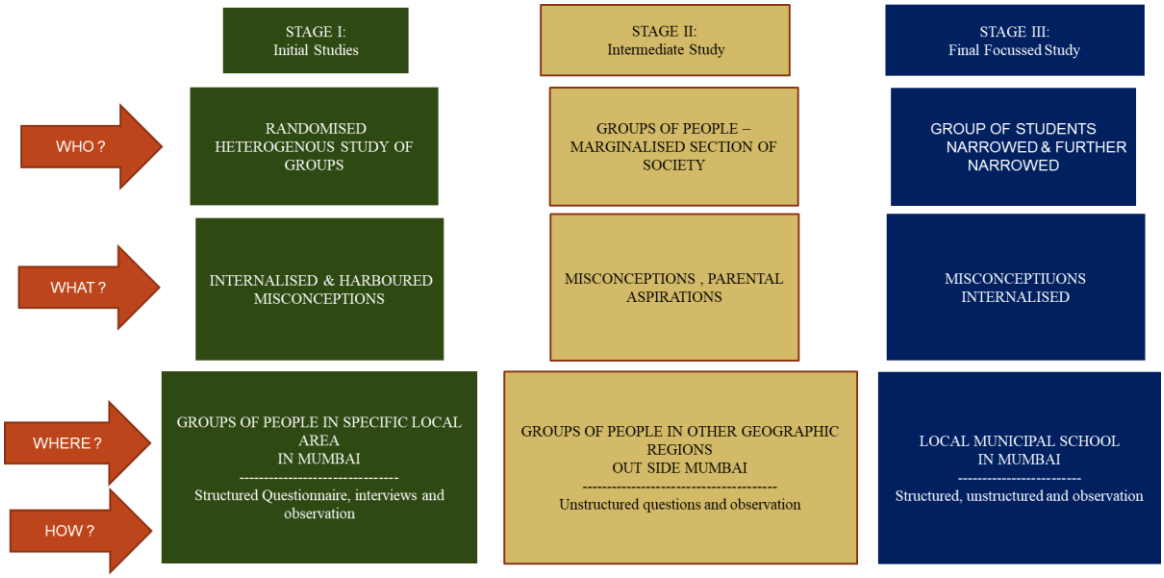
[14] Lave, Jean, and Etienne Wenger. 1991. *Situated Learning: Legitimate Peripheral Participation.* Cambridge: Cambridge University Press. pp. 33, 29, 40. Talks of learning beyond the classroom in a socio-cultural context. How knowledge is transferred in society.

Critical pedagogy (or ideology critique) goes hand in hand with Action research, and without a constructive criticism of the present practices it is not possible to improve for the future. In the world of education Haberman's stages are paralleled by Smyth(Smyth,1989 as in Cohen, 2011) who, too, denotes a four-stage process: description(what am I doing?); information(what does it mean?); confrontation(how did I come to be like this?); and reconstruction(how might I do things differently?). It can be seen that ideology critique has both a reflective, theoretical and a practical side to it. Without reflection it is hollow and without practice it is empty. Teachers often feel threatened by 'theory' [Looking 'through the eyes' of practicing teachers,]. Theory is something they cannot apply or use in relation to their practice. ***First****, teachers feel 'theory' is threatening because theory generated by a group of "outsiders" claiming to be experts at generating valid knowledge about educational practices. To bow to a 'theory' is to deny the validity of one's own experience-based professional craft knowledge****. Second,*** *theory is most commonly 'generalisations of teacher's practices'. Generalisation constitutes the denial of the individual practitioners' every day.* ***Third,*** *feelings of threat are further enhanced by the researcher's employment of models of practice derived from some ideal of society, like social inequalities and injustices, fostering narrow and limited conceptions of human potentials and abilities. In order to answer the research questions, the methodology had to involve gathering 'real' data from actual practice of researcher. Further, it involved developing, implementing, monitoring, reviewing and intervention (cf Newby, 2010, as in Cohen, 2011). Another consideration for choice of methodology was that the intervention had to be applicable in educational research. Considering the above, the researcher chooses action research, as the overarching methodology. Action research starts with small cycles of planning, acting, observing and reflecting which can help define issues, ideas and assumptions more clearly (Cohen, 2011). The author is in a position to implement these cycles in pedagogy. It can be further extrapolated to 'gradually include more of those involved and affected by the practices in question' (Cohen, 2011). All educators do some form of action research in the regular course of their teaching, but the critical point is the rigour with which one applies oneself. "Action research involves keeping a personal journal in which we record our progress and our reflections about two parallel sets of learnings: our learnings about the practices that we are studying and our learnings about the process (the practice) of studying them (Cohen 2011)".*

3.6 Summary of the research design



The summary of research concludes the chapter III.

Chapter IV: Initial and Intermediate Studies

This chapter deals in depth with Stage I and Stage II of the research. This chapter describes the experiments conducted on the basis of the theoretical and conceptual framework. This chapter introduces the frame work of inquiry. The Hypothesis developed is tested; the Questionnaire is designed based on the initial hypothesis.

Groups (subjects) are studied in detail and the expected outcome and the actual outcome of the interview are recorded. The rationale behind the structure of the study is that the pre-hypothesis testing indicates that students have internalised misconceptions. The internalising of misconceptions is a phenomenon observed in Stage I of the research. It was decided to further extend the study to see if the phenomenon existed among the marginalised sections of society across the country.

This extended study of Stage I paved the way to develop Stage II which provided indicators to the process of learning. Stage I and Stage II in turn paved the way to Stage III of the research which finally assisted in decoding learning in individual students by determining the modality of learning.

4.0 Conceptual Framework: Examining ELT in school:

It was important to examine the Experiential Learning activities conducted by CBSE schools. This study to observe students' understanding of area and Perimeter of a Rectangle was initially conducted with class 9 students. An experience-based activity was conducted in school for these students as a part of introducing experience-based pedagogy[15] in schools. The experiential activity was conducted in a journal. Following this, a student and his journal was examined. This student was a high achiever only in mathematics. He did not like studying other subjects and would attempt all his exams strictly following class instructions. He did not study 'out of

[15] Three students of Waldorf school were examined in a previous study. They were quizzed about area and perimeter of a rectangle. They had strong misconceptions about the interdependence of area and perimeter of the rectangle. They were clear that area is the property of an object and that spherical objects have a curved surface area. As a part of their syllabus they were physically shown a field and the area of the field is explained to students. Blocks of wood were given to the students and they were asked about the area and perimeter of the rectangle. This study commenced before the research took shape.

school'. After examining the response to the activity, there was a necessity to design intermediaries for communicating the concept of the Area and Perimeter of a Rectangle.

After studying the journal, the student was examined by questioning him individually in an out of the school environment. This gave an idea if he used the theoretical mathematics and applied it to real life problem solving.

Prior to examining the student, this researcher studied the curriculum and syllabus of the CBSE board, and interacted with students. She then created a task. The concept of mathematics Practical/Journal introduced by NCERT in the year 2010, in a bid to introduce experiential learning in mathematical education, was implemented in CBSE schools throughout the nation since Class 9 students of SSC board don't have this math practical work, they were specially chosen for the study to study the effect of activities based on Experiential Learning Theory.

Curriculum of class 9 Mathematics (CBSE-board) included the following lessons.

Lesson 1	Number System
Lesson 2	Polynomials
Lesson 3	Coordinate Geometry
Lesson 4	Linear Equation in Two Variables
Lesson 5	Introduction to Euclid's Geometry
Lesson 6	Lines and Angles
Lesson 7	Triangles

Student of class 9 responding to Mathematics-practical journal: Class Nine students were examined to find out if they harboured misconceptions built on the learnings from earlier classes. To establish the type of learning in students and the effect of experience-based activities in school, the experience-based activities conducted in school were examined thoroughly.

Topics that have an experiential activity were dealt with and the student was expected to maintain a written journal. The following topics (questions) were covered in the Journal.

1) Finding the value of π practically.
2) Proving that $(a+b+c)^2=a^2+b^2+c^2+2ab+2bc+2ac$ given that a=2, b=3, c=4
3) Proving the mid-point theorem:
4) Proving that "If there are 3 parallel lines equidistant from each other, they will make equal intercepts of a transversal".

Examining the CBSE class 9 Mathematics 'Practical' journal: After discussing the journal activity of CBSE board students an experiment was conducted on **a CBSE student** and **three SSC board students**. All the students who participated in the study were 14 years of age. Students of CBSE schools were already exposed to Math activities in school and the SSC board students were not exposed to the activities. The students of CBSE had studied the circle and its properties as a part of geometry. Therefore, the researcher quizzed them on the circle. The questions on circle were taken up in this case to inquire with the misconception of the interdependency of Area and Perimeter.

In this case, the area and perimeter of the rectangle were not covered in their journal and the questions on the topic covered in the journal were asked. The properties of the rectangle were taken up at a later stage.

One of the activities in the Math practical journal was taken up to see the extent of understanding in students. The aim of the observation was to find out if the experience-based pedagogy was helping students understand the concept more concretely than theoretical approach to teaching.

1) **To measure the value of π.** (Activity done in school by the student in the journal)

   Question: Prove that the value of π is 3.14.

   Procedure given by the teacher:

   - Cut 3 circles of any diameter (assume any diameter)
   - Stick the circles in the journal
   - Take a string and measure the circumference of each circle.
   - Note down the circumference of each circle by measuring with the string and tabulate the diameter and circumference.
   - Stick the string around the circumference of the circle. (to show that the string was used in measuring the circumference).
   - Using the measured circumference of the circle and its diameter was forcefully assumed by the student to prove that $\pi = 3.14$.

The activity as done by the student using his thought process and logic: (fig 4.2.4.a shows a solution given by the student)

- Assumed the diameter of circle 1 to be 7Cms

- Assumed the diameter of circle 2 to be 3.5Cms
- Measured the circumference of circle1 and circle2 using a string
- Calculated the value of π from the circumference obtained, using the formula circumference. c= 2πr

Following this the boy was invited to participate in an experiment to observe his response to specially designed experiential activities.

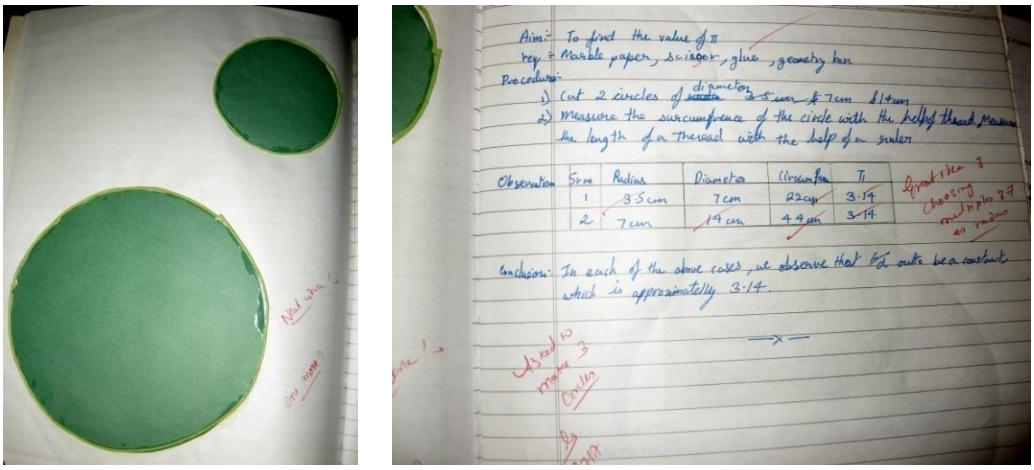


Fig 4.2.4.a: is the solution given by the student in the Math practical Journal

Other children in the class assumed the diameter as whole numbers 5, 6, 7 without reasoning. They could not obtain the value of π to be 3.14 easily because the circumference had to be approximated to the nearest decimal. Totally there were 60 students examined from one section of Class 9 for the Math practical journal.

Problems faced by other students of the same class (CBSE) in the activity of the Journal:

- They were unable to practically compute and determine the value of π as 3.14. The answer expected by the teacher was 3.14.
- Exact length of (circumference of the circle) the string used could not be measured. Length of the string had to be approximated.

Response of the Selected Student to the activity in the practical journal:

- The boy was too bored to do the third circle.

- He said ‘what difference does it make to find out the value of π since it will always be 22/7 but not 3.14 exact’. It is only the approximate value to the nearest decimal. No one can prove the exact value; not even the teacher.
- A girl student examined was unhappy in finding or proving an already known concept.
- Other children in his class, who could not do this activity, felt it was a ‘stupid’ exercise. since they already knew the value of π.

Response to experiential activities by the CBSE student and the three SSC board students: Activities were designed to study the response of students based on Experiential Learning Theory. Four children were examined on the concepts of visualising Area and Perimeter in real life. At this point it was important to find out if 13-year-old children could visualise. There is a permanent circular sitting area in the open. All four children were asked to find out the diameter of the circular arrangement. The student from the CBSE school refused to find the circumference as he was ‘bored’. He said it is possible to count the steps and then multiply by the length of his foot-wear. The students of the SSC board teamed up and used a piece of discarded string that was about a foot long and went around the sitting area tired to measure circumference by adding several smaller lengths (of the string). After sometime they got tired and said they would not do this activity.

Inference from the study of students:

Their teacher did not explain the intent of the exercise given to the students in school. In the study which was conducted as an experiment the students were least interested in performing the activity. The students from SSC board took out their mathematics texts and wanted this researcher to conduct private tutoring classes. But they refused other activities claiming them to be a ‘waste of time’

This study is a precursor to creating activities that are conducive to learning.

4.1 Framework of inquiry (Research Framework):

The framework of inquiry is in three stages (1) plan (2) act and (3) obtain results.

From the feedback obtained from the three stages, modifications can be done to the previous stage to validate the study. Fig 4.0 gives the overview of the framework of inquiry. At every stage of the study the framework of inquiry is the same.

The research framework presents an in-depth insight into the aspects of the inquiry in the research and the clarity of the overall journey

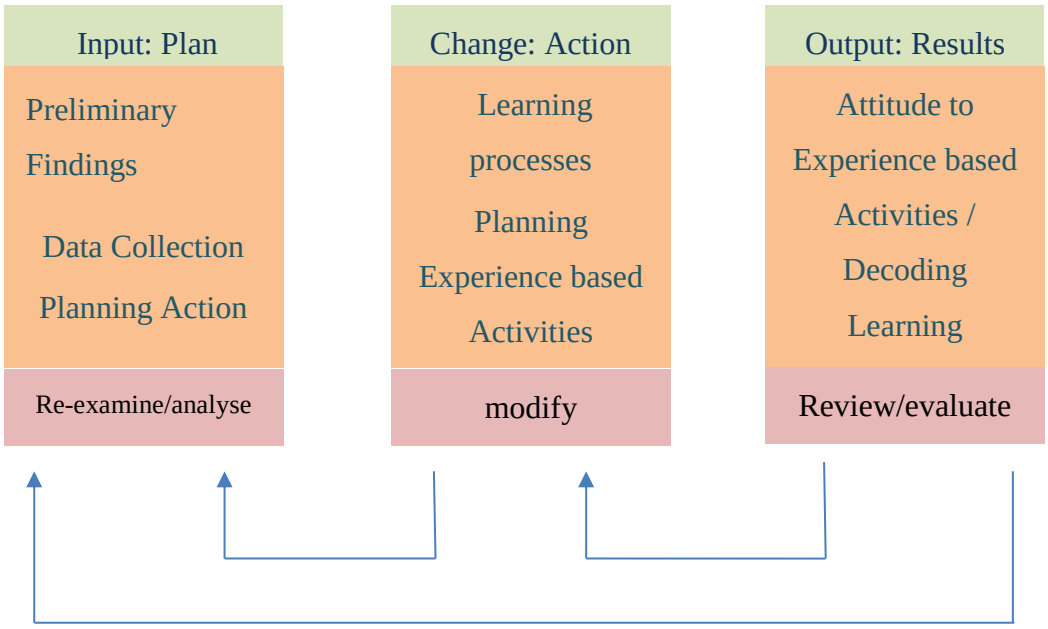


fig 4.0: overview of the framework of inquiry

4.2-Initial Study: Stage-I

Randomised subjects (individuals) were examined in the initial study. Their responses were interpreted and documented. Single instances of people were also studied. This study is essential as the research study is built on the premise that people who have attended and are attending formal school with no exposure to experiential learning have internalised misconceptions. This premise has to be verified. The questions were planned and subjects were randomly chosen for the study, even single subject who were quizzed in-depth were critical to the research inquiry.

Stage I: random samples outside MHCET exam centre

Unstructured interviews on professionals and common people were conducted by administering a short quiz on the Area and Perimeter of a Rectangle. This quiz consisted of questions on squares and square roots, shapes and breaking of shapes to use mathematical operators on the area and perimeter of a rectangle. The quiz also consisted of determining if they

believe that the area and perimeter of a rectangle are interdependent.

Professionals and undergraduate students who were examined had harboured the misconceptions of area and perimeter of a rectangle. They were certain that area and perimeter of a rectangle are interdependent. Postgraduate MBA students were confused on the formula to compute area and perimeter of the rectangle. They however could visualise the area of the floor in terms of square feet. The undergraduate engineering students had harboured the misconception of the interdependency of the area and perimeter of the rectangle. They were not able to visualise the area of the floor in terms of square feet or any other system of measurement. This extensive study on random samples[16] determined that even academically qualified individuals harbour misconceptions on the topic learnt in school.

All of the subjects studied informed that they were not taught to use 'classroom learning' to unfamiliar problem-solving situations. The 'teaching to think' process was not developed in their schooling. It is clear that metacognitive abilities of students in lower classes is not developed due to spiralling curriculum (Bruner et al-) and they had no time to reflect on the concepts. According to the response of the subjects (randomised) it is established that the focus of the teacher was on teaching 'problem solving' instead of developing the concepts of solving problems.

4.3- Need to Study Local Groups:

The need to study local Groups and individuals was to investigate the probability of a phenomenon occurring. Subsequent to this study, if there is a phenomenon occurring among the local groups and individuals, then groups from other geographic areas were studied based on phenomenography.

The Study was conducted by questioning all individuals in their work environment. The questions asked were 'laddered' using an initial question and then all subsequent questions were asked depending on the answer to the previous question. There was a conscious effort to stay in the domain of the topics asked. To keep the subject calm and spontaneous the questions were

[16] Random samples of 150 in number were questioned.

personal and their response was recorded. The spontaneous questions[17] were asked to camouflage the questions of mathematics.

Questions were designed to test the leaning and the understanding of concepts in the individuals of specific communities of practice

1) Questions related to their work/profession.
2) Questions related to Area and Perimeter of a rectangle.
3) Aspirations for their children and themselves.

During the interaction with people in the communities of practice (bamboo craft-group/workers), some of the questions were asked in the form of a dialogue to which the people responded spontaneously. The mode of questioning directly was tried with one individual from the group of farmers. This individual had attended formal school up to Class 8. He saw numbers and a questionnaire and refused to answer saying he had forgotten school mathematics. Therefore, the line of direct questioning was avoided where the subjects had dropped out of school or were unschooled or had a fear of mathematics. The valuable data obtained from the communities was documented.

Following subjects and group of subjects were examined in this study.

- 4.3.1a Shopkeepers and their Assistants
- 4.3.1b Vegetable vendor
- 4.3.2 Maids (domestic helps)
- 4.3.3a Educated maid
- 4.3.3b 100 maids who wanted to start a SHG.
- 4.3.4 Students

4.3.1a-Shopkeepers their Assistants and sales person: Subjects who were working in a business environment were observed when they were serving the customer. School dropouts working as salespersons in grocery shops were observed to see how they perform mathematical computation in day-to-day work and how they respond in unusual situations. Four grocery shops namely Shop 1, Shop 2, Shop 3 and Shop 4 were observed during their working hours.

[17] Camouflaging questions would not create fear or pressure when answering questions.

The sales persons were observed to see if they applied conceptual understanding in computation. A vegetable vendor with no formal education was observed when she sold vegetables. This subject was studied to find how she used money to trade and compute numeracy ratio and proportions. All subjects who co-operated to answer were quizzed on the conceptual understanding of area and perimeter of a rectangle.

Out of the four shops visited and observed during business hours three were selling grocery and one was selling cake mixes and ingredients.

Criteria for the questions asked to shop keepers and their assistants: An odd quantity of commodity was asked to be purchased to check if the sales man could handle this situation of weighing and computing. The quantity asked for purchase was 260 gms. Usually people only take a quarter of a kilogram but never ask for 260 gms. It was important to examine the response of a person to see if he extends the problem solving by extending the principles learnt in school and the reaction to a different and unusual situation encountered while on job. The questions also checked the usual way of computing. (i.e. If they use school mathematics or on-job practices) by examining how they calculate price for standard quantities that they usually calculate. In order to find out the concept of area, questions were asked on area. And their observation on formal education was also asked.

Observation of grocery shop (Shop1). The subjects did not want to be videotaped. The researcher assumed the role of a customer and went to the shop selling ingredients for baking a cake. The Owner[18] of the shop was a school drop out of the secondary school. He wanted to earn money for a living and started the business. He said that the education he had, is sufficient to run a successful business. He did not like school but liked mathematics. He was not willing to talk much as there were other customers in the shop. He said 'The school should teach content meant only to make money rest of the content is irrelevant'. To this subject, mathematics encompassed simple computation and use of calculator as a tool was a 'proud' moment.

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[18] *Local Baniyas are 'vaishyas' from Rajasthan. A caste in the Hindu religion. They are very good in computing and have grocery shops and other general stores. They compute to the last decimal and without calculator. Some of the shopkeepers were also quizzed at other stationary shops later after this study was done. It was found that with the invention of the calculator, they have refrained from using traditional counting and adapt by using formulae and calculator. The salespersons employed by the local stationary shop owner are from their own community. The other shop owners had employed school dropouts from the vicinity of the shop. The school dropouts belong to scheduled caste and aspire to be very successful businesspersons someday.*

The researcher asked for 105 Grams of flour. The shopkeeper decided not to sell flour. The shopkeeper wanted to see the recipe. He reiterated that there was no customer purchasing odd quantity of flour. It was observed that other customers in the shop were purchasing 1 Kg or more than 1 kg. There were no purchases below 1 Kg.

Observation of Sales persons and owners of Grocery shops (shop2, shop3 and shop4).

The questions asked to the grocery shop salespersons were the same. Customers who come to buy grocery do not ask for 260 Grams and quantities of rice sold to customers were 250Grams or quarter kg. This was the response of the salesman in the shop. The researcher decided to assume the role of customer and decided to purchase 260 grams of rice priced at Rupees 24 a kilogram, from the shop. This odd quantity was chosen, to check the response of the subjects and their math ability. (The researcher visited three shops. All shops had other Customers waiting for their turn. The shop keepers and their staff were a part of the randomised samples that were tested).

In Shop 2 and Shop 3 responses were the same as in Shop 1. The owners of grocery shop 2 and grocery shop 3 were migrants from Rajasthan. Sales persons employed were secondary school dropouts from Maharashtra. They weighed the exact amount of rice. All of them used a calculator and used the formula

x (rupees cost per Kilogram) X (quantity in grams). = 0.01 X 24 X 260 Grams.

= 6.24 Rupees.

He arrived at 6.24Rupees and rounded off to Rupees 7 instead of Rupees 6.50.

On further inquiry, it was found that shop owners have taught them the above formula. They could not explain why and how the formula came into being. When the price of 250Gms was asked they calculated by dividing the price of a Kilogram by four.

Cost of 250 grams = Price of one kilogram ÷ 4

= 24 ÷ 4

= 6 rupees.

There were no customers in the Shop 4 that this researcher visited. The salesperson in shop 4 was a 15-year-old and failed in his class tenth secondary school certificate (SSC) examination. He lives in a slum and wants an opportunity to study further and complete basic education. **He was working to meet the financial crisis at home.**

In this shop, this researcher asked for rice. He calculated correctly the price for the required quantity of rice. He did not use the calculator. Since he was calculating with ease, the researcher

asked him for 260 Gms of sugar at the rate of 38Rs per Kg. He weighed accurately on an electronic weighing scale. He calculated the price on a bill he arrived at Rs9.88 for 260 Gms. and approximated to 10. He was practicing the following calculations.

For 100 Gms, the cost is 3.8 Rupees (1/10 the cost of a Kilogram = 38 ÷ 10 = 3.8)

For 10 Gms the cost is 0.38 Rupees (1/10 the cost of 100 Grams = 3.8 ÷ 10 = 0.38)

For 250 Gms it will be one fourth the cost of a Kg. (38 ÷ 4 = 9.5).

Cost for 260Grams = cost of 250 Gms. + cost of 10 Grams (= 9.5+0.38 = 9.88 Rs)

He approximated 9.88 to Rupees 10.

The owners of Shop2, Shop3 and Shop 4 had enrolled their children in formal schools. They did not wish that their children learn with experiential pedagogy. They were of the opinion that on payment of school fee the services offered by the school should be a formal curriculum.

Table 4.3.1 in Appendix 1 gives the Summary of the responses given by salespersons and owners of shops.

Inference of the above study:

- Subjects saw the meaningfulness in terms of business transaction.
- They were using time judiciously, showing their capabilities to an educated and well-informed person (customer/researcher).
- Methods acquired 'On Job' seem to prevail in business and trade practices.
- The subjects -accepted the tool (calculator) and the method for complex Calculations.
- They were able to compute mentally and perform mathematical operations of division.
- Since many traders in India have different traditional practices of measurements, further investigations could reveal the conflicts between math principles learnt in school versus learning from practical contextual experiences.
- Subjects who attended formal school, could calculate by computing on a paper when the problems became complex to calculate mentally.
- Unschooled person was unable to solve problems, which he could not calculate mentally.
- One Subject used 'Tacit' knowledge where measuring and computing would have become meaningless transaction.
- Some used their own methods to apply their math knowledge in general problem-solving situations.

- In Organised sectors like shops, methods derived from trade practices seemed to override any possible individually derived or traditional methods.
- A wider investigation could reveal scope and limitations of individual mathematical innovations in organised versus unorganised sectors.
- Owners of the shop had enrolled their children in formal schools.

4.3.1.b. Vegetable vendor (unschooled):

A lady with no formal schooling who was selling vegetables, was observed. The vegetable vendor belonged to OBC (Other Backward Cast) community of Maharashtra. She believed in Lord Buddha.

Since she was observed on job the questions were different than which were planned. The questions were related to on job computation, Area and Perimeter of a Rectangle and her attitude towards formal schooling. Questions were asked to find out how she weighs and computes small and unusual quantities; to check how she calculated and the quantity of leafy vegetables she gave. To find out if she has the conceptual knowledge of Area and Perimeter of a Rectangle she was asked if saree has surface area when it is hung on a clothes line to dry, if vegetables stacked vertically have surface area. Her views on formal education were recorded.

She does not sell odd quantity of vegetables. This researcher asked for one fourth kilogram of carrots. She knew that one fourth kilogram is 250 grams. She was calculating the cost of 250 grams with ease. She was calculating with ease the cost for 100 grams and 50 grams of vegetables. She was constantly consulting a fellow fruit vendor to validate her calculation. He was helping her with complex calculations, confirming the amounts she calculated. Upon questioning him, he confirmed that he uses price for 100 grams of vegetables as a base to calculate for other quantities required by the customer.

The researcher posing as a customer asked the vegetable vendor for 5 grams of green chillies. She used a stone to weigh 5 grams of chillies and charged Rs, 2 randomly. She gave sprigs of leafy vegetables like coriander (Dhaniya) and curry leaves (Kadipatta) for one rupee each with no basis for calculation.

Several other vegetable and fruit vendors gave the similar reply as the vegetable vendor. They were farmers from the lower economic strata of the society from North India mainly Bihar. They believe only floor has area and fruits that are stacked vertically do not have area. The reason for their logic is that they occupy area of the footpath and the fruits are stacked vertically

and do not occupy (ground) area. Table 4.3.1.b in Appendix I tabulates the response of the vegetable vendor.

Inference from the above study of an unschooled vegetable vendor

- Pleasing customers was the meaning to her activity of selling vegetables.
- She has to device her own methods to compute costs and concludes by taking help of the fellow fruit vendor.
- She has to please customer.
- She has ability to develop tacit knowledge **from previous experience**
- She sells so that she **always profits from the sale** and the customer feels that she has not overcharged.
- Tacit knowledge of the colours.
- Only floor has area.
- The concept of area being that 'only floor has area'.
- This is because the cost of housing in city is not comparable to that in villages. and the meaning of losing floor area is significant.
- Advocates formal schooling.
- Her view on education was "Why should children do experiential activities? They have to study".

4.3.2-observing responses on topics of area and perimeter in Maids (Domestic Help):

The middle, upper middle class and the high societies all function normally because domestic help are hired to assist in daily chores. Maids/domestic helpers do not attend formal school. Their profession is not inherent to the community but adopted to supplement the income of the family. This new emerging community does not fall in the purview of the Communities of practice as classified by Lave and Wagner (Quoted on page 28-29 in this research document). The maids and their children are studied in detail[19]. The numbers of maids working in the city are not documented. They have no place or provision by the law to register them as workers. Wives of migrant workers are domestic helpers in metropolitan cities. They have children who

[19] *In this study in addition to questions on area and Perimeter of a rectangle, they were asked questions on several mathematical concepts and their views on schooling was documented and tabulated. From the data collected inferences were drawn to develop the intermediaries and the mode of communicating the topic.*

study in formal schools. It had to be established if they in any way influence learning in their children, or the education system prevalent in the school.

Study of maids is conducted in two parts:

4.3.3a In depth study of one educated domestic help. *(response in table 4.3.3.a appendix I)*This study is crucial to the research as the **domestic help**[20] are either school dropouts or unschooled. When an educated domestic help is chanced upon, it is important to see how she has understood concepts in school; to understand how she uses the acquired knowledge in real life situations; to inquire if she teaches her children at home and how she imparts knowledge to the children.

4.3.3b study of a group of domestic helps: Hundred domestic helps were interviewed to determine the extent of their conceptual knowledge and the pre-requisite to compute the area of a rectangle. Their aspirations for their children and their knowledge on Area and Perimeter of a rectangle were observed and recorded while talking to them. *(response in table 4.3.3.b)*

4.3.3.a In depth study of one educated domestic help:

It was important to observe and understand and document the acquired knowledge of the educated maid and the reasons for her dropping out of school. She was the only lady who successfully completed her 10^{th} standard exams in the community. The educated maid is formally schooled and it was important to inquire in depth about her applying the acquired knowledge in school to real life situations. As the research focuses on the conceptual understanding of the Area and Perimeter of a Rectangle, she is examined on the knowledge of Area and Perimeter of a Rectangle and applications of this topic. She does not directly use calculations at work but uses computation in her home to divide food among her children.

She had dropped out of school after passing the class 10 SSC board exams. She was aged 26 years and was very willing to participate in the experiment. She was married after she turned 18 and had no chance of pursuing further studies after marriage. She has been doing only household chores and this was an attempt to showcase her academic skills.

Criteria of the questionnaire posed to her: She was asked simple textual questions. The questions were centred around her home so that she could do justice to the answers. She was

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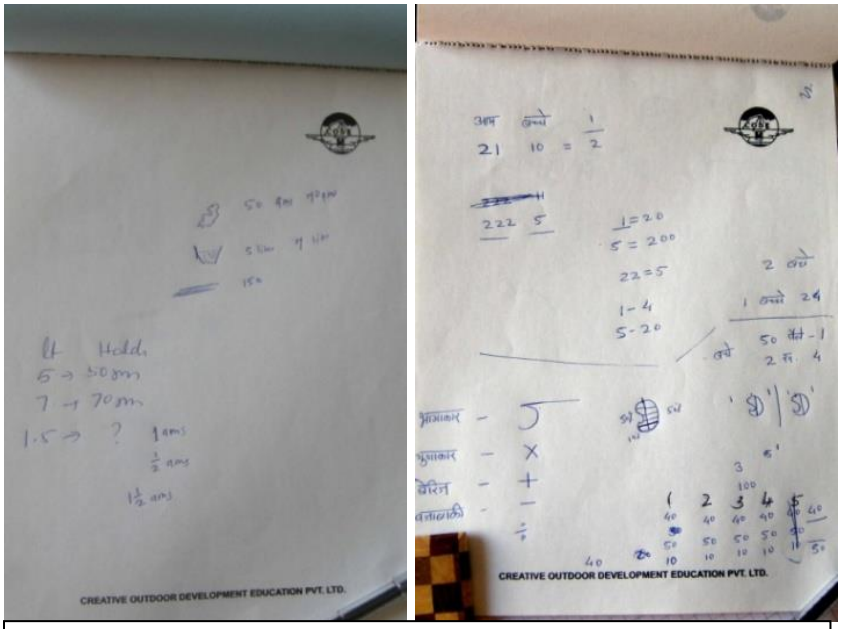
[20] *The domestic helps belonging to the marginalised section of the society. They revere Dr Ambedkar. They are very social and observe cultural events and functions. Buddha Poornima and Abedkar Jayanti are important festivals for the. Some of the domestic helps are marathas. They pray to Hindu Gods and Goddesses.*

asked direct textual problems initially to gauge her understanding. Problems on fractions were given to her to understand the concept of visualisation. The degree of difficulty was increased and her response was studied in detail. According to her response, unusual situations were created. The questions were staggered on the response the strategy would be the same. It was crucial that she should remember her previous response. This would prove that she had answered the question with intent. Using her children as her focus and food as an intermediary, she was asked questions on how to divide food amongst her children. The mode of questioning was personalised and dealt with familiar topics. Questions on ratio and proportions were also asked to check her response. This question is akin to the questions asked to adult subjects in stage II of this study. Questions on ratio and proportion were centred around kitchen activity of cooking, measuring and serving. The questions included solids and liquids. The questions on area and perimeter were centred on identifying objects that possess surface area and if there are objects that do not possess surface area. This was asked so that we could identify if she could understand scaling of area. She was asked to reason out her responses. Questions related to identification of square and rectangle were addressed to understand if she could relate to the properties of the shapes.

While interaction and videotaping the research session, it is observed that she could compute[21] with difficulty.

At one point in the session she felt her head spinning and momentarily forgot everything. She said this happened because of the fear of mathematics.

The questions asked to her and her responses were documented in a video and in person.



(Pictures show how the maid computed using drawings to help the process of computing.)

The questions and her responses can be found on page 196 in Appendix II.

[21] Operations on numbers is a pre-requisite to learning Area and perimeter of a rectangle.

When she was asked questions on fractions using mangoes as an intermediary, she drew mangoes and made cuts and figured out by trial and error method. Since she could not physically cut and observe she had to draw from imagination. She was drawing on the sheet to figure out how she could distribute equally.

In real life situations, problem solving becomes the main criteria. To physically cut one fifth (1/5) of 2 mangoes is unusual and complex.

Math manipulations made when 'difficult' / complex situations arise are observed during the study of people and students[22]. In study of the educated maid, (Fig 4.2.3.a) she drew mangoes and made marks to simulate cutting representing fractions.

She had earlier cut one mango into 5 parts by drawing but for two mangoes she had to again draw 2 mangoes and cut. She did not see the previous solution and deduce from it. In real life it is not very critical to divide mangoes equally among children.

Fig 4.2.3.a: respose of one maid using visuals to solve problem

The other task given to her was to find out how she responds to situations where the commodity is a liquid, as the previous task given was pertaining to weights and measures of solid goods (food stuff). This was to study her responses and document her understanding of concepts learnt in school, in a different situation.

This was an attempt to find out how she would mathematically solve if she would rely on any analogy to solve. This problem was another situation that was similar but perceived by the domestic help as complex as she found the problem addressed both solid (bamboo strips) and liquid (medium of dyeing) measures instead of solids.

Dyeing of bamboo strips is a task taken up by unschooled people. The person learning bamboo work need not necessarily be from the communities of practice. The task of using Dyeing Bamboo Strips was given to her.

Dyeing of bamboo strips with Haldi, requires water and Haldi (turmeric). This situation is akin to daily kitchen activity[23] familiar to the maid. It is not a complex procedure. The process involves boiling bamboo strips in a solution of Haldi. Haldi is weighed, required amount of

[22] Also observed among the shopkeepers and students observed in this research

[23] Haldi (turmeric) is used in cooking. Cooking involves liquids.

water is measured and a fixed number of bamboo strips are immersed in the solution. The process consists of weighing, measuring and counting physically

The Manual for Dyeing Bamboo Strips was given to the maid. Procedure given in the manual *50 Gms. Haldi to be dissolved in 5 litres of water.* The maid was then asked***:*** *How much Haldi is needed for 7 litres of water?*

She could not solve the problem involving ratio and proportion in calculating the required quantity of Haldi. To compute quantity of solid to be dissolved in the liquid, she tried using the rupee (tangible object of daily use which is familiar to her) as an analogy. She realised it was not yielding a solution and responded "It is water not mango" She was confused. The concepts of solid and liquid in a problem had caused the confusion.

After these unsuccessful attempts she was trying to recall concepts learnt in school. She tried drawing pictures to visualise adding Haldi in Water. Drawing was an aid to her to enable computing through visualisation.

Fear of mathematics caused her to develop a head ache. Therefore, after a gap of an hour questions on Area and perimeter of a rectangle were asked. She was offered beverage, and the questions were posed in an informal setting.

The second interview eliminated any direct questions and the use of pen and paper. Verbal questions were asked on Area and Perimeter of a Rectangle. For this purpose, a saree, which is also a rectangular object, was used. When asked if the saree had surface area, she said that a saree has surface area when folded and kept in the cupboard but that when drying it on a clothesline, it did not have surface area. According to her only an object on a horizontal plane has surface area. (Similar response was observed with other subjects also). Her responses are tabulated in table 4.2.3.a.

Since Cloth is measured in units of length (because the breadth is fixed by loom), she said saree has only length but no breadth. She also mentioned that the length of saree is 5 metres (single unit and not unit square). She deduced this concept from the analogy of land having area. She is aware that area (as a concept) cannot be measured with one unit.

Then she was given a tangram puzzle made of plastic and asked to make a square. She created a square with the pieces given.

After this a tangram made with cloth was given to her to make a square. She replicated the solution of the earlier exercise. She knew that for a square the length is equal to breadth

(identification of a square and knowledge of the properties of a square). She still laboured under the misconception that the same object if placed vertically did not have area.

When the cloth square was taped to a book, she said it had area. When the book was kept at 90 degrees to the horizontal plane, she realised that the area of the surface did not disappear but existed in a vertical plane. Thus, she realised that objects can have area in the vertical plane. She also concluded that area does not disappear.

Since she had young school going children, it was important to find out her views on education and the education system. She was of the opinion that her children should be formally educated. She believed that the incorporation of skills in the curriculum is acceptable if it was useful to help them earn and support family. However she advocated against experience based activities in formal classroom learning.

Table 4.3.3a in Appendix I gives the questions asked to the educated maid and her response to them. She commented that the questions asked were "hard" and it is not the way the school asks the questions.

In order to inquire about the living conditions, socio-economic status and lifestyle the researcher visited her house. This observation would give an indicator to the life that her children are exposed to. Visit to this maid created confidence amongst others living in the area and the researcher could gain entry into their houses. During this visit the researcher befriended other maids living in that neighbourhood and obtained permission to inquire about their personal knowledge.

The domestic helps interviewed, belonged to Other Backward Caste (OBC). They supplement their family income by working as domestic helpers. They are unable to complete tasks at their own home like cooking cleaning and filling up water by themselves. Their children assist them in the household chores. Their husbands are alcoholics. Some (90%) of the domestic helps have been tortured by their husband. They live in nuclear families as they have migrated to the state in search of job prospects.

They wish that their children were educated and could attend formal school.

4.3.3.b Observing the response of a hundred maids (Domestic helps) to real life problems:

On analysing the responses given by the educated maid, her personal knowledge was assessed. Thereafter the other members of the community were interviewed. They were living in small

houses, with just one room and kitchen. The toilet was common to several houses. They did domestic work for the affluent families. They spent over 3 hours in each house. House hold chores included sweeping the floor, swabbing the floor, cleaning vegetables, cutting vegetables, cleaning foot-wear, assisting children in the employer's house. They were paid very little money for domestic work.[24] They were constantly observing the children in the employer's household and often compared the children with their own children. This caused them to send their children to private tutors for instruction in addition to classroom instruction. This phenomenon caused them to seek alternative jobs to supplement the income of the family.

Local politicians wanted to help the ladies who work as maids, to set up a small business to supplement their family income. They invited the ladies (maids) to attend a party meet. They offered loans from bank and brought in an expert to address the issue. The researcher was permitted to attend and no photographs or video recording was permitted.

Hundred ladies working as domestic helps wanted to start a business to supplement their income. They wanted to make and sell cooked food items on a daily basis. They were offered loans by bank. The rate of interest was not disclosed. They all wanted to do this business[25] and thought cooking was an extension of their regular work as they cooked every day. They then were ready to take loans. When this researcher asked how they would estimate the quantity of ingredients in the food, they could not compute the quantity of ingredients they needed. It was observed they had difficulty in numeracy, ratio and proportion. They decided to take a course on how to bake a cake. This was encouraged by the people who suggested the scheme.

They did not agree to the idea of collaborative work by pooling resources. They were against the idea of forming Self Help Groups. They felt that some might have to over work and some might just enjoy the benefits of others hard work. They were interviewed individually. One person was formally schooled and passed class-X SSC board examination. The rest of them were unschooled. They aspired that their children have formal school education and they wanted them to have government jobs.

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[24] The website gives an idea of the salaries of the maids. Referred on 22-8-2016.https://qz.com/675217/the-shocking-way-india-is-underpaying-its-maids-nannies-and-cooks-in-six-charts.

[25] All hundred ladies wanted to make 'idli-dosa-chutney' then they started to argue and concluded that all cannot do the same product. Some argued that they could jointly do it. Some wanted to bake cake but they did not have the infrastructure and did not have the knowhow.

To examine their acquired knowledge, questions were asked to them and responses recorded. The questions were asked so as to understand if they had knowledge /skills of numeracy, as it is the prerequisite to the topic of area and perimeter. They have small houses; the area of the house is 150 square feet. It is assumed that they could visualise measurements pertaining to length and breadth of the room and therefore questions on measurements were asked (length of the string to hang wet/damp clothes). This would give an understanding about their acquired knowledge of lengths and measures.

It was essential to find out if they had any previous knowledge of area and perimeter of a rectangle; if they could visualise area of the floor. They clean floors. Since the carpet area is 150 square feet it was important to understand if they have any way of estimating the area of the floor by noting the time to clean floors (bigger area requires more time and smaller area requires less time. Knowledge of floor area would enable them to ask for appropriate salary while working as a domestic help in flats (some flats have more floor area than others).

It was also important to ask them questions on the system of measurements to find out if they had acquired any knowledge to measure area.

Questions on costing were asked to determine how they cost for household work.

The question on determining if saree had surface area was asked to find out if they harboured any misconception.

Questions were asked to determine if they have the knowledge that vertical surfaces have surface area. In the studies on random groups in chapter III it was established that the subjects interviewed believed that vertical surfaces did not have surface area. They believed that only floor or horizontal surfaces had surface area. Therefore, they were asked if their walls had surface area.

They had the belief that soft fabric had no area if hung vertically as it did not occupy space in the horizontal plane. This study is crucial as this is conducted in the vicinity of the subjects (children), observed in depth to understand why and how they learn and the reasons for drop outs in school. Their response to questions is in Table 4.3.3.b. in Appendix I

All questions asked to the group were questions similar to those asked to the maid who was schooled concerning division of food.

Questions were extended to liquids to understand their response. Since they were going to start a SHG to make food, it was important to know if they understood liquid measures and if they had any knowledge how to estimate quantities using ratio and proportion. All measures used

were tacit measures in their daily life. It was important to understand if they could quantify them.

It was important to understand if they could estimate and optimise the use of water. Questions were directed to issues related to the day-to-day activities as water supply is scarce in slums. In order to find out if they consciously use mathematical operators on liquid while filling and consumption of the scarce commodity (water).

Inferences from the study:

The table clearly indicates they have harboured misconceptions. They are not confident in a situation when facing an educated person. They feel inferior to others academically and feel that the educated people exploit them. They are unable to quote the salaries they need. Since they do not undergo training, they commit errors and sometimes lose their jobs. They work in flats where they see children living in upper middleclass families attending English medium school try to overcome academic challenges by attending tuitions. They follow this trend and send their children to tuition classes thinking it will solve the problem of academic incompetence. The tuitions classes in effect compensate for their inability to monitor the daily lessons. The impact of living as migrants in a city takes a toll on their wellbeing. Their focus shifts to attaining more financial status by working and they instil this value in their children. To all these subjects 'learning' is a meaningful activity if it helps to generate additional income.

4.3.4 Examining children who are observed while performing a task with simulated situation (scenario-based exercise) (table 4.3.4 appendix I): After studying the curriculum the tasks are designed. Students were exposed to simulated practical situation (scenario-based exercise). All children in this study were asked the same questions. While designing the question, circle and its properties are taken up as a task and then, the area and perimeter of a rectangle were given as another task. Students from both CBSE and SSC have not followed the pattern of the questions posed by the researchers in this study. This approach was used as the children were learning the circle and its properties as an experiential journal activity. Properties of rectangle were studied in class 7. To keep the children in a familiar situation questions from their curriculum are addressed. And then extended to the previous concepts. The task was given to examine if children use concepts learnt in school to real life situations. An experiential task-A given to three students as a part of data collection.

Task-A: Design a label for the given a can of perfume made of aluminium. The label should not have overlapping ends or gaps. The label should envelope the container surface only once.

Calculate the length of paper needed and verify the radius (Steel rule, string and stiff paper were given to complete the task).

Response of Student 1 to task-A: 14yr old boy: One Student of SSC board class 9th did not participate in experiment. This student gave the following reasons for declining to participate in the experiment.

- The student said he did not remember the formula and had forgotten all about circles. He did not want to continue
- He is very short and said he would be teased if he does something wrong.
- He was asked the area of a rectangle: he wrote it as 2l+2b and the perimeter was the sum of the sides of the rectangle.
- He remembered there is 'Length', 'Breadth' and '2' in the formula. He then gave up doing the problem. He did not carry on further.

It is observed that he had low self-esteem and did not wish to be jeered. He had decided to give up studying mathematics in the future and would focus only on commerce stream.

Response of Student 2 to task-A: 15yr old Boy SSC board Marathi Medium:

He asked "Can I use the string?" "or should I use the paper?" the choice of using either paper or string or both was suggested to him.

"I can use the paper only but since string is given probably you want me to use the string also"

- He took the string and enveloped it around the surface of the can.
- Marked the string with pen
- Cut the string with reference to the marking
- Placed the string on the steel ruler and measured the length
- Placed the ruler on the paper and cut off the length(L) required for the label (L=15.9cms)
- Placed the label on the surface and found a gap.
- He went on to verify the radius using the formula $C= 4/3\ \pi r^2$
- Had had the wrong formula.
- He measured the radius with the steel ruler and said it is '2.4 something'.
- He managed to make a label but had a 4mm gap at the ends.
- He completed the task and exclaimed that taking paper would have helped instead of the string.
- He said he liked doing this activity and learning rather than learning formally.

- He had not done such work in school or anywhere else.

The activity performed by this boy was based on his observation in a home industry near his house sticking labels on boxes. He was familiar with labels that were rectangular. He was asked about the area and perimeter of a rectangle. His response to questions were as follows:

- He said Area of a rectangle =LXB (product of length and breadth)
- Perimeter was the sum of the sides of the rectangle. He did not remember the formula for the perimeter of a rectangle.
- He had misconceptions of the area and perimeter of the rectangle being dependent on each other.
- He said saree has area as it is rectangular in shape
- Currency notes had surface area but coins do not have surface area. When asked about the circle and area of circle in the previous task he said circle has an area but coin does not have area as it is placed vertical in the wallet. When he was asked that notes are placed vertically in the wallet, then how is it that notes have surface area but coins do not? He responded that the rectangular objects have surface area.

It is observed that the student has no conceptual understanding of the Area and perimeter of a rectangle.

Response of Student 3 to task-A: 15yr old Boy SSC board Marathi Medium: The student completed the task in the following steps:

- He cut a long piece of paper of required breadth and enveloped it around the surface of the can.
- Measured the circumference of the given can.
- Got the correct measurement
- Finally measured piece of paper was cut to design the label for the can (L=16.2 cm)
- No gap was seen and it was perfect
- He went on to verify the radius using the formula $C=\pi r/2$
- Had forgotten the formula.
- He measured the radius as 2.5
- There was no gap between the ends.
- This student also liked the task.

- He exclaimed that he would like to participate in any other task anytime.

He knew that a saree and currency notes have surface area but coins do not have area. He believed that rectangles have surface area. He had no prior knowledge of seeing labels. He did it by visualisation. He asked for 'free' (unpaid) math lessons during his lunch break. He dropped out of school to supplement his family income. He was interested in attending formal school and liked learning with activities.

Table 4.3.4. in Appendix I compares the three students and their responses to problem solving.

Inferences from this study: It is inferred from this study that people should find meaning to solving problems in real life. If they don't find meaning to solving problem, they refrain from the activity. This is an indicator that activities in schools pertaining to mathematics must be meaningful to children to remember, recall and reuse the concepts learnt in previous classes.

All the subjects tested are a heterogeneous population and tabulated in appendix I. It is observed that they harbour misconceptions in mathematics. The misconceptions are internalised by formally schooled individuals. The internalisation of the misconceptions and harbouring them in adulthood is the occurrence of a phenomenon.

The initial studies provided a strong indicator that people not only internalise misconceptions but harbour them lifelong until corrected or by self-discovery and self-correction through mediation.

The indicators obtained from the study of maids show that they would want their children to be formally schooled with access to private after school tutors.

It is established from all the initial studies that there is an occurrence of a phenomenon amongst the people in Mumbai. To investigate if this is a local issue, or a national issue, groups of people in other parts of the country have to be studied in the similar manner. This would give a clear picture of the research study.

The final study is proposed to be conducted in Mumbai of the marginalised section of the society. Therefore, people from the similar backgrounds are studied in other areas of the country.

This study leads to Stage II or the intermediate study based on the tenets of Phenomenography.

4.4 Stage II - Intermediate study:

From the initial study on heterogenous random subjects a phenomenon was observed. The phenomenon observed among the subjects in a particular geographic location (in this case city of Mumbai in Maharashtra) who had internalised misconceptions and could not relate concepts to real life situations. The initial study had to be extended to people of the other parts of the country. The intermediate study was planned to determine if the misconceptions were common to people in the other parts of the country. If the misconceptions existed amongst people in the other parts of the country then the cause of this phenomenon has to be established.

Observing phenomenon across groups: Groups of communities living[26] in the various pockets of the country must be analysed within the framework of Phenomenology. The misconceptions if harboured would establish that phenomenon exists in other areas and is not localised. This study would give an idea if people across the country have a pattern of understanding concepts and if they have common viewpoint, and expectations of the education system. This study would give a clear understanding if they influence their children perception to learning based on experiential activities.

In the initial stage, it was not clear what could be the expected outcome as several small groups were tested. Educationists questioned this study initially and wondered if it could yield any relevant and valuable data. Outcome of this study at this point was to question how people learn, understand and apply concepts in real life situations.

The study examines if socio-economic factors affect the mode of learning in primary school children. Once this was studied and understood, the focus could be on how children learn. Learning in children could be understood better if their backgrounds and socio-economic status are understood properly.

The Study aimed at finding out if

(1) Learning in children attending formal school belonging to certain stratum of society is affected by the socio-economic factors.

(2) Parental aspirations to educate children and how they might be detrimental for child's learning process.

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[26] Lave, J., & Wenger, E. (1998). Communities of practice: Learning, meaning, and identity

Lave, J. (1991). Situating learning in communities of practice. *Perspectives on socially shared cognition*, *2*, 63-82

(3) Do parents of the children influence the education system?

(4) Are children pressured into being ‘formally schooled’?

(5) How do parents and children react to experience-based activities in school?

This study would determine ‘how children learn’ based on the questions above. The answers are like a black box with no information or it may give a whole lot of information that would determine how children learn. This was a journey into the minds of people who are parents. Initially quantitative information was obtained from several groups and individuals. The subjects were narrowed down to that belonging to Scheduled tribes working as bamboo craft artists. Before narrowing the groups, several local groups were also tested to determine if there is a possibility of understanding how people learn.

Conceptual knowledge on area and perimeter of a rectangle was tested among the individuals of the various groups. In order to establish mode of learning in children, it is inevitable to understand the knowledge of the people in groups and communities (Lave and Wagner 1991). According to Lave and Wagner, Tacit knowledge that exists within a community or group spreads to the younger generation. People in groups are innovative. Social learning occurs in Communities of practice by collaborative learning. Wenger gives a simple definition: “Communities of practice are groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly.” “Social processes dictate the learning in communities of practice”. There are three components to establish a group as a community of Practice.

(A) There needs to be an area or domain with an identity defined by a shared domain of interest. In this study the domain is bamboo craftsmanship. The people in this community share the same domain and have a commitment to the domain.

(B) The second component is for a community to exist with shared activities, sharing of resources and interaction amongst the people

(C) the last component is for the existence of practice.

In this study of the groups, the members of the community shared resources like tools, experience and new product development in bamboo craft. They devised their own methods of problem solving by identifying gaps, discussing any new knowledge and mapping knowledge by identifying gaps.

The initial aim of the study was to find communities of practice who are from the marginalised section of the society. These communities have stayed in pockets in the city as migrants from

other states. The study aims at understanding of how people use math concepts in daily life **(**Ference marton 2015). The study[27] focusses on how conceptual misconceptions, if any, affect problem-solving in real-life situations. The inquiry would lead us to investigate if there is transfer of knowledge to children from adults. In the study of school dropouts, it is important to find out if they transfer acquired knowledge to their siblings or friends. It leads us to find out how and from where they learn the concepts of mathematics. It would give a clear picture of understanding how misconceptions are internalised. The mode of conducting the study is

- Questioning all the individuals in their work environment.
- The questions asked were laddered using an initial question and then all subsequent questions were asked depending on the answer they gave.
- There was a conscious effort to stay in the domain of the topics asked and sometimes to keep the subject calm and spontaneous the questions were personal.

Intermediaries comprised of wooden cubes 1" X 1" X 1" (one-inch cubes). Subjects in this study included masons, undergraduate students of design, bamboo workers from Karnataka who have migrated to Mumbai, farmers of North and North East, bamboo workers of Chattishgarh and Bamboo workers of Nagaland.

4.3.1 Masons Knowledge of Geometry:

Masons use traditional methods to compute floor area to tile the floor. It is important to understand how they compute the floor area. In 2013 one Mason from a traditional community belonging to Varanasi was hired to tile a floor of a bathroom in Mumbai, Maharashtra. The floor had an unusual geometry with triangles and rectangles. When he and his apprentice could not tackle the problem of tiling, he took help from several others. (ISTEL-2017- Hiroshima Japan, conference proceedings page 92).

The design of questionnaire for the masons was based on their profession. To understand if they had knowledge /skills of numeracy, as it is the prerequisite to the topic of area and perimeter.

- Questions on measurements and lengths would be posed to them.

[27]Misconceptions internalised by an individual, is a significant indicator to find the source (instructor) of misconceptions, Ference Marton 2015 found it necessary to study qualitative data to understand learning.

- String to dry wet washed clothes is measured in metres and was available in the desired length. As a pre-determined length was available. It was important to understand if they would use the lengths available or if they would measure the length needed and then purchase with intent.
- Questions on area and perimeter of a rectangle would be asked to ascertain if they have any previous knowledge on this topic.
- To estimate the tiles of a given area they use tacit knowledge. Therefore, questions on estimation of tiles and visual measurements were developed.
- Currently the MKS system has replaced all other systems of measurements. In the villages of India area is measured by a local unit called "GUNTA", acres and square feet. Questions on the knowledge of the metric system were designed.
- All masons questioned in this study, find it difficult to seek jobs and have to depend on the contractor for making a judgement to pay them. It was important to know how they charge for their work. Some of the areas of the flat are big and some are small. Questions on costing for their work are posed.
- The question on the area of the saree[28] was asked to find out if they could relate to area of objects placed vertically and as the property of the object. Saree is often measured in metres, not in "square units". In order to see if there is conceptual understanding this question was posed.
- To find out if they have conceptual knowledge of fractions and use this knowledge to divide food, amongst family members; the questions on fractions were designed. The response would determine if process of using fractions in dividing is done consciously or they do it without intent.
- They buy from the milkman and rely on the milkman's knowledge of giving milk. They accept any quantity. Questions were asked to find out if they observe how he measures the required quantity and also find out if they know how to divide liquids by using measures

The designer who designed the interior of the bathroom was very particular that grooves between tiles should (match) be in line with the grooves of the adjacent tiles. The Mason from

[28] Saree is a draping fabric which is five meters long and width 3 feet or 3.5 feet depending on the loom. It is hung vertically to dry.

Varanasi and other masons attempted this problem. It was difficult for them to match the grooves. When they were given a template to visualise tiling, they could figure the pattern and match the grooves by breaking a complex shape into simple geometric shapes.

fig 4.3.1

During an interior layout of the bathroom floor (fig 4.3.1, fig 4.3.2), two masons were laying out tiles to decorate the floor. One end of the floor was rectangular and the shape of the floor at the opposite end was a combination of geometric shapes. This was an unusual shape and not encountered in tiling. The shape of the floor at the end with complex pattern had to be broken into regular known geometry for cutting tiles and fitting onto the floor. The geometric figures were one irregular heptagon, two quadrilaterals, two triangles (one triangle was further cut into one quadrilateral and one triangle) and one rectangle, to match the groove of tile pattern to the rest of the floor. One end of the irregular floor looked like a parallelogram and this had to be broken down into a quadrilateral and a triangle.

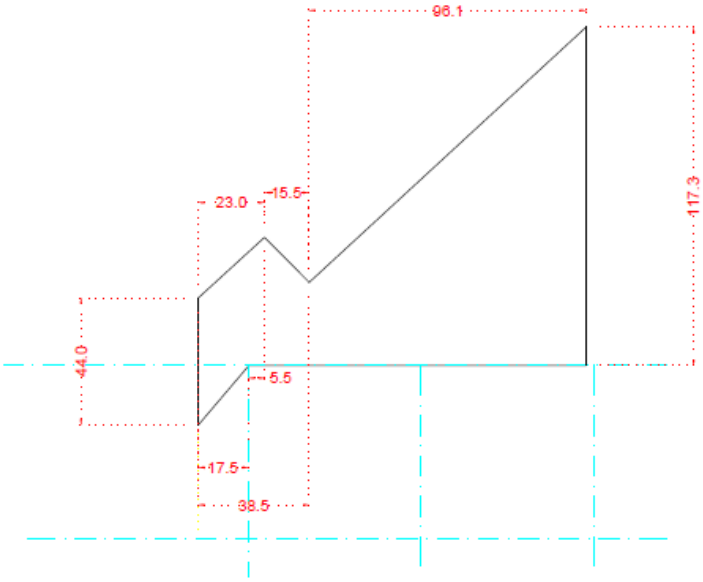

fig 4.3.2

All four masons visually estimated that four 2'X 2' tiles were required to tile the complex area of the floor. The task in the flooring problem (of the complex shape) was to estimate the number of tiles required to tile the complex shape of the floor. The other task was to match the existing pattern on the tiled area of the floor with that of the complex floor area.

The tiles were textured, black and 2'X2'in size. The complex shape at the end of the bathroom floor is given in fig 4.3.1. The tiling pattern and measurement is given in figure 4.3.2.

All masons wanted their children to travel abroad and work abroad. They wanted their children to attend formal school. They considered the profession they were doing is not appropriate for their children. Table 4.3.1 in Appendix I gives the responses of the masons during the study.

Learning from the tiling problem attempted by masons:

- They knew that perimeter and area of a rectangle are not dependent on each other. This was tested by the fencing problem and by estimating the perimeter visually.
- They did not know how to divide complex geometry into simple shapes to match the
- existing geometric pattern.

To the masons Meaning of learning is for additional income. They must learn formally in a school. Experiential learning in school will be like their profession and they do not wish their children to work while 'learning'. They want their children to study from books. The tiling problem given to masons was to be checked with students.

4.3.2-knowledge of Area and perimeter in Undergraduate students of design:

Time had elapsed during the study of various groups. It was necessary to find if students still harboured misconceptions. To validate this issue Undergraduate students were studied by revisiting the problem to subjects other than the marginalised section of society.

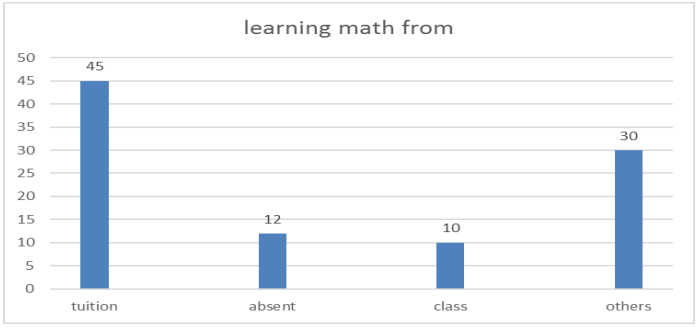

Fig 4.3.2.a

It was important to study how undergraduate students of design responded to the same questions the masons had attempted. Design is a pragmatic science. Students of design are required to interact with skilled workers and participate in real time design to provide Design solutions. Product design students take up interior design projects and tiling at times forms a component of the design. Such a study is included in this research to understand if students use concepts learnt formally in school to solve real-life problems which are a part of Design education. The study of this group included hundred Undergraduate students of Design.

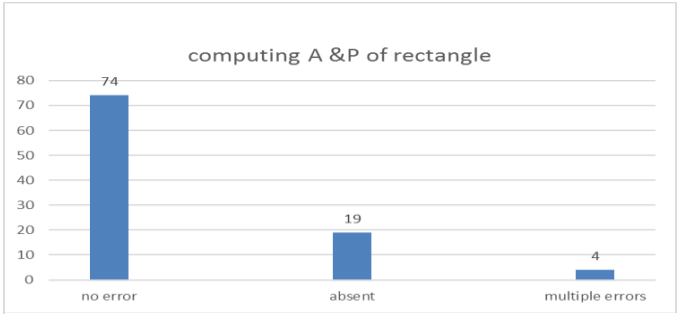

Fig 4.3.2.b

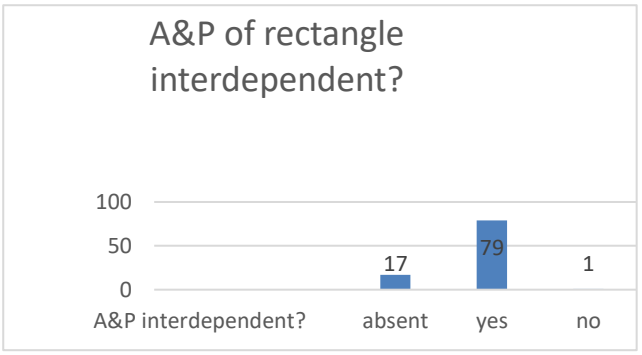

Fig 4.3.2.b

After passing board exam of Class 12 they took up Design as an undergraduate study. The group of students examined were of several backgrounds 60 students had taken up science in their pre-university studies (grades 11 and 12 after class/grade 10).

All students were tested on the concept Area and Perimeter of a rectangle and were subsequently given the tiling problem given to masons as in fig 4.3.1 and fig 4.3.2.

Inferences from the study on Undergraduate students of Design: Except one student, all others had misconceptions on the interdependency of Area and Perimeter of the Rectangle. They approximated the number of tiles to the nearest decimal like textual problems in school mathematics. They could not visualise the floor meant for tiling. They were confused between the formula of the Area and Perimeter of the Rectangle.

Students of design were given the freedom to move around, draw, etc. to visualise the floor for the tiling problem. Fig 4.3.2.a: Whilst in School the students attended Tuition classes and learnt mathematics from other people. Fig 4.3.2.b: 74% of the observed students could compute the area and perimeter of a rectangle.

fig 4.3.2.c: Except one student all others had a misconception that area and perimeter of a rectangle are interdependent on each other. This proves that students have harboured the misconception from school. Realising this they advocated for experience- based pedagogy in schools.

4.3.3 Knowledge of Area and Perimeter in Farmers of north and northeast:

The farmers selected for the research study were school dropouts. They knew the concept of area and perimeter in the traditional manner. As people are associated closely with land and find meaning in land and agriculture, twenty-five farmers were quizzed on the concept of Area and Perimeter. A simple mathematical problem was given to them to understand their knowledge of perimeter. They could calculate perimeter but not the area. They could **estimate** the area according to the traditional standard units of measure area called 'BIGA'. They visually estimate the area of land in terms of 'BIGA'. When researchers showed that the areas measured according to MKS system and traditional way are similar they responded as 'SMAASAM', which means equal.

Fifteen farmers[29] from Rajasthan belonging to the Scheduled Caste were interviewed. Their young children resided in government hostels to obtain formal education. Their children were well taken care by the government with free accommodation, food, school uniform and stationery. They wanted their children to attend formal school. They kept the children away from their farming environment. They did not want their children to pursue the traditional profession of farming.

They had rich knowledge of crops and the growth of crops that are local to their area. They owned small patches of land. They did not purchase the land but inherited it. They stored the crops that they grew on the land to sustain themselves for one year. They sold anything that was surplus. The crops are invariably scarce if there is drought. It is during this time that male members migrate to other states to take up jobs as construction workers. Some other people travel to the Middle East to work as manual labourers. They cannot save the money they earn to send it to sustain their family. They are unable to travel to their village during cultural or

[29] Their personal beliefs: All farmers believed in the supernatural like Ghosts, witchcraft and dark spirits. They believed that people practice black magic to harm them. There are instances that they are petrified of going towards a temple at night due to the presence of a Ghost. Verification of this claim is beyond the scope of this research. Drinking liquor daily, which is prepared locally and a habit they have formed. They binge drink during cultural occasions. The people of this community fight with each other after binge drinking. They do not marry outside their caste.

social functions. They have to quit their jobs to do so. In their village, they take up bamboo basketry for sustenance.

Farmers were quizzed on the concepts of the perimeter of rectangle during conversations with them. They confided that were school dropouts. They dropped out of school between class 5 and class 8. Three of them dropped out of formal school after class 5, one dropped out of school after class 6 and one other dropped out of class 8. Criteria for the questions asked to the farmers were based on their knowledge of calculating the perimeter of the field and further relating it to the area of the field. Questions on computing area of flat surface and relating it to the area of field were asked. The reason to this line of questioning is that farmers are very close to their land. They relate all their conversation to land that they own or that their friends own. Therefore, it is assumed that relating area of objects by giving the analogy of a field would trigger thought processes amongst them. Questions on schooling for their children, and their views on experiential learning using experience-based pedagogy needed to be probed.

All farmers knew the traditional method to calculate the perimeter of a field. A simple task to calculate the perimeter of certain area was given. Farmers were given intermediaries to find out their concepts on Area and Perimeter of a Rectangle. In the case of the knowledge they had on the concept of Area and Perimeter of a Rectangle, it was important to find out if they applied the traditional knowledge to abstract concepts by translating it to textbook like problems. Through this inquiry, it was found out that they relate to the problems they have in farming by

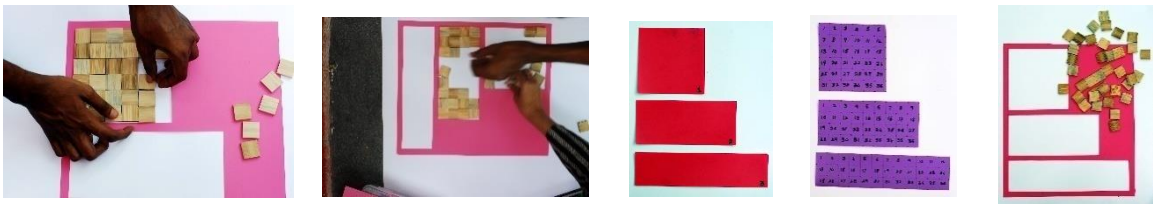

Fig 4.3.3.a farmers manipulating blocks to solve area and perimeter of rectangle problems posed to them.

growing of crops, order of growing crops and solve that problem with the intermediaries provided. Pictures above (fig 4.3.3.a) are farmers manipulating blocks to find out the interdependence of Area and Perimeter of the Rectangle. They were calculating the perimeter of a rectangle by counting. In a problem from the text book the length of wire required for fencing was asked to the farmers. The answers obtained from the farmers were practical and interesting.

One farmer had studied up to class 8 and said the text book does not take into account the corners. While turning the wire to fence the field. Due to this they cannot give a definite answer

to the question in the text book. They could calculate the perimeter correctly by adding (counting around the blocks). They added the sides of the diagram given and computed the perimeter. They were aware that different plots could have different perimeters but have the same area. They were able to manipulate intermediaries and translate real life problems and compute the perimeter of a rectangle.

Farmers had a very different way to compute volumes. The process they used to compute is detailed in the table 4.3.3 in Appendix 1 and in Fig 4.3.3.b when they demonstrated the resultant volume using a measuring jar.

Fig 4.3.3.b **farmers manipulating liquid to solve milk –ratio problem.**

4.3.4 Bamboo workers in Maharashtra: A group of Bamboo workers in Maharashtra who have migrated from Karnataka to find work in Mumbai were observed. They belong to a Scheduled Tribe in Karnataka where as in Maharashtra, they are not given the status of scheduled tribe. They belong to the 'Medar' tribe of Karnataka State. In Maharashtra, they are confused with the local Maharashtrian 'Burud' community. This tribe is closely knit and has rich tribal culture that they practice as a community. This group falls in the purview of communities of practice as Lave and Wagner suggest and meet the criterion of the tribe. In Karnataka they have practices characteristic to tribes. They worship stones and tools used in profession. They earn a day's salary and spend it his all the same day.

Fig 4.3.4**: Bamboo workers of Maharashtra measuring using hand measures.**

Presently, they are not interested in work related to Bamboo and bamboo craft. They make bamboo packaging for fish. They don't need exact dimensions to make the packaging. The baskets they make are of different sizes. They use hand as measures to determine linear measurements. The width of the strips is estimated visually and not measured. They try to maximise the strips from a segment of full Bamboo. They are aware that tape exists to measure cloth but do not use it to measure the baskets. After gaining formal training to make baskets, they acquired the know-how and the knowledge of using the measuring tape. Despite acquiring the knowledge of measuring with the measuring tape, they continue using hand and visual measures. There was no criticality or necessity of using measures. The packaging was discarded eventually and they found no meaning in working with accurate measurement and dimensions.

Twenty-five families were observed by asking a series of questions on their abilities to measure, compute, and estimate dyes used in Bamboo strip dyeing. The questions asked to the bamboo workers were the same as the questions asked for domestic help as they do all the activities that domestic help perform.

The criteria for asking the questions were based on the acquired knowledge / skills of numeracy as it is the prerequisite to the topic of Area and Perimeter. They used numeracy to count baskets, money spent and received. To find out if they could measure lengths, a question on measuring the length of a string to hang clothes was asked. It was crucial to observe if they used measures of length in real life while measuring the length of the bamboo strips and to observe if anyone in the house actually understood linear measures. They live in very small rooms. It was essential to find out if they had knowledge about the area of rooms and since they own land in their village it was essential to find out if they had previous knowledge on area. Questions on visual estimation of surface area were also asked. Area of land in their village is measured by a local unit called "GUNTA". In addition to GUNTA, people measure land in square-feet in the city. Since they have migrated from their village to the city. It was essential to probe if they could use the MKS system of measurements. In order to probe how they cost their baskets it was important to probe costing, planning and estimation of the baskets they make. In order to find out if they had misconceptions on surface area, questions on saree hanging vertically were asked. It has been observed that there are misconceptions harboured about area of objects placed vertically. Most people in the preliminary study were of the understanding that objects placed vertically do not possess surface area. In order to probe if they had misconceptions on fractions questions on dividing food were asked. They divided the roti into half and one fourth and they knew that more parts the smaller the pieces. They make huge 'rotis' one foot in diameter. The roti is folded and cut into half. The half roti is folded and cut into a fourth to store in a roti container. The one fourth roti is cut into a one eighth when they have to feed small children. This question gave an insight of the personal knowledge used to divide food. Extending this conception to the area of land would give an insight to mathematical operators and fractions used in land division. Questions of the division of food included the division of seasonal fruits among their children. To find out their concept on liquid measures, questions were asked on buying milk and dividing liquids using measures. How they purchased milk from a milkman needed to be understood. Liquids are measured tacitly in daily life. They were not asked questions on water storage as they got sufficient water and stored it in drums and they said they did not know exactly how much water a bucket could contain. They fill water into plastic drums with a steel vessel and can visualise volume of liquid in a container.

In the case of Bamboo workers, both males and females participated in the study. A total of 25 females, 22 men and their 7 adult children participated in the study. All 47 adults were unschooled but their children were attending formal school. Among the children having formal

schooling, six children dropped out of school after failing in their 10thboard exam. One among them completed Bachelor of Arts and obtained a job in the private sector. The grand children of the bamboo workers are attending formal school. In addition to the formal school they are attending private tuition class in the quest to gain 'more' knowledge and excel in the formal school. The grand children of the bamboo workers were between the ages of 5 years and 10 years.

All questions posed, were similar to that asked to the subjects in the previous study. From their response to the questions, it was evident they had no concept of surface area. They were clear that they wanted their children to attend formal school and experiential activities in formal school according to them are mundane. The youngsters learn bamboo craft just by observing the elders working at home. They wanted their children to obtain a degree from college and hoped that they obtain government jobs. They did not want the children to sit on floor like them and work instead they preferred them to have white-collar jobs sitting on chair with a table in a formal setting.

They used hand measures to measure diameter of the finished products (baskets) and arm to measure the length of strips. This is because precise measures are not critical in the products they make.

Their outlook towards education and how they school their children was probed. Their views on experiential learning was probed further. They reiterated that skill was mundane like the work they were doing. They want their children to attend a formal school. They do not want their children to be exposed to experiential activities in school.

4.3.5 Knowledge of area and perimeter of a rectangle among Bamboo workers[30] of Assam:

Bamboo workers from Assam were mostly migrant Muslims from Bangladesh. They live in the outskirts of Barapeta, Assam, India. Twenty-Five people had visited Mumbai from Barapeta for training in product design with Bamboo. They belong to the minority community. Usually they fell bamboo from nearby forest and bring it to Barapeta. These people are highly skilled and make intricate mat designs and patterns with bamboo. They are not aware of the correct measurements of the mats. One person in the group had knowledge of measurements and numeracy. He helped the groups with computation of lengths and other calculations. The

[30] They were observed over a period of 6 years and are still being observed to document the changes in their lives and the impact of technology in their professional and personal lives. They are constantly willing to learn and change. They don't know the concept of area till date(2016). In order to do this vertical study of the same topic the study is continuing to determine the effect of internalising misconceptions and determine the point when there would be conceptual understanding.

calculations were simple additions and subtraction. According to him, multiplication is just repeated addition. He was not aware of how to cost the products after making them. They sold their finished products without actually costing the product. One person fixes the cost of a product randomly. In some cases, they exhibit their goods and sell them in in various cities. They find out the cost of readymade goods in the city they exhibit, and price their goods with respect to the prices they observed. All other workers then follow the trend. When they fail to sell their products, they lower the price and sell it off. They do not treat the bamboo for borers or fungus. They make full bamboo furniture and jewellery. The bamboo products they make are smoked. Smoking protects bamboo from insect attack and gives a good surface finish. For smoking the bamboo, they use kerosene blowlamp. While deciding the total product cost, they don't include charges incurred for smoking and finishing bamboo. If an order for a new product was placed with them, they question "Mai kitne me doon" literally translated as "For how much should I sell?". The researcher in this study obtained insights from them through regular interactions during training. While calculating the price of their products they would not include the cost incurred for raw materials like cane, scrap nails and glue/ binders. The jewellery they make include intricate working with cane and local handmade tools. Regarding the pricing of the products, usually they follow the fellow competitors from other states. If the competitors charge 'X' for their products the bamboo workers will just decrease it to half (X/2) in order to sell their products, with no forethought. They do not calculate the loss or gains incurred. They wish to educate their children in formal schools and don't want them to continue with traditional bamboo work. All subjects examined have no knowledge about area and perimeter of a rectangle as they occupy open land. They live in small houses in open land. Their lands are not fenced, they farm and grow produce only for their sustenance, they fish from the river nearby. They had no concept of area of fabric.

If they had an opportunity, they wish to attend formal school. They give prominence to formal schooling and education. This was the view of every single person that was interviewed for this study.

4.3.6 Knowledge of Area and perimeter among Bamboo workers of Chattisgarh:

The bamboo workers from Chattisgarh[31] belong to the Scheduled tribes. They are very meek and not very vocal. They did not question the trainer during the training session. They were not

[31] *Indian Journal of Traditional Knowledge Vol. 10 (2), April 2011, pp. 386-387 Traditional fishing techniques of tribes in Bastar region of Chhattisgarh: lists the various techniques in fishing and the equipment made with bamboo to fish.*

skilled but developed their skills during the course of training. They fall within the community of practice (Leve and Wagner) as they share resources, transfer skill and knowledge to others in the community. Their skill is making packaging material with bamboo. They make baskets which are used during occasions like marriages and religious ceremonies. They use synthetic dyes to colour the baskets used in festivities. They obtain bamboo from forests.

They have no personal knowledge on the area of a rectangle. They can count two-digit numbers and were unable to perform complex calculations. They are skilled in making fish traps and hunting fish using bow and arrow. Some of their baskets have highly evolved designs with the handle being a part of the basket. They use the Bamboo skin in basketry. All twenty-five of them wished that their children attend formal school. Children in this community learn bamboo craft from elders. The concept of area to them was only land and they had no concept of perimeter.

4.3.7 Bamboo workers of Nagaland: The Naga people, through the centuries have used bamboo for variety of uses. Bamboo is an integral part of their life. They use bamboo to cut the umbilical cord of new-born babies, bamboo mats are used to wrap the dead for burial,

fig 4.3.7 1 : measuring from the other end of the scale & not from 0

for making agricultural tools, for making houses and they eat bamboo shoots. Their lives revolve around bamboo. A total of Twenty-five Nagas were interviewed during the training workshop. They were highly skilled. They have no concept of theoretical geometry but they built highly geometric structures using bamboo and tacit knowledge. They pay attention to intricate details.

Sky Morrison Canadian citizen working with women in Bastar with an NGO called Aditi has managed to raise money for the women in area. The women are a victim of abuse by society. Some of them tell a story through stitching. They are sheltered by the NGO and educated. Basic communication skills and computational skills are imparted to these women. The NGO was founded by Viji Srinivasan and after her death it is run by her husband. Thy make wearables and bed spreads. All these goods are sold in Canada. Some of the women visited Canada and displayed their goods.

They use natural dyes and they export their goods through organisations and government.[32] They do not know how to use measuring tools. Their numerical knowledge is limited to addition of two-digit numbers. Among the subjects studied, two were graduates but they do not like mathematics. They use hand measures and visual measures only. They wish their children are educated in formal schools and that their children could run profitable bamboo business. They are not against experiential education for their children, but wish for formal schooling.

4.3.8 Inferences of all the studies conducted on the subjects above:

Meaningful Action in real life:

- People will act or react in a real-life situation only if there is a meaning to the experience they undergo.
- Subjects saw the meaningfulness in terms of business transaction. They were using time judiciously.
- Subject (school student in the initial study) did not accept the math challenge as he did not see the meaningfulness to the task.

Display of Acquired knowledge:

- Subjects in study showed their own capabilities to prove their self-worth to experts.
- They were interested in solving puzzles and problems provided by experts.
- Internalising mathematical processes during 'on job' training or instruction:

People on job acquire skills based on trade practices and experiences.

- These job skills or knowledge may not have been acquired from school (formal education system) but internalised during 'on job' situations.
- The internalised knowledge is acquired knowledge and is applied to real situations.

Ability to extend knowledge obtained theoretically to a physical task or activity.

- Some people apply the knowledge acquired in a school/ formal system for a real physical task.

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[32] *NAGALAND BAMBOO DEVELOPMENT AGENCY Manual-I Particulars of organization, functions and duties. (Section 4(1)(b)(i) of Right to Information Act, 2005) gives in detail about the Naga association with bamboo as an integral part of their lives and the norms that govern bamboo as resource and bamboo as enterprise*

Ability to apply simple mathematical operations (addition, subtraction, multiplication, division) while solving practical problems.

- Some subjects of study apply basic math concepts to solve complex mathematical situations in real life.

Methods acquired 'On Job'

- Methods acquired 'on job' seem to prevail in business and trade practices.
- Subjects of study (shop – salesman) accepted the tools (calculator) and learnt the method for complex operation of multiplication.
- They were able to apply their math knowledge to tasks like division by four which they could calculate mentally.

Internalising observed experiences.

- Ability to draw their own methods or conclusions based on previous experiences.
- Some people have the ability to use analogies based on previous experience and apply them to the present task.

Ability to develop tacit knowledge

- Ability to develop tacit knowledge related to domain is based on past experiences.

Affinity towards formal schooling:

- All parents and students liked formal schooling.
- Parents had enrolled their wards in formal schools.

Extra classes to complement inputs from school:

- They assumed that going for extra tuition classes (private instruction in addition to classroom instruction) would enhance the chances of scoring higher grades in school.

Perception of experience-based pedagogy:

- Experiential activities are considered to be just craft activities and not educational.
- Some parents (subjects) felt that their children should not do any work but have only formal education.
- Use of traditional practices:
- Since many traders in India have different traditional practices of measurements further investigations could reveal the conflicts between school-learnt math principles versus learning from practical contextual experiences.
- Schoolchildren were found to apply personal knowledge rather than mathematical concepts learnt in school.

- Schoolchildren had forgotten math concepts taught in school but they could complete the given mathematical task. Personal knowledge was dominant amongst schoolchildren
- This study needs to be probed further in order to obtain knowledge about learning patterns and relationship between and acquired innate learning capabilities. This extensive data was based on commonality among the subjects.

Study involving a focussed group consisting of only students to understand how they internalise and harbour misconceptions:

The focus of the research is to decode how children in primary school internalise and harbour misconceptions. In order to inquire this effect, the subjects of the focussed study are primary school children. In order to have a deeper understanding of the problems among the subjects, a smaller group of students was to be studied. This detailed study is dealt with in the next chapter. Understanding issues in learning amongst children of the lower economic stratum of the society is important in order to determine the reasons behind increasing school dropouts. The subjects who are diverse and heterogeneous samples consisting of domestic helps, street vendors, to skilled artisans, shop keepers, school dropouts, children having formal schooling are observed in this intermediate study. This in-depth study provides a deeper understanding of their knowledge and priorities among the parents and children over a geographic area. The study of the groups of random formally schooled subjects, school dropouts, persons practicing a profession, and groups of the marginalised section of society across the country indicates a phenomenon occurring over a distributed geographic area. Irrespective of the sample size and their demographics, the misconceptions were noticed among all subject were the same. This is an important feature of a study based on phonomyography. This research aims to find out other factors like learning preferences of parents and children which will help determine the type of intermediaries to be used to be effective in communicating classroom instruction by the mediator.

This concludes the study, paving the way to narrowing the subjects and obtaining the pattern of internalising misconceptions.

Chapter V: Final study

From the inferences of Chapter 4 it is observed that misconceptions on the topic of area and perimeter of a rectangle are a phenomenon observed locally as well as in other geographic areas outside of Mumbai. Since the dropout rate is increasing among the marginalised section of society (according to the survey by Government), people from this section were particularly observed.

Decoding how children learn in school and establishing how misconceptions are internalised is of prime focus and concern for the study. The outcome of the study should answer the question as to what actually prevents a child from a marginalised (lower socio-economic) strata of the society from developing conceptual understanding in school and the research questions viz if attending experiential learning sessions enables children from municipal schools to **develop cognitive and metacognitive strategies** to link experience to formal school problems. If children attending municipal schools could **be motivated to attend** formal school after attending out of school (Saturday school) experiential sessions. Allied questions that seek attention with respect to the inquiry are the sub questions. The answers if children attending municipal schools would be motivated to attend formal school after attending out of school (Saturday school) experiential sessions. These are the destress Saturday sessions. The research seeks to answer if the curriculum with experience-based pedagogy inclusive of life experience-art-craft, linked to academics with mediation, be effective with children from an economically underprivileged background. The study inquires if the cognitive ability, cognitive curricular load[33] or social parameters that deter the children from learning with understanding.

Based on the studies on different groups in chapter 4, it was evident that parents wish that their children attend formal school. They are unable to impart academic content to their children and guide them. They do not want their children to follow their traditional means of lively-hood. Based on the observations and the indicators obtained from the study, propositions for the final focused study are generated.

The topic around which the subjects were tested is Area and Perimeter of a Rectangle. Area and perimeter of a rectangle in real life is familiar to children as they live in small houses. In

[33] This is described in the Bruner's spiralling curriculum causing impact of current curricular content which is dependent on the curriculum based on the previously dealt concepts.

Mumbai due to the limitation of living space and small housing, adults and children often know the area of their house. They have land in their village and hence they are aware of the comparison between their Mumbai residence and their house in the village which is surrounded by a plot of land used for farming.

All subjects interviewed in Mumbai had the knowledge of surface area with respect to floor as the floor is horizontal, whereas they believed that all other surfaces other than the horizontal (such as walls or any object which is perpendicular to the floor) does not possess surface area.

The topic of research encompasses numeracy, use of mathematical operators for computation, squares and square roots of numbers as they are incidental and a pre-requisite in computing the area and perimeter of a rectangle.

These topics are included in the study as the children observed are being schooled formally. The syllabus of the previous class is a pre-requisite to the main topic of questioning. This mode of selecting topics for questions would indicate the exact deficit in the pre-requisite that causes the students to internalise misconceptions.

5.1 Attempting to answer the research questions in chapter III:

The studies in chapter IV are directed towards observing a phenomenon and it is established from the previous study, that nationally the phenomenon exists amongst the marginalised sections of the society. In this focussed final study, an attempt to answer the research questions in depth is planned. Propositions are formulated in order to answer the research questions. The in-depth final study would inquire into the details of learning with understanding and attempt to answer the research questions.

From the inferences of the earlier studies, by taking into account the views and expectation of the subjects observed, the following propositions are formulated for the final in-depth focussed study.

- Necessity to introduce experiential activities into formal education/learning through camouflage by scaffolding. This can be achieved by design intervention based on experience-based pedagogy[34].

[34] ELT – by David Kolb discussed in literature survey.

- It is evident that the adult subjects (parents in the groups of people in chapter 4) interviewed, do not wish for their children to learn through experiential activities.
- They did not want to expose children to their profession and they do not wish that their children take up their profession as a career.
- Experience based activities were therefore designed and introduced in formal learning / training modules in a manner that the student finds it motivating to participate and relates them to the curriculum.
- They should be able to relate and reflect on the activities so as to learn with understanding.

- Children from the marginalised section (lower socio-economic stratum) of society need **to be motivated** to attend class/school.
  - It is important for the groups to observe community functions as they are close knit groups. The constant talking about their life style and situations are deep rooted in children.
  - The children should wish and look forward to attend school regularly without abstaining from school. (to reduce the cognitive curricular load)
  - They must look forward to attending classes for learning.
  - Motivation to attend school may be one of the factors that help the school to reduce the increasing school-dropout rate. (This is a proposition and needs to be validated).
- Inquiry **must be made** as to how students' study/learn, understand concepts and develop misconceptions (in subjects like mathematics) and why children/students drop out of school abruptly.
  - It is essential to find out how children learn fundamental concepts by decoding the process of learning.
  - To find out how they acquire new knowledge and build new concepts on 'old knowledge'.
  - The 'old knowledge' they had acquired would pertain to the topic of inquiry. (Acquired/old knowledge are the pre-requisites to the current topic in question)

- It is essential to determine if there is a correlation between the reasons to drop out of school due to the modality of learning and understanding basic concepts.

- To study if other children from the same stratum of society have same or similar pattern of understanding the concepts.
    - It is essential to determine if the pattern of understanding concepts is very typical to all the children living in the specific stratum (marginalised section) of the society. This social setting does not form the communities of practice (Leve and Wagner). The subjects[35] who are a part of the study do not fall as individuals within the purview of communities of practice.
- It is necessary to narrow down the scope of research by studying only few students belonging to the marginalised section (lower socio-economic strata) of the society. These students who are 'underperformers' academically in the school are chosen for this in-depth inquiry to find out how they think and learn. For the purpose of inquiry, children attending SSC board schools are studied.

5.1.a Research approach based upon propositions:

From the earlier interaction with parents and groups of professionals, it is observed they had strong views regarding education and learning. It was important to find out the attitude of children towards learning and mode of communicating the subject by the teacher to children/learners. It is how the children develop learning skills that would give a direction to decode learning amongst children.

A heterogeneous group of students from class seventh SSC board were chosen as subjects for the pre-test. They belonged to lower, middle and upper socio-economic backgrounds. The results are interpreted and hence it is an interpretative study. They were tested on the concepts of Area and perimeter of a rectangle in the Euclidian plane to understand their conceptual understanding and the modality of learning.

From the inferences in chapter IV and the propositions above, research study is planned by choosing students form class 7 and class 8 then narrowing down to 20 children and finally studying three children. This approach is a staggering down approach. Narrowing down the

[35] The commonality among the subjects of the study is only the socio-economic status and not the profession they practice.

study to specific subjects and planning research and hypothesis development is achieved by focussing on specific geographic region of Maharashtra, Mumbai.

The phenomenon of increasing dropout rates[36] and failure rates in academics was observed to be occurring in various pockets of the country among the marginalised section (lower socio-economic strata) of the society.

Since the commonality among the subjects are the socio-economic factors, it became crucial to investigate deeper into the minds of the children and decode their learning. At this juncture the impact on 'learning' among the children needs to be studied in detail to determine if the mindset of the society, economic constraints, psychological or any other factor causes drop outs in this section of social class.

5.1.b Initial Research questions and initial **hypothesis** (based on chapter III):

Initial research question and hypothesis was conceived by investigating the phenomenon based on learning from experience and experience-based pedagogy[37], extending the need to inquire in depth if necessary. The initial hypothesis was based on the premise that learning by experience reinforces conceptual understanding and generates interest in learning with understanding. On enquiring with groups[38] of people and school dropouts, they indicated that they did not like to learn using experiential activities.

Social factors based on the tenets of Phenomenographic studies of the research were not taken into consideration to test the hypothesis. The curriculum and the mode of teaching-learning in schools where children from middle-class attended was reviewed before the framing of the initial hypothesis. Subsequently all the curricula were reviewed and the initial hypothesis was framed.

Experiential education was advocated by Bruner, Kolb, Gandhiji, Tagore and others (literature review), it was assumed that the mode of educating the children in the marginalised strata of the society would be based on experience-based pedagogy and would be accepted by their parents. Based on this initial hypothesis, the intermediaries were planned and the workshop

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[36] This phenomenon is taken from the national census as explained in the chapter III

[37] Experience-based pedagogy is based on Experiential learning Theory and MLT. For example if a person working accidentally cuts oneself then it is a bad experience. For a novice to find out if the knife is sharp, it can be determined by visual inspection of the blade.

[38] All subjects from the earlier chapter formulated in the initial and intermediate studies from table 6.5

encompassing experience-based activities was conceived and designed. Experience-based activities are categorised into two forms.

1) learning from one's own experience in real life and relating that experience to problem solving in school
2) learning concepts through a related activity. The activity is an experience which is related to the concept in the syllabus.

The second of the two, an approach based on Experiential learning, was taken up and the Intermediaries were designed for a child to experience a concept. The experience gained from using the intermediaries would help the child to extend his conceptual understanding to solve real life problems or problems in another situation. Since experience-based pedagogy based on ELT is not followed by schools, it was decided that children should be exposed to experience-based activities in an informal setting.

The 'out-of-school' workshop was planned for children with the assumption that children enjoy activities and would gain conceptual understanding through an activity. It is assumed that the real life experience for a child. It is therefore not advisable to deduce concepts from real life and connect with concepts for class room instruction. Real life experience could be in the form like hardships faced at home, which a child desires to forget hence it was decided to discard real life analogies to understand concepts. It was therefore decided to take up experience-based activities with intermediaries to help a child understand concepts.

Designing intermediaries for explaining concepts in mathematics to children: Intermediaries were designed for use in the out-of-school workshop and these were used throughout the focussed class room observation. The intermediaries for the workshop included flash cards which were designed to form a part of a game to understanding fractions, a clock was designed to understand angles from the hour and minute hands\\, a seven-piece tangram puzzle was introduced to understand shapes, fractions, and Area and Perimeter of shapes. Full bamboo was given to students to create and experience 3D space and to understand the 3D geometry.

Since the topic of Area and Perimeter of a Rectangle was constant though out the study, some of the intermediaries used in the focussed study would be deviant from that of the 18-week workshop.

5.2 pre-test on children of class 7th SSC board:

This test was conducted parallelly while designing intermediaries for the workshop. Children were selected from two schools to pinpoint the area of misconceptions. The pre-test on the knowledge of Area and Perimeter of a rectangle was administered to 85 children of class 8 and 60 students of class 7. This test was a 'pen and paper-based' exercise. Personal interactions with all subjects were documented after the test.

The Pre-test was based on the knowledge of:

1) Numeracy and measurements: Numeracy is a pre-requisite to the topic of Area and Perimeter of a rectangle. It is therefore important to determine whether the subject understood the number system and measurements.

   Unit measure was used to measure linear measures (Length) and Square Units were used to measure area. This is an abstract concept where a child has to learn about linear measure and does not understand why square measures have to be used for area measurements. It was necessary to observe if they understood the difference between linear and square units (to check if they used concepts of liner measures for representing area).
2) Ratio and proportion: Subjects needed to be tested on the topic of ratio and proportion to understand if they had a conceptual understanding of interdependence of Area and Perimeter of rectangle while scaling the sides of the figure.
3) Area and perimeter of a rectangle: The conceptual understanding of Area and perimeter of a rectangle. Land and everyday objects were used as analogies to inquire if children had developed misconceptions.
4) Logical analysis: Simple questions were proposed to understand if subjects applied their cognitive abilities to respond. This would lead us to questioning how people react to known/learnt concepts while solving problems in unfamiliar situations.

Experiment and observation: For the purpose of inquiry, Pen and paper-based test was administered to a group of subjects (students from SSC board school). The test was based on concepts learnt from school. This test contained problems that needed (thinking, reflection) individual metacognitive processes. Questions framed were based on concepts that they learnt in school and had to apply to unfamiliar situations.

a) Observation and narration: A task and problem was given to the students. The students had to observe, identify and narrate the problem as they understood it. This involved vocalising the thought process.
b) Recording the observation: All activities in class were observed and recorded on a day-to-day basis.
c) Inference from the Pre-test that was conducted on 85 children of class 8 and 60 students of class 7, resulted in establishing further that students lacked conceptual understanding in mathematics.

The students developed misconceptions in the topic of Area and Perimeter of a rectangle. Misconceptions of area and perimeter among class seven children exist due to the following reasons:

- For a given rectangle the area is measured as 'square units' and the units of perimeter are a 'linear' unit. This concept of 'units' is not understood by children.
- Confusion between concept of area and perimeter arose as they focussed on the formulae rather than the concept itself. If there was conceptual understanding, this issue would not arise.
- Use of formulae in computing Area and Perimeter: Teachers taught[39] the formulae for Area and perimeter of a rectangle in school. Their teaching method for formulae and concepts were disconnected entities. There is isolation between the concept, and the formulae. Since both Area and perimeter of a rectangle involve length and breadth, students often confuse the formulae of area and perimeter.
- Students do not treat area and perimeter as the property of the surface of an object.
- Students were unable to visualise mathematical operations on area and were unable to articulate the changes in the area of the rectangle.
- Students believe that the area and perimeter of a rectangle are interdependent on each other.
- Students in class 7 were unable to connect principles of area and perimeter already learnt in class 5 curriculum to the problems in class 7. When they are promoted to class 8 they are not able to connect to the knowledge acquired in their class 7.
- Students were unable to visualise scale and proportion in real life situations.

[39] It is observed from earlier studies in chapter 4 and from the 'teachers training workshop' attended by the researcher. (Frobel, 2007)

- Students were unable to connect real life situation to 'pen and paper 'based problems.
- Social learning is taking place in their house through interactions with family members. Students learn from their family. This was inferred from the visit to the houses of domestic help and other subjects where parents talked and opiniated on topics. This opinion of the parents was absorbed by the children and they formed judgements. Misconceptions internalised by family members are transferred to children in addition to the misconception they had already internalised. (Lave J. , 1991).

5.2.a Studying the learning ability of students from SSC board school in an 'out of school' setting:

An eighteen-week long workshop (Doors of Learning) was conceptualised on experience-based pedagogy (in particular ELT). This workshop was based on the initial hypothesis in chapter III, that experience-based learning can motivate children to attend classes and learn with conceptual understanding. This workshop was to De-Stress children so that they learn in an environment that advocates activity**.** The researcher participated in a project called 'Doors of Learning'[40] and was a part of the project from the day it commenced up to 18 weeks of the study. The researcher assumed (took-up) the roles of an observer and sometimes a teacher to understand the effect of communication in a class and obtain a deeper understanding of what children understand. Workshop sessions were videotaped.

The idea was to conduct workshops with experiential activities for class 7 based on the SSC board curriculum. The curriculum for mathematics in school contains concrete concepts up to class six. Abstract concepts in mathematics are introduced from Class 7 onwards. Children from Class 7 develop misconceptions while trying to understand the concepts especially in mathematics. In the preliminary studies, the children claimed to have innate fear of mathematics from class 7 whereas up to class 5 their favourite subject was mathematics. The age group between 13-15 years was chosen as the dropout rates were high amongst the children between

[40] As a part of 'Teaching Learning Platforms' the scope for designing an effective curriculum for primary classes 6 and class 7 would be attempted. The design of kits and games is done in Bamb'U' Studio IDC IIT-B. Prof A G Rao had conducted workshops earlier with school students. The researcher was a part of the workshops and was conducting them alongside the Professor. At the onset of the workshop certain strategies are adopted as a blanket for the entire sessions.

class 8 to 10. It was important to inquire if there is any co-relation between the dropout rates and the school curriculum. It was difficult to assume the cause of the increase in dropouts among the children because there could be multiple parameters to be ascertained or eliminated. The parameters that probably were the reasons for underperformance of children in schools, could be social stigma, economic status, teacher efficacy, misconceptions of tuition teachers, ineffective teacher training, experiential learning and inefficient/inadequate curriculum. In this study it was found that effect of marginalised status in the community (socio economic status) could be a possible influencing parameter in increasing school dropout rates. The other contributing factors are probably peer assisted learning, and teacher's inadequacy in understanding and communicating the subject to the students. The teacher's social conditions could also influence the teaching in school. In unstructured interviews the teachers of three schools were having some problems and they mentioned it to this researcher. One teacher of the primary class mentioned "who has the time to develop activities?" "I have so much work in the house".

The misconceptions in Mathematics have been very well researched. (Fraudenthal, 1972) The State Board mathematics text book has been revised, printed and implemented. The students still develop misconceptions. It is crucial to understand how and why they develop these misconceptions. For this understanding the students' need to be examined in their natural environment.

It is believed and proven by John Dewey, Kolb and other philosophers that experience-based activities would help learning with understanding by developing conceptual understanding, and motivate children to attend school. The workshop was an initiative to observe and understand the learning trajectory to design an effect CSI model of instruction. On comparing the syllabi of the State Board, Central Board of Secondary Education and IB was found that the IB curriculum is appropriate to develop cognitive strategies of students. Parents often prefer ICSE and CBSE syllabus as both syllabi cater to preparing for common entrance exams of engineering colleges (both the state and national). The children from the marginalised section of society attend schools run by the government and have the state board curriculum. They cannot financially afford the fee of private schools. The children attending these schools are intelligent as they are rich with real life experience (Robert Sternberg 1986). But they are not considered at par with students of ICSE and CBSE schools.

Background of the children chosen for the workshop: Ten students from School 'C' attended the workshop. Their school hosted the space for the workshop. (In order to protect the identity

of the school they are named as ‘C’, ‘TV’ and ‘DS’ schools). Five students were from the ‘TV’ school and five students were from ‘DS’ school. The students participating in the series of workshops were already exposed to social learning from their parents and surroundings. The drop-out rate in municipal schools is very high (in Chapter III- Literature Review). The parents of these students are convinced that their ward is academically incompetent and enrol them for low cost tuitions. The cost of the tuitions varies from 100 to 500 rupees per month. The private instructors (tuition teachers) are themselves school dropouts in some cases and sometimes NGO appointed teachers. These private tutors/teachers impart academic content no different from school. The students complete the school homework in the private tuition class. There is no time for a private instructor (tuition teacher) to impart conceptual knowledge to the students.

The students chosen for the workshop have rich real-life experience compared to students attending private schools. The students of this section of society live in shanties called ‘chawls’. The living conditions are challenging in these areas. The children have to help with the house hold chores, attend school and private tuition classes. The schedule (academic and private instruction) gives them no scope to think and reflect about concepts to solve academic problem. It is important to understand how these students think when they encounter an academic problem and the strategy, they use to solve problems. This would give a direction to devise an effective school curriculum. The curriculum in the Saturday workshop is designed so that all students attending are given the opportunity to express themselves and enjoy the session and internalise the concepts. The tuitions teachers and school teachers are invited to discuss the strategies used in the workshop. The design of intermediaries for the workshop is taken up with available materials and made cost effective. The Saturday sessions include all subjects from the syllabus. There is no specific order to choosing the subject for the workshop. Mathematics has been the prime focus of the workshop since students find mathematics difficult and unappealing after class 6. The workshop sessions were videotaped. Pedagogical Strategies are used in creating assignments. These assignments are administered to children in the out of school eighteen-week workshop:

1) The emphasis is not laid on the methodology of solving a problem. It is essential to accesses their acquired knowledge and establish the factors deterring the academic progress. They are observed while solving problems similar to those they encounter in their text books.

2) After the answer sheets are obtained, they are scrutinized and discussed in the following session. Feedback is given to them individually.
3) The children are encouraged to read and solve problems on the white board.
4) The use of computers is not encouraged at this stage.
5) The children are encouraged to attend the sessions by providing incentives such as stationery, refreshments and writing material.

Pedagogical Strategies that have been followed in designing the out of school eighteen-week workshops are:

1) The objectives of the teaching are documented for the designers and the teachers. A lesson plan is designed taking a topic from the text book. The topic is examined thoroughly and the module to be delivered to the children is designed.
2) Short notes of the key points are discussed and written down. After noting down the key points the design of the intermediaries (kits manipulative and games) is taken up.
3) The material to be developed, is scripted in the form of points and circulated amongst the participant designers and teachers.
4) The workshop methods vary on each day that the workshop is conducted. Games are played by forming groups. Videos linked to mathematics are screened for children; work sheets and craft activities linked to mathematics are designed and given to children during the workshop session.
5) Verbal explanations in English, Hindi and Marathi are given and material is translated into the local language ‘Marathi’. Examples are given in the work sheet. The instructions are short and crisp.
6) The whole material for the workshop is reviewed by the team before it is presented in the workshop.
7) Children are encouraged to borrow and read story books. It was found out on talking to them that they do not read story books. Simple story books that fuel imagination and trigger creativity were purchased as a part of the project and given to children. This would encourage a child to read and understand content. And help a child to visualise a situation.
8) They are given tasks to be completed at home over the week since the sessions are on weekends.
9) There are no exams to make comparisons between children and their learning is evaluated on a case-to-case basis.

Strategies used by the professor to evaluate children attending the eighteen-week 'out-of-school' workshop:

1) Personal interaction to assess the knowledge.
2) On the spot assessment with verbal interaction.
3) Asking them to represent concepts on paper and assessing the outcome.
4) Checking out if they have a strategy to link real life experience with abstract concepts.
5) Checking school results to find out the impact of learning in Saturday session.

Topics taken up during the out of school eighteen week-week workshop:

- Fractals
- Fractions
- Angles
- Measurements
- Simple Equations

Using larger pictures, the children tried and attempted the exercise. When the students found it difficult to understand the figures, they were scaled down.

Observing the effectiveness of 'Experiential learning' in the 'de stress Saturday' an 'out of school' setting (workshop): Twenty Class 7 students were chosen to attend the workshop.

- One school chose 5 students who were high performers to attend the workshop. They sent high performers to gain recognition and assumed the workshop was a testing body that would rate their school.
- 10 students were selected from School C (which hosted the workshop) to attend the workshop. Of the ten students, seven students were not high performers but had failed the exams conducted in school.
- The municipal/government run school sent 5 students to attend the workshop. Of the five students, two were average students. The other three were failing in school exams.

Research Design: The 'group intervention' study was called "de-stress Saturday" it was specially designed to introduce experiential learning, to understand the reaction of children and to find out if they could learn with conceptual understanding (mathematics) by using intermediaries. The intervention in school took place in 45-minute sessions for over two months. Pre-tests and post-tests were administered to two groups.

This research design involved assessment of the student's problem-solving capability. The conceptual understanding of Area and Perimeter was based on the figural constructing task. This task was given prior to and after the intervention. A total of 20 Grade 7 students took part in the study.

In formal education, the students have an innate fear of examinations and as the questions are too many, and not shown to students. In earlier studies in chapter IV, students were found to panic when the questionnaire was administered to obtain the response in the 'test' mode as this reminded them of school examinations. On the other hand, the questions and the intent of the questions are explained the table 5.1.a.1 in appendix I. The questions are also based on the questions asked throughout the earlier study. Hence Design Research as a methodology was followed here with iterations.

Three children out of the five children from the municipal school performed poorly in the workshop. These children were of great interest to this research. The routine of the children attending the workshop was noted in detail. The activities they engaged in after school hours were recorded by personal interaction.

The analysis of 10 other students from the same school (English-medium) yielded a similar result. They wanted to have 'correct' solutions and resorted to copying from one another.

The five students from another school who were high achievers could not perform in creative exercises. They, however, would clarify doubts with the instructor and work. They were performance driven and made all attempts to take assistance from the instructors individually.

The workshop output of the three students who were the main subjects of the focussed study was taken up for detailed analysis. These three students had dropped out of the workshop after 18 weeks. At this stage (after they dropped out) it was decided to observe these three children in their school environment.

Analysis of the Students S1-S, S2-T and S1-R during the workshop:

Story using Tangram shapes: - students were asked to create a story by using shapes made with the tangram puzzle. A sheet containing shapes of animals was provided for reference. Initially this student had difficulty in creating the shapes. All students had to write a story.

- Student S1-S wrote the modified version of the story of the Rabbit.
- Student S2-T did not write the story initially. Later, on coaxing her she wrote the story of the Hare and the tortoise with no change.

- Student S3-R was copying from the host school. He befriended them and started copying.

Tasks on Trade: - Tasks on trade were given, to purchase using representative money and compute the cost of fictitious food.

- Student S1-S revealed that she does not buy anything as no money is given to her in real life. She makes erroneous calculations. She has difficulty in Problems related to Numeracy.
- Student S2-T, like the student S1-S, revealed that she does not purchase goods for her home. She is not given any money by her family members in real life. They fear she would lose it or miscalculate. She makes erroneous calculations. She has difficulty in Problems related to Numeracy.
- Student S3-R is given money by his mother but not his father. He can compute and had skills of simple numeracy limited to counting two-digit numbers and subtracting two-digit numbers. He has no idea of negative numbers.

Composition with Leaves: - All students were asked to make a composition with leaves. They had the freedom to choose what they wanted to create. They could compose an animal, bird or represent nature. They were told not to make a composition of 'man made' objects.

- Student S1-S took inspiration from other students. She had inhibitions to work because of a complex. The other children were teasing her. She had a language barrier as she was studying in a vernacular (Marathi) medium school. She wasn't mixing with other students from the English medium schools.
- Student S2-T took inspiration from other students. She had inhibitions to work on her own. She revealed this in a personal interaction that 'English medium' students knew 'everything'. When the other children teased her friend, she stood up for her friend and defended her strongly. It is then the researcher realised that she had a complex and fear of being compared with other children.
    - Student S3-R made it a point to copy from the students studying in the English medium school and performing well in the workshop (according to him).

Game using fractions: - Flash cards were designed and clues were given on the flash cards to find equivalent fractions. The flash cards contained pictorial representation of the fraction and numerical representation. They had to match and find the pair (picture and fraction).

- Student S1-S was constantly seeking clues.

- Student S2-T was looking blank and moving frantically showing her card so that the student with the equivalent card could find her. She could not cope with this game and finally just waited at the corner of the hall till another student came up to her and asked her for the card and matched it.
- Student S3-R was excited and quickly interacted with other children and found the matching card.

Building a Tetrahedron with pieces of full bamboo: - Mace (pronounced as 'MES') bamboo a local variety was chosen for this activity. The diameter of this variety was one inch. In order to understand geometry, tetrahedrons were made using skewers and rubber bands. A short video was shown to the students on the use of tetrahedron and geodesic domes.

The activity of tetrahedron (3D structure) included building a huge tetrahedron with an inclined length of 10 feet. The sides had structural members which were translated from the fractals exercise that they had drawn in 2D.

> Student S1-S and Student S2-T played hop-scotch. Student S3-R and the other two students from the same school were eating and roaming around. All five children were not participating in creating the tetrahedron and understanding the space. They indicated they were not interested in this activity and it was 'boring'.

Game using a clock to determine the angle between the hands: - the students were shown a clock with hour and minute hands. They had to identify the angle made by the hands and measure the angle using a protractor.

- Student S1-S did not know the meaning of angles.
- Student S2-T did not know the meaning of angles.
- Student S3-R did not know the meaning of angles but was prompted by his friends with solutions. Some of the solutions were deviant.

Student S1-S showed no motivation or interest in the intermediaries. She was taking tailoring classes and cut patterns with her hand. There was no precision in her work. Student S2-T showed no motivation or interest in the intermediaries. She was attending all extra craft sessions in school that were conducted during holidays without complaining about illness. She wanted to validate what she had written and throughout the workshop session she would try to befriend

the person conducting the workshop and try to get solutions from them. When they did not give inputs, she would run around the students of other schools and copy their solutions directly. Student S3-R was found to participate in all activities but made it a point to copy from the students studying in English medium school.

Except for S1-S and S2-T, all other children could measure lengths of straight lines. Both these children, started measuring from '1' instead of '0' on the scale (like the farmers interviewed from the previous study). The reason given by them was that 0 is non-existent and hence not significant at all. 18 children out of 20 children (one child dropped out early after attending two sessions) attending the workshop found it difficult to measure angles. They did not know how to centre the protractor and align it to measure the angle between two lines.

Other observations during the workshop were significant to understand the misconceptions that are internalised in children

The observations and analysis over 18 weeks is tabulated in Table **5.2. b.4**.

- 15 students had misconceptions (this assumption is made based on the results from the examinations conducted in their school). Children who had scored high academic grades needed to be prompted when thinking.
- The students who had internalised misconceptions earlier, continued to have misconceptions.
- Except for three students, all other students had to be prompted towards thinking.
- All except one student found that studying mathematics was a meaningless activity.
- They enjoyed the workshop activities.
- They developed motivation and confidence after the workshop. This was inferred from talking to their teachers and assessing their participation in class. Prior to the workshop the teachers had complained that the children were not participating in the class.
- During the workshop the 5 children from the municipal school (who dropped out of the session) did not participate in making the 6 feet tall tetrahedron. They were socialising. The boys were playing and distracting other children from working. They were eating local sweets and savouries. The girls were chatting amongst themselves. They were talking of the attire they would wear for the final day at school. They were discussing film personalities and their attire in movies.

- Five students (four of whom dropped out of the Saturday sessions after 18 weeks) were found to harbour misconceptions in the topic of numeracy and area and perimeter of a rectangle.

  On re-testing the children post workshop with the same topics covered in the workshop, it was found that these children **continued to harbour** misconceptions after the workshop.

From their response, it was observed that the concepts internalised by the children dominated the cognitive inputs and clearly indicated that they needed remedial education to develop conceptual understanding and a deeper study[41] of how they misinterpreted the cognitive inputs which resulted in misconceptions.

Decoding learning amongst the children would actually pinpoint the cause of undesirable learning and determine the cause of accumulating misconceptions, internalising misconceptions and then harbouring them lifelong.

Evaluation Criteria for the students taken as a strategy for the out-of-school workshop:

Shape recognition: All children were able to recognise the triangles and the square. The parallelogram was new to all of them.

All except Students S1-S and studentS2-T could identify the right angle of the right-angled triangle. They could identify the hypotenuse.

Properties of shapes: None of the children knew the property of the parallelogram. They treated the parallelogram as a single shape. They could not form the parallelogram using two triangles.

Manipulation of shapes: The triangles, square and the parallelogram had to be manipulated to solve the puzzle given to them. KT-C5 and SS-C3 from campus school were using the shapes and manipulating then to solve the puzzles.

All other students were crowding around these two students and watching them solve the puzzle.

MPK-DS1 and RGU-DS5 later figured out the mode of manipulating the figures and solved it on their own. Tangram puzzle was given to the children as homework.

[41] From this indicator the children were shadowed to find out how they misinterpret the cognitive inputs.

SS-C3 had internet connection at home and she used the internet resources to solve the puzzles.

The story using Tangram shapes: the stories using tangram shapes were imaginative, routine or reproduced from somewhere. Even when the 'hare and tortoise' story was reproduced they gave a twist to the story. However, some children took inspiration from others.

Assessment of students in the workshop sessions: Students tend to be shy if is examined in the workshop session as other students are watchful and pass remarks. After 18 sessions of workshop all students were invited to IDC and individually examined in an informal session for conceptual understanding. They were examined for the metacognitive strategy that they use for problem solving. The material of the workshop is examined carefully to understand the strategy used by the students to solve problems. Their school performance as rated by their teacher is reviewed. The two results (examined individually and examined at school) are compared.

After three sessions when they were sure that they were not being judged by marks they started being participatory and vocal with their own ideas for the solutions. They were not able to use instruments in geometry to measure angles and draw angles. The construction of a physical tetrahedron was done in the playground. Both boys and girls enjoyed this activity after constructing it. During the construction, the girl students of the Municipal school and campus school seemed disinterested. Table 5.2.b.4 1. shows the grades obtained during and after the workshop 'Doors of Learning'

Learning from the exercise:

Ability to repeat the creative exercises occurs but with help from others.

Ability to apply the manipulations to other puzzles is not observed as they do not connect and extend the concepts to other situations.

They have no ability to reflect on the concepts learnt, due to lack of time because they engage in social activities (household chores/ functions/watching movies/illness).

Children started dropping out of the workshop. Five students initially started abstaining from the sessions Later they withdrew completely. Their parents complained that the workshop sessions did not add any value to academics. The children did not perform the experiential tasks. The experience-based pedagogy did not generate interest amongst children and was not convincing to parents. The grades were not an indicator of children having conceptual

understanding as they exhibited the internalising of misconceptions after the sessions, indicating that the experiential session did not help the children gain conceptual understanding.

Select group of 20 students of the same socio-economic stratum of the society who were observed earlier over 18 weeks, in establishing information about experience-based activities in and out of school settings were re-examined. This workshop, in accordance with the initial hypothesis is expected help children to attain conceptual understanding and decode how they learn. Thereafter 15 students who were underperformers academically even after a gap of 6 months were tested to inquire if they have internalised the concepts learnt. This proved that the workshops activities were not effective in communicating concepts. The workshop had addressed the pre-requisites of the topic Area and Perimeter of a rectangle.

5.2.b.5. Failure of the initial **hypothesis**:

Initial research question and hypothesis was conceived based on the concept of advocating the advantages of learning from experience, based on experiential pedagogy. In depth extension of this study was found necessary as the initial hypothesis had failed. It was further decided to observe the students who dropped out of the workshop in their school setting. It was evident from the above studies (5.1.b.2 and 5.1.b.1) that there was a probability that experience based pedagogy would be conducive for students in internalising the concepts of learning. Based on the study above, research questions were formulated with a re-look at David Kolb's experiential learning theory (ELT). ELT was extrapolated to determine the understanding of mathematical concepts by design intervention. From the data collected in the initial inquiry of the research and the data collected in the study above (5.1.b.2 and 5.1.b.1), it is evident that the parents and children advocate formal school and learning. The students learning was augmented through extra private tuition classes apart from normal regular school. Most of the learning in the children after 18 weeks workshop over a period of six months, was found to have happened outside the classroom. This pattern was observed with the entire class that was observed.

Revisiting Paul Cobb and relooking at his methodology gave a direction to conduct the in depth study. Paul Cobb's methodology for class room action research is as follows:

Step1: Class room research

Step 2: One-to-one teaching

Step 3: Experiment design for class room based on step2

After these three steps

Step 4: Revisiting minimum of two children and finding exactly how they study.

"Teaching experiment methodology" (Cobb & Steffe, 1983;Steffe, 1983): Under this scaffold, a one-to-one teaching experiment focussing on understanding how children learn, rather than a change in the mode of teaching) was studied.

Based on these one-on-one (individual) teaching sessions, the class room instructions were planned. The need for classroom teaching experiments arose when the research programme (socio-constructivist) analysing traditional instruction produced negative impact from instruction by teachers. This traditional instruction imparted advice to the teachers like "Don't do this, don't do that." which was unwarranted. To create more productive classroom environments, the researchers took responsibility of designing classroom-based instructions for an extended period of time. In doing so, the one-on-one teaching experiment methodology was expanded to classroom (instruction) experiments also. The focus on understanding is an important characteristic of the designed research as it advocated by Bruners (1994). The research design in this study was based on this and it is very different from the research done along the lines of an experimental or quasi-experimental design. In this research after step 3 the students were tested for the misconceptions which persisted even after 3 months of initial workshop. The misconceptions were so ingrained in the students that two students were shadowed to see how they learn concepts with distorted conceptual understanding and how they develop the misconceptions 5.2.b.1 pre-test class 7^{th} SSC board. Students who attended the workshop were tested after 6 months to check if they could relate to concepts or if they learnt through experience-based activities. While designing intermediaries and the content development, it was inevitable to go back to the SSC Board English medium school (from which 10 children attended the workshop) and take feed-back from the class teachers.

After the workshop sessions ended, the students were tested on the topic of Area and Perimeter of a Rectangle, and Fractions. It was found that they still harboured misconceptions. They all had better performance in the end term exam and were motivated to attend school. They remained absent for any social function (only 15 students were tested as the other five students were high performers with access to help from school teachers and professional guidance). The five students from the workshop who attended municipal school had moved on to a secondary

school nearby to attend class 8 after the workshop. Post workshop intervention[42] was carried out in the secondary school.

5.2.b.6 Studying the learning abilities among students who dropped out of the 18-week sessions:

Using the tenets of the design research it was decided to redesign some of the intermediaries by iteration. The intermediaries used in the workshop were ineffective and hence they needed to be redesigned and some of the intermediaries used were designed by taking into account the pre-requisites of the previous classes' incidental to the topic of Area and Perimeter of the rectangle.

The intermediaries designed for use in classroom studies include square blocks using wood and three types of blocks made using bamboo. Tangrams were designed with cloth so that students can play with it and also relate to cloth as having area. Card board cut-outs of different shapes were given to demonstrate area calculations and other measurements like multiplications and divisions. These cut-outs are designed in a manner to help children feel the area and learn the calculations. Students always divide a geometric shape into obvious known shapes. It was important for them to understand that the geometric shape can be divided into half by manipulating in several ways. Square blocks with Flash cards from the workshop were used in the class room to determine the understanding of area and fractions. In order to determine the knowledge of the teacher, the mathematics teacher of the school was asked to correct and sign the test papers that were administered in the study. This was done deliberately to find out if the teacher had any misconceptions.

Design intervention was attempted in school and four children who dropped out after eighteen weeks from the workshop were observed closely. The children were observed in a formal school setting along with the students of the class they attended. The topic of Area and Perimeter of a rectangle was taken up as a learning objective and goal. Based on the responses of the students the Table I.1 (in the Annexure I) was generated. They deviated from the learning goal at various stages. Every stage was a prerequisite to the learning goal. This deviation was very atypical

[42] During the inquiry in a post workshop intervention, the children are asked questions on the same topics covered in the workshop in a verbose and written format. This is done to assess if the children understood and applied the concepts that were taught during the workshop using experience-based activities.

(individualistic). The reasons for the children deviating at every stage could have been due to one or many of the following factors.

(1) **Spiralling curriculum**: This curriculum provides no scope to revisit the previously learnt concepts.

(2) **Abstaining from class**: Children skip classes due to ailments and other social functions. Supplementing family income or due to illness of a family member in the house.

(3) **Teacher knowledge**: Teachers were found to have lack of conceptual understanding. In this study the questions on area and perimeter were administered and the teacher was asked to evaluate the students. While evaluating their student's paper the teachers were asking the researcher for inputs.

(4) **Peer knowledge and communication**: Children take help from one another especially during exams or before. Peers could transfer misconceptions as a part of collaborative and group discussions that are not monitored by a knowledgeable mediator (teacher /adult).

(5) **Knowledge of the private tuition teachers**: These private tutors with their personal knowledge create and develop misconceptions among students. They teach children to memorise procedures. These tutors conduct tuitions in batches and there is no scope for individual attention and sessions to improve the level of the children to bridge the gap to the expected learning goal.

(6) **Evaluation criteria:** The end examination evaluation does not indicate misconception internalised by the student. This evaluation is only based on the understanding of the students which could be limited. With this limited understanding, student may score good marks. Marks could be obtained by rote learning of solved examples.

(7) **Exhaustive curriculum**: Children study six subjects every year. From Class 4 every subject has its own complexity and correct assimilation by students depends upon a communicative approach by the teacher. Subjects which have a narrative approach like history are easily understood by the students. Children form an affinity to art and craft due to its creative approach. Physical training is another subject that they look forward to. This is verified by the observation during classroom action research. Children were observed over a period of three weeks continuously and these inferences were made from the participation of the children in social studies, art-craft and sports sessions.

(8) Attitude towards Art and Craft: If art and craft or physical training is linked with a topic in mathematics the children look at it from the perspective of performance. They do

not enjoy the task involving thought process and reflection[43]. They want to perform and 'finish' the task. The outcome of the task is so crucial to the children that they seek validation from the mediators (instructors) intermittently.

(9) Attitude of teachers towards creating intermediaries: The teachers have their own commitments to home and society and therefore cannot put extra effort to create interesting intermediaries to communicate effectively. This was told to this researcher by teachers in primary classes of twelve schools. There is no single data base for teachers to approach and brainstorm teaching methodologies. They have to rely on teacher training workshops which do not address inputs which are beyond the scope of the curriculum.

Children find no sufficient time either to reflect or rid themselves of the misconceptions developed while learning (acquiring knowledge).

Details of occurrences during and after the workshop: Four children (who attended municipal school) and were attending the workshop, dropped out of the workshop suddenly. Their parent had visited the workshop venue and expressed their displeasure to the teacher who had selected the children to attend the workshop. Their grievances were that their children are 'just drawing', 'colouring'; there is no curriculum that is addressed. They felt that this method was not like a private coaching class but more like an entertainment. This method of teaching would not yield marks in the term end examination at school. Explanation of ELT or the description of Experience-based activities did not help them analyse the objective of the workshop. They withdrew their children. The children were also of the same views as their parents.

The research was now focussed on a classroom study which was conducted in the school where the children (who had dropped out of the workshop) attended.

To conduct the research and find out why children dropped from the experiential session and develop misconceptions, earlier material and content of the workshop was reviewed.

1) Designing intermediaries that are physical objects, aid children to understand and discover mathematical concepts by manipulating the intermediaries. In the research conducted by Freudenthal, (Fraudenthal, 1972) Frobel in the 1800's (occupations (Frobel, 2007)) and Montessori (Montessori, The Absorbent Mind, 1995), they have advocated that physical objects aid children in understanding concepts.

[43] This fact was inferred while administering the questions on the application of concepts learnt.

2) Manipulation of area of a rectangle by performing mathematical operations (add, subtract, multiply and divide).
3) Revisiting pre-requisites to understand area and perimeter of a rectangle.
4) Designing real life tasks to understand area and perimeter of a rectangle.
5) Extending concepts to pen and paper exercises.
6) Sense of scale and proportion in applying acquired knowledge to unfamiliar situations or Hypothetical situations.
7) Role reversal in teaching concepts for confidence building, motivation, and recall of internalised concepts. This would help understand at what juncture the learning of misconceptions occurred.

Five students who belonged to the marginalised class studying in the state-run SSC school and attending the workshop, were observed during class room sessions. Four children dropped out and one child continued to attended the out of school experiential session. All 5 were observed and three of the five were studied as they were not performing in school. They were observed closely in their regular class room where these children attend. Their class had forty students. The general response of forty students in their class was recorded. All forty students of their class were observed in a 'class room observation'. A new set of research questions were formulated and answered.

This researcher paid a visit to the homes of the maids whose children were studying in the same school as the 5 children from the workshop. They were observed in their natural surroundings. What was observed was an eye opener for the designing activities. Their life style depended on the clock. Every moment was valuable. (Their daily activities were recorded). The children **have no time to reflect on concepts learnt**. All the above facts were known earlier and verified after the workshop (Doors of Learning) and personal interaction. The children were repeatedly asked the same questions on the concepts of area and perimeter and its pre-requisites before during and after the workshop. Their response proved that they had not understood the concepts. In order to understand further, specific children who were having life skills but fared poorly in academics were observed.

The following important points came out of the discussion with the children and parents

1) There is no parental monitoring of the children's academics. Parents blindly believe their children's narration about academics and class. Parents develop certain notions about teachers based on their children's opinion. Parents are not formally schooled and

they cannot handle the academic content. They do not ask their children if they have to complete, study or revise to prepare for the curriculum of the next day. They believe the private tuition teachers would take care of school work.

2) All parents expect the formal syllabus to be addressed instead of experiential activities. They consider experiential activities like craft and do not connect it with academics. When the children were colouring fraction sheets in the workshop, the parents believed that the child was playing and were upset regarding this. They openly voiced their concerns and did not wish their child to attend the experiential sessions (workshop).
3) They feel oppressed in society because of their caste. Their constant words were "you are big people" "my child should not sit on the floor like us but should sit on chair like big people". In their view sitting on floor is a crafts/lower caste like activity and sitting on chairs and using a table conveys equality and dignity.
4) The children abstain from school for long periods of time to attend personal functions. They abstain from school for short periods of time when a family member is ill or when there is crisis at home.
5) They were aware of reservations provided by government and they are of the opinion that a minimum basic qualification will get them a "good job"
6) The families are nuclear as all the families have migrated to Mumbai from nearby villages. They have no immediate family support in crisis. The neighbours provide limited help to them.

At this juncture it was again important to address the research questions and look at them from a different perspective. This is because the children did not develop an understanding of the concepts even after using experience-based activities to communicate concepts. They continued to possesses misconceptions on the topic of Area and its pre-requisite.

5.3 Class room study/research:

The research was conducted in the Class room of the school where the four children (the children who dropped out of the 18-week workshop) attended. Observation of their behaviour in the group they are familiar with (natural environment) was included. During the workshop they faced the ridicule of other children. The peer group dynamics was to be understood and the dynamics of the teach and student in a formal setting was to be understood. It was important to find out if the teachers were authoritarian and the students were submissive to the teacher's

authority. It was noted that during the out-of-school workshop, the children did not pay heed to the instruction and ignored the instructor.

In order to conduct the class-room study the questionnaire was re-designed. The intermediaries were redesigned by iterations.

5.3.1.a Design of the questionnaire:

The questionnaire was designed from the misconceptions observed in the groups that were studied earlier and from the learnings of the 18-week out-of-school workshop. The questionnaire would determine if the students understood the concept of area and if they developed any misconceptions. The answers to the questions would determine the quantum of misconceptions in children. Questions from the text were administered directly to the children to find out how they attempted to answer them. Surface Area is the property of the surface and it is an abstract concept.

The children faced with everyday challenges in life that they do not observe their surroundings and connect to the curriculum. The questions in the table 5.3.1 are connected with everyday objects children see at home.

Mother of one child who had formally schooled said that saree does not have surface area as it is hung and when folded it occupies area in the cupboard and if spread on the floor it had surface area. Clearly there is lack of understanding that area is the property of a surface.

The questions in the table above were the same questions asked. This time the number of questions were reduced to reduce the cognitive load and to hold the interest in the topic. The children had a short attention span and less questions would help children focus. The student's response to the questions asked were recorded in tertiary with a Yes, NO and don't know. The response 'not answered' and 'don't know' were of little significance to the study as this proved that the respondent had no knowledge of the topic. Whereas a Yes or NO would mean the respondent has understood the concept or in some cases not understood the concept and this tertiary response is very important to this study. The student response is recorded as Yes =1, No=0, Don't Know=2 and Not Answered =3. Table 5.3.1 in appendix I reiterates the questions asked to students. They are the same throughout the study with iterations modified to assess the acquired knowledge amongst children. the questions not answered were only coded by the researcher and not given as an option to the students.

5.3.1.b Design of a grading system for the students.:

At this point the assessment was not indicative of the misconceptions harboured or internalised. In order to process corrective measures which would be student friendly a system of grading was conceived before classroom observation. The indicators obtained in the previous studies were incidental in designing the Grading System for evaluation of conceptual understanding.

How to evaluate using an effective assessment system.

The cue to assessment is drawn from the Van-Heilie method of geometric learning. While collecting data it became increasingly difficult to identify the pre-requisite of the topic that the students needed to re-visit and have conceptual understanding of the topic before attempting to learn new topics.

When evaluating the students in school it became difficult to grade as the present grading system does not incorporate misconceptions harboured. When the three children were compared with the class, they secured 20% which means 80 % of the content as incorrectly understood. It was difficult for the school to find out how much they actually know. The grading system was conceptualised to evaluate a student's conceptual understanding.

To explain this concept of grading, it is essential to elaborate the process of computation. The example of evaluating Area and Perimeter of a Rectangle was taken up. The analysis of the syllabus was given in the following steps. To simplify, only the topic of computing the area of the rectangle is analysed. The procedure can be extended to the computing of the perimeter of the rectangle or any topic the teacher or school desires. There are 13 pre-requisites to learning Area and Perimeter of a rectangle in class 7.

I. In an example of class 7 the goal of learning is the Area of a rectangle:
II. Expected knowledge or pre-requisite to the Goal: the learner must be able to
    a. Pre-requisite no 1: Count numbers (contained in the syllabus of class 1).
    b. Pre-requisite no 2: Add and subtract numbers (contained in the syllabus of class 2).
    c. Pre-requisite no 3: Multiply two numbers (contained in the syllabi of class 2, class 3 and class 4).
    d. Pre-requisite no 4: Define polygon, triangle, rectangle, square, equilateral triangle, parallelogram. (Contained in the syllabus of class 4).
    e. Pre-requisite no 5: Describe the procedure for finding the area of a polygon (contained in the syllabi of class 5, class 6 and class 7).

f. Pre-requisite no 6: Recognise that area is measured in square units (dividing the square into unit squares) which is contained in syllabus of class 5.
g. Pre-requisite no 7: Discover and Restate the formula for the area of a rectangle as addressed in syllabus of class 6.
h. Pre-requisite no 8: Apply area concepts and formulas to complete interactive exercises as contained in the syllabi of class 7 and class 8.
i. Pre-requisite no 9: Recognise the difference between perimeter and area from the syllabi of class 5 and class 6.
j. Pre-requisite no 10: Compute the area of a square, given the length of one side contained in the syllabus of class 7.
k. Pre-requisite no 11: Squares of numbers contained in the syllabus of class 7.
l. Pre-requisite no 12: Square roots of numbers contained in the syllabus of class 7, and class 8.
m. Pre-requisite no 13: Compute the length of a side, given the area of a square, as contained in the syllabus of class 8.

The children observed, could not multiply numbers and had misconception of the place value of digits in a number. In this case they do not have the third prerequisite to learn area. So a scale called "Root stability"[44] is developed to reinforce the prerequisite no3 or root3 or r-3

In another example a learner may have pre-requisite 4 to 9 and may be stuck at 10 then the student would be termed as r3,10. As a remedial measure it is essential the student bridge the gap between the pre-requisites to the expected learning objective. As a remedial measure the student is expected to attend the bridge course of the syllabus of class 2, class 3 and class 10 for this given topic. This will help the school understand where the conceptual understanding has not taken place. Table 5.3.1 shows an in-depth analysis of the learning goal of one topic (area and perimeter of a rectangle).

[44] The term "root-stability" is introduced as a new concept from the analogy of tree and its root. As the root provides foundation to the tree, so also the foundation to the current concept is provided by the concepts learnt in the previous class.

Table 5.3.1: Mapped depiction of in-depth analysis of the learning goal of area and perimeter of a rectangle.

Student outcome/reaction	**Topic in the syllabus**	**Pre-requisite to the Goal in**	**Grading / evaluating student knowledge**
Over generalise previously learnt concepts of mathematical operations	Mathematical operations	**Class 1** **Class2** **Class 3** **Class 4** **Class 5**	The children observed could not multiply numbers and had misconception of the place value of digits in a number. In this case they do not have the third prerequisite to learn area so a scale called "Root stability" is developed to reinforce the prerequisite no3 or root3 or r-3 The learner may have pre-requisite 4 to 9 and may be 'stuck' at pre-requisite10 then the student would be termed as R3,10 and if the student in this case answers correctly for 15 marks then the student by this system is awarded R-3,10 M-15 and then sent to remedial classes. To bridge the gap. (pre-requisite refers page 135 above).
	Addition	**Class 1**	
	Subtraction	**Class 2**	
	Multiplication	**Class 2** **Class 3** **Class 4**	
	Division	**Class 4** **Class 5**	
	Square	**Class 7**	
	Square root	**Class 7** **Class 8**	
Difficulty in recognising shapes (parallelogram) Recognised shapes (triangle, square and rectangle)	**Shape identification** **Rectangle** **Triangle** **parallelogram**	**class 4**	

Difficulty in visualising rearrangement of known shapes.	**Rearrange shapes according to the activity**	**Not dealt in school and out of the purview of syllabus**	
Difficulty in braking known (previously learnt) complex geometric shapes into simpler shapes	**Deconstruct / break down complex shapes into simple shapes**	**Not dealt in school and out of the purview of syllabus**	
Difficulty in computing Area by use of first principles	**Find area of shapes using unit squares**	**Class 5**	
Confusion to distinguish between Area and Perimeter	**Compute area and perimeter of rectangle**	**Class 5** **Class 6** **Class 7**	
Could compute Area of Rectangle by the use of formula Could not compute the length of the side given the Area	**Extension of the property of rectangle to the use of formula.**	**Class 7** **Class 8**	
Student attitude to activity: Seeing by doing. Taking help from peers. Wanted to do "correctly".			Students have peer pressure, their own house work, meet expectation of parents, home-work, tuitions.
Parent reaction to activity outside formal class: Hostile towards the concept of workshop as a waste of time.			Parents aspire formalised education, do not like activities to be a part of curriculum.

This grading system be used to evaluate and grade the children during the study**.**

5.3.2 Class room observation:

Class room study included simple tasks that were planned. The tasks were small so as to avoid cognitive load on the children. Smaller tasks require shorter attention span and short attention span motivates children to develop interest in the intent of the activity. (Atkins SM, 2014) Simple tasks were administered in the class room sessions for all children in the class. Among the intermediaries given to students were a paper rhombus and square. The students were asked to perform the

following tasks using the intermediaries. The tasks administered in classroom studies were as follows:

Task 1: A square piece of paper the side of which measured 6 centimetres was given to students. They were asked to Divide it into 2 rectangles and then calculate the area and perimeter of the resultant rectangles. They had to tabulate the findings as shown in table 5.3.2. they were given the table to write down the values they obtained.

The outcome of Task 1: Students folded paper only along the diagonals. One student by trial and error discovered that the square can be folded along the line joining the mid points of the opposite sides. After he demonstrated it to others all caught up with the idea. Peer learning and mimicking were prevalent in the students observed. A table 5.3.2 is in Appendix I was given to the students to record their findings.

Task 2: A Rhombus and a Square were given to students and they were asked to cut them into known shapes, explore and discover

The outcome of Task 2: Students were not familiar with the shape of the rhombus. This shape is covered in class 5. But they could not identify the shape.

Task 3: Making a tangram using a square paper. The students were given a square piece of paper. They were shown how to make a tangram, by folding the paper several times to yield shapes. They were then encouraged to draw the shapes of the tangram on the paper using the folds as guides for drawing. They were then asked to cut the paper to make the seven pieces.

Outcome of Task 3: Students attempted several times till they figured out the folds. The children who attended the workshop also faced challenges in making the tangram shapes. The children later cut the shapes with bare hands and the shapes were organic as they were cut (torn) by hand.

Task 4: The students were given a tangram made with cloth. They had used the shapes to make squares with 2, 3, 4, 5, 6, 7 pieces and state the observation. They had to tabulate the shapes they used to create the square. The solution is given in Fig 5.3.2.a. Outcome of Task 4: All students could manage to pick two shapes (two triangles) with pieces 4, 5 and 2, 8 to make two squares. The three students who dropped out from the workshop and who were studied in detail, could create squares with triangles. They could not create other shapes with other pieces.

Task 5: Rectangles with same area and different perimeters were given to the students and they were asked to tabulate results and state observations.

Rectangles cut out of PP sheets with same perimeters and different area were given to students and they were asked to tabulate results and state observations. They were also given blocks made with bamboo that were used in the earlier studies. They had to manipulate these blocks to find the area of irregular shapes and compute the perimeter. This was given to see how they manipulate 3D blocks after manipulating 2D shapes Outcome of the Task 5: All students tabulated and inferred from the exercise. They were confused about how the perimeter changed when the blocks with the same area were moved around and different shapes were created. They computed the perimeter of the different shapes they created.

Task 6: Puppet making in craft class: A puppet with a square body was made in class by all students. After making the puppet with A4 sheet they had to repeat it on an A3 sheet. A one-centimetre grid was drawn on the body of the puppet. This gave flexibility to scale and observe the area and perimeter. They had to state the observation on the area and perimeter of the puppet and also when it was scaled up in size.

Outcome of Task 6: Students made the puppets of different sizes. They scaled the drawings and computed the area and perimeter of the body of the puppet. They were not so keen on the exercise as they considered it as a craft activity.

Task 7: The students were asked to make a photo frame and compute the area of the frame and the area of the photo that is visible. Right angle templates were given to them along with strips

:

Square with 7 pieces (2,3,4,5,6,7,8)	Square with 5 pieces (2,3,4,5,6,7)	Square with 4 pieces (2,3,4,5,)	Square with 4 pieces (2,4,5,7)	Square with 3 pieces (4,5,7)	Square with 2 pieces (4,5)
					

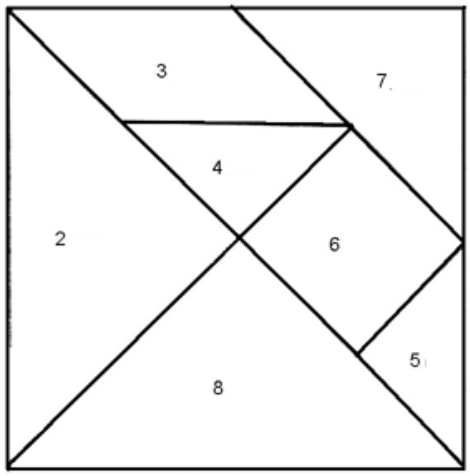

Fig 5.3.2.a 1

of pre-cut cardboard. Then they had to figure out the area of the frame. In this task there was area that had to be deducted at the ends of the frame.

Outcome of task 7: Three students could relate to the problem and computed correctly. The other two children could relate to the problem but could not compute. Rest of the class did not relate to the problem. Of the three children under observation, two did not relate to the problem and were socialising in class. The other one continued to do other work in class.

Task 8: The students were asked to measure the rupee notes to determine the area of the notes. The students had assumed that small denomination currency notes have no surface area. All students measured and determined surface area using the formula A=l X b where A is the area l is the length of the side and b is the breadth the length of the other side.

Task 9: The students were given a cuboidal box and were asked to determine the surface area of the box.

Outcome of task 9: This problem was not solved by anyone in the class. They just did not find the meaning to this problem. Thereafter a bar of soap in its box was shown and the task was re-administered.

Task 10: The students were encouraged to frame a question on the surface area of a rectangle for fellow students to solve.

Outcome of task 10: They were shy and instead of framing the questions they were reading the question from their text book.

Task 11: Computing area of irregular shapes from the known areas, then computing perimeters. The students were given irregular cut-outs. They had to draw a one-centimetre grid on the irregular shape and compute the area of the given shape. The were given a string to measure the perimeter of the shape.

Outcome of task 11: the students could not compute the area or the perimeter as they could not approximate the half or one-fourth of a square on the square grid. While finding the perimeter the thread was slipping out of their hands.

Task 12: Drawing a well in a garden. Problem: A well of 7 feet radius is to be dug in a square garden of size 7' X 7' (the centre of the well has to coincide with the centre of the square garden).

Find the area of the garden that can be used after the well is dug.

They were asked to draw this problem using a scale of 1 cm=1 foot. This problem is very interesting as the area of the well is bigger than the area of the garden and it was important to study the responses. The question posed to the children in their text book was to compute the area of the well within the plot.

Outcome of the Task 12: All students constructed a square 7cmsX 7 centimetres. Found the mid-point as the intersection of the diagonals of the square and drew a circle with the radius equal to the distance between the mid-point and the side of the square. The resultant figure was the well. It was inside the square. If constructed correctly the well would be bigger than the land. There would be no part of land to have a patch of garden.

Task 13: The instructor/teacher in class reversed her role. The teacher sat among the other students and asked the student to conduct the class.

Outcome of the Task 13: the three students who were being observed were asked to explain the concept of area and perimeter to the class. One boy refused to participate. The other two girls teamed up and were clearing their doubts on numeracy.

After design intervention the student response to the task was documented. No task was repeated but some of them were modified. Form the task output it was inferred that students still had misconceptions. In order to study how they harboured misconceptions three months after design intervention they were again examined with some tasks modified. Table 5.3.2.b in Appendix I gives the exercise and student response before and after the intervention.

5.3.2.a Revisiting the research questions framed through a new lens using focussed critical approach:

Research questions were to be answered through experiments in classroom and the content was developed using the intermediaries.

The whole process is tabulated in the table 5.2.b.6 in the appendix to have an overview of the process.

5.4. Understanding how the students develop and internalise misconceptions in mathematics:

The three students who dropped out of the experiential sessions (18-week long session which were out-of-school experience-based learning) were studied in depth. The tasks given to these children were from the syllabus that dealt with the pre-requisite for calculating surface area and the perimeter of a rectangle. The students were given the task of multiplying two double digit numbers. They simply added zeros without any logic when multiplying number in the tens place. They were unaware why the zeros are needed.

It was observed that one student told the others “chal zero daalna hai” (you have to put a zero) then other students puts a zero with no knowledge of ‘Place value of numbers’. Interacting with students in person led to the discovery that children don’t intend to learn in any specific manner. This led to the coining of ‘**Disoriented learning’, because they are not aware that they are internalising misconceptions. Students who dropped out of the sessions were examined in their class room in the school they attended. The table 5.4 below gives the analysis of their behaviours in the class.**

After the classroom observation, the claims and findings were tabulated against the activities. It was observed that activities that are simplified reduce the cognitive load in children. If the pre-requisite to any topic is not met, then the simplification of activities would not entail learning in children. They have not found time to reflect on the classroom instruction. Table

5.4.I gives the overview of the claims and findings of the classroom observation. The gap between the topic of the classroom instruction and the previously internalised concepts had to be bridged. Unlearning and re-learning of concepts has to take place for the children to learn with conceptual understanding.

Classroom observation reasons for students being inattentive:

- Lack of time to do work at home: Two children were trying to complete an assignment given as homework as the dead line was approaching.
- Socialisation: Children formed groups and were talking. The topic of conversation was movie stars and dance.
- Influence of media: Both boys and girls were talking about the film stars and their dressing,
- Lack of interest in Academics: One student was drawing continuously in class

The learning of children had to be measured while observing them individually. This was to determine the extent of conceptual understanding developed after 3 months of intervention. It is clear from the table 5.2.6.b in the Appendix I that children harbour misconceptions even after 3 months of intervention. A deeper understanding of how children learn by de-coding learning among them is to measure learning and mode of learning. A pen and paper test was administered to the three children. They were interviewed on a one-on-one basis. Once the learning was assessed, they were graded. The following steps were followed in measuring learning amongst the children after 3 months of intervention and classroom observation.

1) Paper and pen exercises (post-test)
2) Personal interview of all subjects to see if social learning affected the thinking.
3) Analyse what they knew earlier and what they learnt after intervention (reflection)
4) Asking the questions after 3 months of intervention and checking out learning.
5) Developing a grading system to measure individual learning that incorporates misconceptions.

After three months of intervention it was observed that the concepts were still unclear to the three students who had dropped out of the earlier workshop and were being observed in class. The next step in this study was to examine these three children closely to establish their mode of learning. To determine the mode in which they internalised misconception was crucial to understand the children. They were followed and when they interacted for academics the conversation or studies was observed closely.

The students were shadowed by following them around as a friend and observer

Studying student1 (S1-S) by following her: She does not attend tuition classes. Studies sometimes from elder brother who beats her.

- She wakes up in the morning at 6.30 am brushes her teeth has breakfast and does house hold chores.
- Sweeping and swabbing the floor.
- Her elder brother does not do any household chores.
- She then goes to school at 9 am and in the school up to 1.30 pm. Watches TV and works simultaneously.

She is observed in school and her behaviour pattern is noted and tabulated. She is constantly chatting with her friend.

- She returns home after school at 1.30 pm.
- She had to fill water for the household work and drinking water.
- Then she had to wash clothes as her mother works as a domestic help.
- After this she helps in dinner preparation.
- If there is a test or exam she studies.
- Does not find time for regular school work.
- She asks her friend for help (class mate)
- She 'rote' learns the procedure and gets utterly confused.
- She does not understand numeracy, but she is not bothered.
- She attends tailoring class in the evening.
- She cuts patterns with her hands without the use of tools.
- She makes small dresses for infants. She believes that accuracy is not required in stitching infant's clothes.
- She is tired and sleeps off
- She goes to school and during the school break copies the homework from others.

How she attempts to compute when faced with problems in numeracy: It was observed that her numeracy skills were not developed. She sees numbers and during multiplication

extends the rules of multiplication by adding zeros or sometimes shifts the place value according to her frame of mind. If she feels two zeros have to be added she adds two zeros. The logic is that if the number has more digits, then more number of zeros have to be added. This is over generalisation of the concepts. She uses her fingers to count and cannot subtract easily. She adds with ease up to three-digit numbers. Beyond three digits she is confused with the concept of 'carryover'.

Studying student1 (S2-T) by following her:

- She wakes up in the morning at 7 am brushes her teeth, has her breakfast but does not do house hold chores at home. Household tasks are divided in her house between all people. (activity analysis was done in order to determine the number of tasks she performs before attending school. This would indicate if she is tired during class and needs time to socialise and relax rather than study).
- Sweeping and swabbing the floor at times. She does not attend tuition classes. She 'Hates' to Study. Always she shies away from academics with stomach pain or head ache as an excuse.
- She stays with her grandparents. Her parents are in the village and she is sent off to Mumbai to attend formal school.
- She does craft activities at home in order to escape from working at home.
- She then goes to school at 9 am and is in the school up to 1.30 pm. he comes home and watches TV.

In class either she is sleeping with 'stomach pain' or chats with her friend S1-S. on enquiring and checking her health records it is evident that she is not suffering from any chronic illness. One of the two possibilities is that she has some unexplained pain or complains to escape academics.

- After school she goes home.
- She has to fill water for the household work and drinking / cooking.
- She washes her own clothes. It is not clear how her grandparents sustain themselves. They did not tell their source of income. They evaded the question of income. The student said that her parents were supporting the grandparents.
- If there is a test or exam she studies.

- She procrastinates. She complains of illness when asked to study.
- She asks her friend for help (class mate student S1-S)
- She rote learns the procedure and gets utterly confused.
- She does not understand numeracy but she was not bothered.
- She attends craft class in the school during vacation.
- She does not remember the craft activities.
- She is then tired and sleeps off
- She goes to school and in school copies the homework from others.

How she attempts to compute when faced with problems in numeracy: It was observed that her numeracy skills were not developed. She just copies from her friend. She makes no attempt to compute on her own. She was very vocal about the procedure and keeps saying add one zero or sometimes she says add two zeros. When she was asked in a personal interview, she said her stomach was paining and could not do the problem. Once she said this, we could not press her to answer.

Studying student3 (S3-R) by following him:

- Wakes up in the morning and studies.
- He does not do any household chores.
- He then goes to school up to 1.30 pm
- He then returns home.
- His father is a painter and mother is a domestic help.
- He attends tuition class. Most of his time was spent in tuition class
- He studies on a day- to- day basis.
- He does school work in class and does not pay attention in class.
- He does not play in the evening.
- He had a sense of numeracy

How he attempts to compute when faced with problems in numeracy: It was observed that his numeracy skills were developed. He knows how to multiply as a learnt procedure. He could not talk about place value. He questions his tuition teacher so his concepts of numeracy were very procedural with no conceptual understanding. He understands concepts from the tuition teacher. When the tuition teacher asks him to stop questioning, he learns the process of computing by method of comparison. He looks at

solved examples in the text book and what the teacher has taught. He then figures out the procedure and mimics it. The concepts were not clear. As long as he can do the problems without error he doesn't care. He does not like it if he does not get his way. If his father abuses his mother and him he complains and stands up for himself. His father is an alcoholic.

While observing children, a significant discovery about skill development was observed. Activity of cooking was observed to find out how children cook the right amount of food by utilising right amount of ingredients and if cooking could be a way of teaching fractions. Children cook tacitly, they do not use measures. In the final stage, cooking as an experiential activity was not designed to address the concepts of fractions. This is because the focus was on surface area as a whole and not fractional area (example: one fourth of a chapati was given to your sister, one fourth of the field had a bed of red roses etc. in this study the mathematical operators on area were limited to addition and subtraction; in specific cases division was also asked).

5.5 Data Analysis:

- Result was analysed by interpretation and making categories.
- Class performance without intervention was studied.
- Class performance before intervention was studied and compared with performance after intervention.
- Math Teacher was trained to conduct the intervention. The session was documented. The outcome was interpreted.

The data was collected for all subjects yielding a tertiary output and the output obtained was interpreted. It was clear at this point that experiential activities in Saturday "out of school workshop" had motivated the children to attend class. Three students showed the grades improved in the exam. The grade improvement could not be attributed to the activities. This is evident from the table and conducting the interview for conceptual understanding after the exams. The children were attending private tuition classes and majority of their syllabus was covered by the tuition teacher. The others had shown no significant improvements in grades. On interacting with the teachers at campus school, it was found that there were no academic improvements in terms of grades.

After the exams the children were again asked the concept of area and perimeter of the rectangle. All the students had the misconception on the dependency between area and perimeter of the rectangle. This was done on a verbal mode in the school in the presence of the school teacher. They also had misconception in the topics of fractions and ratio and proportion. The other topics were discussed as they had just studied these topics for the final exam. Due to the observations that there was no conceptual understanding with experience-based pedagogy, the following questions were critical to the specific study of co-relating other factors with learning among children of the marginalised section of the society.

Did the Experiential Learning Theory in this context fail?

Was the Design Research flawed?

Was the mode of delivery ineffective?

5.5.1 Findings

The parents of the five children (subjects of the study) interviewed[45], constantly used the words which meant "You are Big People and we are Small People" and "You are educated and we are uneducated", "We are poor". These words were categorised, data was analysed by interpretation and repeated questioning. The aspiration for education indicated that they would like to obtain government jobs in the reserved category. The relevance of job to them was the need to complement the income of the family. The reason for girls dropping out of school was the need to help in household chores as both parents were employed or the need to be married. Boys dropped out of school to escape attending class and start working and earn for themselves and the family. There is a government directive that till class 10, children cannot be detained (failed in the exam). This was to decrease dropout rates amongst children. Taking advantage of this directive the children were not serious about academics but took it casually.

This phenomenon was earlier observed with bamboo workers when 65 people of a scheduled tribe had clearly said they would never want their children to sit down on the floor and take up bamboo craft but sit on benches and go to school where teaching happens on a black board

[45] Overview of the questions, experiments are given in table 5.4.1

This phenomenon was earlier observed with bamboo workers when 65 people of a scheduled tribe had clearly said they would never want their children to sit down on the floor and take up bamboo craft but sit on benches and go to school

Research study showed the pattern of learning in children was Disoriented, and hence the term Disoriented Learning was coined and used herein. It is observed that the learner unknowingly is lost in a maze of self-generated, misunderstood or assumed concepts. Hence the individual learning trajectory is deviant from the expected goal of learning. Fig 5.5.1 gives a pictorial representation of Disoriented Learning. At any point in their life (even in adulthood) the student may redirect learning towards the expected goal by relearning the misunderstood concept. If the learner is unable to orient towards the expected goal, by learning the concepts sooner or later with understanding, the learner lives with misconceptions.

Children tested, develop misconceptions and build new knowledge on the misconceptions, hence deviate from the goal (object of Learning). The learning that takes place thus, is in a different plane. The students assume that they have learnt the concept.

The factors affecting the Disoriented learning are found to be:

1. Lack of motivation to study
2. Influence of social media (movies, Television)
3. Feeling of inferiority- Socially.
4. Single parents.
5. Children working to substitute the working parent,
6. Social Activities

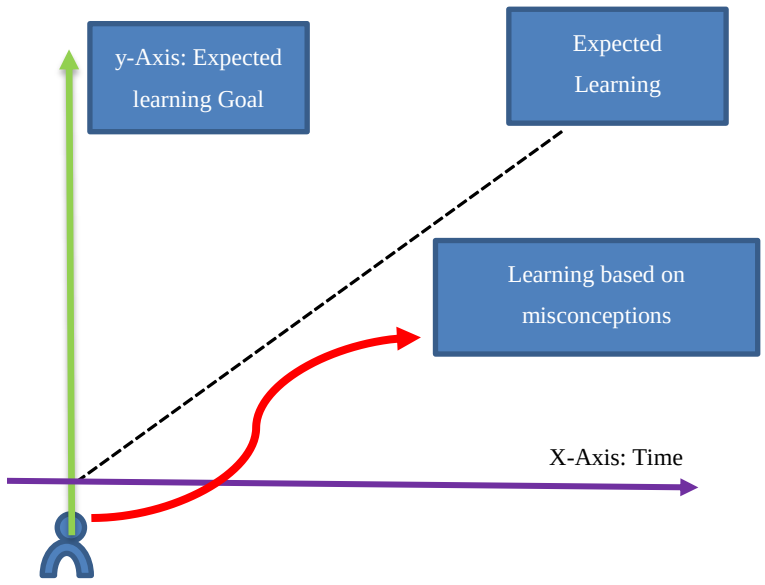

Fig 5.5.1

7. Expected mode of teaching.
8. Instilling “right” and “wrong” mode of teaching
9. Learning from peers who lack conceptual understanding

10. Economical factor (children working to complement the income of the family),
11. Illness,
12. Food and Nutrition.
13. Ambiguity of the concept in real life
14. Teacher's inefficiency and lack of in-depth knowledge of the subject

The children abstain from school for long periods of time and cannot cope with the spiralling curriculum (Bruner**).** The learning trajectories are mapped on an X-Y graph as in fig above and in fig 5.5.a and it is found out that the learning takes place in an undesirable manner. The learning trajectory is changing every day and with the subject. This is directly proportional to the misconception harboured and learning.

Learning Skills are developed by way of hearing, seeing and communicating. Learning skill is the ability to develop a methodology to understand and internalise the learning. This is a personal choice and correlates with Honey and Mumford who classify learners as theorist (understand theory behind actions), pragmatists (translate theory to practice), reflectors (Understand actions from different perspectives behind theory) and activists (learn by doing). Sleep patterns (Dennis Molfese, 2013)in children were not critical in this research as the children were sleeping for 6 hours a day.

Answering the research Questions:

Research questions	**Answers based on the study of Stage III**
Will attending experiential learning sessions enable children from municipal schools to develop metacognitive strategies to link experience to formal school problems?	During classroom research, in Stage III 3 children who were subjects of the focussed study were trying to question themselves and develop cognitive abilities during the role reversal. On mediation all three students tried to reflect on their though processes and were directed to Metacognitive process but they did not develop meta-cognitive abilities.
Would children attending municipal schools be motivated to attend formal school after attending out of school (Saturday	While experience based activities were being conducted in class, on any given day 10 children abstained citing various illness.

school) experiential sessions?	On enquiry from others in strict confidence it was found that they had social functions to attend. This question needs further inquiry and would be out of the scope of this research.
	All 40 children examined in school (Stage III) prefer to socialise in class during experience-based activities and ignore the activities that are linked with real life experience. In Stage III during the out-of-school-workshop sessions which had only 20 selected children similar phenomenon was observed. It is observed from the attendance in school (host school 'CS') that 10 children observed, were motivated to attend classes from their attendance record
Should the curriculum facilitate experience-based pedagogy inclusive of life experience-art-craft, linked to academics with mediation, to be effective with children from an economically underprivileged background?	It is found from class room observation in Stage III focussed studies that if the instructor uses intermediaries to communicate concepts, that 40 children try to understand the concepts and apply them effectively (class room action research and observation). All 40 students during art classes were asked to create the intermediaries and manipulate them. This repeatability of using intermediaries and creating familiarity with intermediaries created thought processes and for the topic of area and perimeter it was found to be effective. The effectiveness was validated as the test was repeated after three months.

5.5.2 Discussions:

From the class room observation and talks between teachers, parents and children it was inferred that educators are not creative while communicating concepts. Therefore, it is important to sensitise curriculum makers and educators to the needs of the people.

From the classroom sessions it has been observed that if intermediaries are designed and given to children after the concept is dealt with in a formal mode, there is better understanding of the concept. Using this technique, the area and perimeter of a rectangle and circle was introduced formally in class. On giving a problem of the application, the concept of area and perimeter of the rectangle and circle, the children realised and came up with the premise that the question was erroneous. One student boldly stood up and went on to say "the question is wrong" and then another one come up with the concept of area being eaten up or land being grabbed and understood the relevance of area and perimeter. They were given the tools and every single child was taught how to handle the tools.

Children in Municipal schools cannot be forced to think or work in school. They come with the mode of receiving information. They are all preoccupied with the stress from home. Question –Think- Answer mode does not work in this situation. The teacher has to be compassionate and direct the student to think after training them with examples and later introducing intermediaries. This technique worked in the Municipal school that was observed. If the intermediary (tool for teaching) is initially introduced the children were distracted and did not connect or think. They were more awed by the teaching tool and lost interest. In class they exchanged news about neighbours or home situations. When doing an experiential activity, they grouped together and ended up not doing the activity as the activity reminded them of their work at home. It has been observed that connecting an experiential activity with their life experience does not help them understand concepts, in fact it deters them from attending class.

From the interviews with the groups in the earlier chapters it is found that people of the marginalised section of society do not want to expose their children to experience-based activities in school. From this an insight was gained as to why experiential schools that were set up in the 1900[46] could not gain popularity. The schools that survived have affiliated to the CBSE or ICSE boards of curriculum as parents preferred their children to attend formal schools.

One has to be careful and sensitive in designing an experiential learning curriculum for State run schools attended by children coming from the marginalised section (lower socio-economic strata) of the Indian (Asian) society.

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[46] The schools set up in the 1900 were based on practical and experience-based studies. Children were subjected to tasks as a part of skill development. Since the tasks were imposed, they did not like it. During this decade, children from the upper middle class were home schooled or attended private schools. People from the marginalised sections wanted equality in education and slowly dropped out of experiential schools.

The motivation for children to study is to get out of their present social situation and get marks "somehow". They will study the subject in the easiest possible manner. The key to this is mimicking the tuition teacher, elder sibling or friend and sometimes class teacher. They will not give up their social activities to study as it is important to their culture. Illness and cultural festivities were the main reasons for remaining absent.

Misconceptions are compounded due to peer learning, previous misconception that are internalised, tuitions teacher's knowledge and 'teacher' knowledge.

Factors at home which are cultural, illness related, house hold chores related are causes to abstain from class.

When misconceptions reach a threshold, the student is unable to understand newer concepts of the spiralling curriculum. They fake illness like head ache, stomach pain and blow these out of proportion to avoid attending class. In the previous chapter it was observed that the domestic maid (educated) had complained of headache when faced with problem which had to be solved by applying concepts learnt. Children prefer attending formal school even when there is cognitive curricular load due which they have difficulty in understanding the concepts in class and have harboured misconceptions.

5.6 Modelling Learning:

Learning goals of 5 children were mapped and analysed so as to enable mediated learning. All five children responded when addressed alone. The prerequisites of the learning goal were documented from the syllabus analysis of each class. The final outcome of learning was documented on a case to case basis. Fig5.5.a. represents how children learn and their learning trajectory is modelled. This figure represents the learning among underachievers in Municipal school.

Explanation of the figure: In the figure 5.5.a, the learning trajectory should be linear with respect to time in this case the learning trajectory is depicted as a red curve

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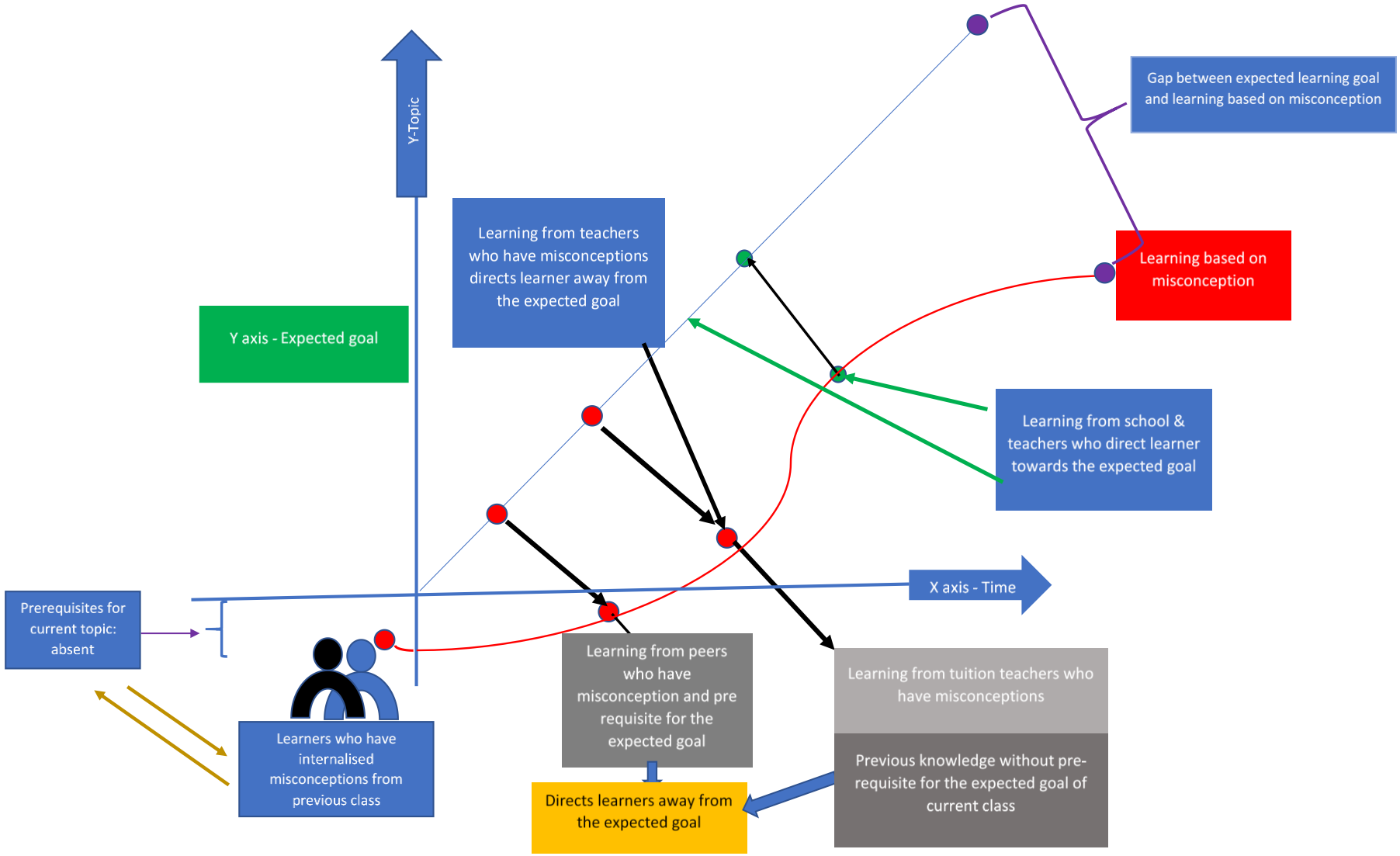

Figure 5.5.a : modelling learning

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Some of the factors that are conducive to learning are class room instruction, learning from texts etc. these push the learner towards the Y-axis whereas the factors that cause misconception are learning from peers who harbour misconceptions, teachers who harbour misconceptions. These factors pull the learner away from the Y-axis causing them to move away from understanding the topic. This pull-push action of the learning trajectory causes confusion in a learner and due to the cognitive curricular load caused by the spiralling curriculum the learner learns topic unconsciously. This learning of concepts in an unconscious manner from various sources is termed as Disoriented Learning. The learning trajectory is below the X and Y axis as the learner has harboured misconception from the previous classes.

The spiralling curriculum and socio-economic conditions further compound the problem of learning in children, create fear, distaste of studying and finally children drop out from school.

Student's **EG (C1+C2+C3+C4+C5+C6+CPC7) = EGC7.**

Abbreviations used:

Expected Goal = EG (in this case Area and Perimeter of the rectangle),

Syllabus of class 1= C1,

Syllabus of class 2=C2,

Syllabus of class 3=C3,

Syllabus of class 4=C4,

Syllabus of class 5=c5,

Syllabus of Class 6=C6,

Syllabus of class 7=C7,

Concepts pertaining to topic of the Syllabus of class 7=CPC7.

The learner has acquired knowledge and internalised misconception when the learner is in class 8. Therefore, the learning based on misconception (the red line) starts well below the x axis.

The y axis represents the expected goal. In this case the expected goal is the calculation of the Area and Perimeter of a Rectangle.

The progression is linear. At every stage over time the learner is pulled away from the Y-Axis and directed to compounding the misconceptions and the learner is unaware that he/she has harboured the misconception.

This phenomenon of internalising misconceptions without the learner's knowledge from multiple sources is termed herein as 'disoriented' learning as explained in the paragraph above. This phenomenon is also observed in adult undergraduate students of Design who were examined earlier.

From the studies in the earlier chapters and the reaction of students to experience based activities, it is observed that there is a resistance to teaching with experience-based activities. The socio-economic class structure dictates the mode of teaching in schools and learning among children studied, the parents and their wards do not consider art and craft as a part of academics. They found intermediaries intriguing but were not happy if their child was to make an intermediary. They welcome the idea of using the intermediary as a teaching aid by the teacher in a formal school. Validation happens incrementally with each stage. This chapter concludes the whole study. This is a process of theory in practice.

Chapter VI discusses the synthesis of results and concludes the Research.

Chapter VI: Synthesis and conclusion

The previous chapter gave a deeper understanding of how children acquire concepts (fig 5.5.a) with 'understanding' that form the basis of future learning. The crises they face in life and school, which affects this crucial learning stage[47], is documented. In the classroom research (chapter V) every child was asked how they learnt for and during exams. Three students were attending Private classes where the tutors 'taught' them. They were learning to 'solve' problems from the prescribed mathematics text book. They rote learnt all the and some 'tough' problems in mathematics the answers were then reproduced during exams.

One student was asking her older sibling to help her out. He older sibling was also 'rote' learning and reproducing what she had learnt. The older sibling was asking her younger sister to solve problems and was correcting the answers by referring to the 'answer key' in the text. The answer key contains solutions to the problems in the text book. The questions in the school exams are a replica of the questions in the text book. The rest of the students including the students who were observed in the focused study, studied in groups with peers and internalised misconceptions in the hurry to 'finish off' studies.

6.0 Synthesis of the results:

Data was analysed as suggested by Strauss and Corbin (2008). The data was obtained in the binary[48] form. The co-relation between the phenomenon of internalising misconceptions and the acquisition of new knowledge (with misconceptions) is evident from the data obtained.

There is a strong evidence that **socio-economic factors** are impacting the acquired knowledge amongst children of the marginalised section of society. The instances recorded show that children have difficulty in coping with lessons communicated by the instructor in the classroom due to the **irregular attendance** which in turn negatively impacts the conceptual understanding as the curriculum spirals out (Bruner et al). It is found in this research that children abstain from school and stay home when a single parent is sick or the child has to do household chores and take care of the house. In the Indian society culture is deep rooted in families. Social events and

[47] Stage from understanding concrete concepts to learning and trying to understand abstract concepts.

[48] In this questionnaire the response is interpreted as YES or NO being one output and don't know is interpreted as second output. The not answered is the interpretation of the researcher for the purpose of data analysis.

cultural activities are given prime importance and children abstain from school due to social events.

Effect of abstaining from class for a long period of time:

- Students remaining absent from class for long periods of time miss out on the topics and are unable to bridge the gap for the next class. The gap widens when the students further miss class.
- In this study, the '**expected goal'** is the understanding of Area and Perimeter of a rectangle which is dependent on the previously learnt concepts (in the earlier classes). If a student misses' instruction in a topic, the expected goal of the topic is not attained. The student has to bridge the gap between the previous and current topics.
- The expected goal of a topic in a class would consist of

    1) Understanding and Knowing the expected goals of previous years.
    2) Extending the concepts learnt in the previous years to unfamiliar situations.
    3) Translating and relating concept to a real-life situation.
    4) Understanding the current concept.

    EG (C1+C2+C3+C4+C5+C6+CPC7) = EGC7.

    (Abbreviation used: Expected Goal = EG, class 1= C1, class2=C2, class3=C3, class4=C4, class5=c5, Class6=C6, class7=C7, concepts pertaining to topic of class 7=CPC7)

    School Curriculum is spiralling outwards (Bruner 1960).

    The cognitive load with the spiralling curriculum (Bruner, 1960, 1977) keeps increasing and with pre-requisites to the current learning being missing, the students are forced to **rote learn from multiple sources**. This has been observed from the data collected.

    There is a strong co-relation between the cognitive load and the mode of learning amongst children of the marginalised section of the society. This has been proved by the learning trajectory of individual students and from the pre requisites to the expected goal (based on misconceptions that they harboured).

Previous knowledge and acquired misconceptions: new knowledge is built on the acquired knowledge. If the acquired knowledge is flawed, then the building stone of new knowledge is also flawed.

- There is a correlation between peer assisted and collaborative learning in the **transmission of misconceptions** from the instructor (peer) to the learner. Since children

learn from multiple sources and from peers of similar background, it is but inevitable that they pick up misconceptions from these sources. **Lack of conceptual understanding among peers** leads to disoriented learning since the peers too may have internalised misconceptions. When collaborative learning occurs, the misconceptions are imbibed form those who learn from such peers.

- A correlation between **fear of assessment** of the end term exams and fear of being unsuccessful in exams deters children from learning the concepts and resort to learning from peers or anyone else who is ready to instantaneously impart knowledge (with or without misconceptions.)

Teacher (class teacher and tuition teachers) knowledge: It was found that the Math teacher of the school had lack of conceptual understanding. The tuition also teachers harbour misconceptions[49]. Children internalise misconceptions from all sources. The teachers interviewed were not willing to change the mode of delivering the content in class. They relied heavily on text books and did not expand their knowledge base.

Other factors influencing the learning in children

- Categories of data formed by the study indicate that the social stigma attached by the society towards the social status (including their being unschooled and financially marginalised) mainly dictates the mode of learning amongst their children.

6.1 Conclusions:

The paradigm (chapter IV) illustrates the conceptual framework of the study and how design intervention can be incorporated into the school curriculum to decode how children learn. The incorporation of the design intervention in the primary school curriculum and its application to the end recipient of the study, the school and its stakeholders opens a pathway to remedial learning. This in turn facilitates the unlearning of internalised misconceptions and re-learning with conceptual understanding to facilitate lifelong education.

[49] The data collected during the 'teacher training workshops', testing the teachers in school by asking them to correct the questionnaire administered during classroom action research, interactions with teachers during training camps and from interacting with tuition teachers where the children in this research attended workshop and class.

This work seeks to establish that a unified curriculum[50] based only on Experiential Learning Theory is not suitable for teaching and learning in SSC board schools. Some experiential activities are only conducive to learning in some children. On the contrary it was found that students in the schools tested respond better to formalised Learning. Children like to be controlled by the teachers and like formal schooling. Parents of the children from the marginalised section of the society preferred formal schooling.

The findings led to the emergence of a probable theory of how children learn in school. By investigating how children learn, misinterpret and internalise concepts it was possible to find out the other factors affecting their learning.

6.2 Findings from this research:

After the initial hypothesis failed[51], the study was narrowed down to specific subjects to decode how misconceptions are internalised. The following points have emerged from this study.

1 Failure of experience-based Pedagogy in state run schools: It was found that Experiential activities have not been effective in communicating concepts to school children in State run schools of Mumbai. Experiential learning activities as a part of experience-based Pedagogy aim to create curiosity and a mode of inquiry amongst children. The activities when introduced in an 'out of school' setting, was attended by the children yet, eventually some children dropped out. The same activities were conducted in the school that they attend to see if there is change in attitude and acceptance to the mode of 'mediating academic content'(as pert MLT). The result was alarming. The children were not receptive to this mode of learning due to reasons mentioned above (6.1).

2 Effect of MLT: It is seen from the overall observations that mediation according (Ruven Feurstein) along with Kolb's Experiential Learning Theory works best in a class room. It has been found through this research, that students are oriented and motivated towards the learning objective / goal by learning in class with intermediaries that explain concepts which are related to the syllabus and co-relate with exercises from the text. Intermediaries are used to explain only one challenging problem. This gives students room to reflect on the concept.

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[50] NCERT is framing and proposing to introduce, Experiential Activities in education across boards of the country; this does not help learning in students of SSC board school.

[51] Research study documented in chapter IV.

In this research, one of the intermediaries used was a tangram made with cloth. This tangram made with cloth created an understanding that cloth has surface area.

3 **Design intervention to incorporate art, craft and intermediaries in curriculum:** Creative exercises as a part of art and craft class when co-related to syllabus are more meaningful for the students to understand concepts.

Concept of folding cardboard as an intermediary was used to understand that a 2D square can be divided into half in several ways and not just along the diagonal as the children assumed that a square can be divided into two equal parts along the diagonals however, It was found that experiential activities that are designed around the personal experiences[52] of the students have not been effective in teaching school children in State run schools of Mumbai.

4 **Bridging gaps between art, craft and curriculum:** The use of intermediaries in communicating concepts and the correlation to craft activities, helps in building connections between art & craft and the curriculum.

The activity of creating a 2D puppet gave a deeper understanding of area and perimeter as not being dependent on each other.

The use of wooden blocks (one square inch surface area) as intermediaries to explain the concept of 'units of surface area' of a geometric shape helped children understand the concept of units.

It was observed that there was a resistance to experiential activities in the 'out of school' setting. This led to the introduction of experiential sessions/activities in a formal classroom setting.

5 **Disoriented Learning among children: It is observed in this research that children, acquire knowledge from several multiple sources outside the school. Children pick up information from others who have harboured misconceptions, academic content from school texts and school teachers. Information from all sources is absorbed and the child fails to connect, filter and retain the relevant chunks of information to meet the expected goal of the topic (Area and perimeter of a rectangle) taken up in class. The term 'disoriented' is used as the children are unaware that they are learning and internalising misconceptions.**

6.3 Contributions of this research to the existing body of knowledge:

[52] In depth study is beyond the scope of this research.

Two prime contributions to the body of knowledge emerge from this research.

Contribution 1 of this research:

Grading akin to Van Hiele system has been developed to evaluate misconceptions and grade a student for conceptual understanding based on the misconceptions internalised.

The absence of the having correctly internalised the pre-requisite / pre-requisites to a topic would compound the misconceptions further. Currently in the grading system there is no way of determining the misconceptions and pinpointing the cause of it.

Case 1: The children observed could not multiply numbers and had misconception of the place value of digits in a number. Therefore, they could not address problems of Area and Perimeter of a rectangle. In this case they did not have the third prerequisite to learn area so a scale called "Root stability" was developed to reinforce the prerequisite no3 or root3 or r-3.

Case 2[53]: If the learner has pre-requisites 4 to 9 and is stuck at 10 then the student would be termed as r3,7. As a remedial measure it is essential the student bridge the gap between the pre-requisites to the expected learning objective. Remedial education of this child begins with addressing class 3 syllabus or pre-requisite to the topic 'Area and Perimeter of a rectangle'.

Contribution 2 of this research:

Decoding Learning among primary school children of marginalised society: Information from all sources is absorbed by the child and the child fails to connect, filter and retain the relevant chunks of information to meet the expected goal of the topic taken up in class. In this manner misconceptions are built up. Reflective observation (David Kolb R. J. Sternberg and L. F. Zhang (Eds.), Perspectives on cognitive, learning, and thinking styles. NJ: Lawrence Erlbaum, 2000), in these children is 'belief'. 'Belief' means what they construe as truth due to the influence of someone else or the self. This belief is based either on misconception or sometimes on concepts learnt without reasoning.

[53] Chapter 5 sub point 5.1.b.8 details the pre-requisite for area and perimeter of a rectangle and depicts the case 2 above.

That proves they are not reflecting on the concept but choose to believe the source of their information. This mode by which they learn is 'disoriented' as they pick up concepts from individuals who have no conceptual understanding.

The whole process of learning is 'disoriented' as the child is unable to judge the authenticity of the knowledge being imparted. The mode by which the children learn over a period of time, hinders the ability to reflect, as learning is based on beliefs.

It is observed that the learner unknowingly, is lost in a maze of self-generated, misunderstood or assumed concepts, hence the individual learning trajectory is deviant from the expected goal of learning. At any point in their life (even in adulthood) the student may redirect learning towards the expected goal by relearning the misunderstood concept. If the learner is unable to orient towards the expected goal, by re-learning the concepts with understanding, the learner lives with misconceptions.

Children tested, had developed misconceptions and build new knowledge on the misconceptions and hence deviate from the goal (object of Learning). The learning takes place thus, in a different plane. The students assume that they have learnt the concept.

From this research it is found that several factors affect learning in children of the marginalised society as in the study from the section 5.4.3 of Chapter V. The factors affecting learning are grouped into categories to prioritise and summarise the findings.

The factors[54] leading to 'Disoriented learning' are found and narrowed down to :

Lack of motivation to study: Children find no motivation to study. They have fear of exams. Study is an 'imposed chore' by the society, that believes in formal education. Economic factors (children working to compliment the income of the family) prevent them from attending school regularly. Some of the children abstain from school due to illness. When they resume classes, they are demotivated as they have to bridge the gap in academics of all the subjects.

Acquiring knowledge from multiple sources: Learning from peers who lack conceptual understanding is an impediment to learning with understanding in children of the marginalised society.

[54] Deficiency in Food and Nutrition cause a child to be tired and demotivated to study (beyond the scope of this research).

Teacher's inefficiency and lack of in-depth knowledge of the subject is one of the reasons the children internalise misconception. Instruction is received from school and tuitions by the children. In both cases the misconceptions of the instructor are transmitted to children.

Applying conceptual knowledge to unfamiliar / real life situations: Children cannot relate to concepts learnt in school to real life situations. They have an ambiguity of the concept in real life. When they translate concepts to real life situations they are faced with challenges and are demotivated to accept challenges. They refrain to revisit the situation.

Influence of social Media (Movies, Television): Conversations in class room centre around movies. Children dress up like their favourite movie stars when they attend functions. They remember these occasions and talk relentlessly about the attire and movies even when in class. This is a deterrent to concentrate on academics during class.

Social influences on education affecting learning amongst children: Single parents or social activities demand that the child abstain from school. They may substitute the working single parent or assist them while the parent is ill.

Social functions and activities are very important in their lives. During such occasions the children miss classroom instruction because they remain absent.

The society expects the education to be formal and not on the experience- based pedagogy. They consider experience-based activities as craft activities. They have strong preconceptions about "right" and "wrong" mode of teaching (they advocate formal education).

6.4 Recommendations:

This research gives a direction to the designer to design activities around the syllabus, such as would help children relate to academics. Experiential activities that relate to their own life experience[55] have unpleasant memories and are strenuous to the student. Students do not accept these activities and refrain from performing them. Activities relating to experience are effective tools to communicate concepts.

[55] In depth study of own unpleasant memories is out of the scope of this research. However data is collected by visiting the children's home and talking to them about their real life situations.

Conceptual understanding in children occurs by effective intermediaries. Effective intermediaries are a part of design intervention in curriculum design.

Experiential activities have to be designed with caution without directly using the children's own unpleasant experience. It is recommended that designers and curriculum developers be sensitive to the community and children while designing the curriculum.

It is found in this study that children get distracted with purely experience-based activities. They focus on the activity and fail to deduce the concept from the activity. The instruction is effective if the instructor demonstrates the concept using an intermediary and then encourages the students use the intermediary too. It was also found that the experience-based activity introduced as an example to an application of the concept learnt is more conducive to reinforce the concepts amongst children.

6.5 Future of this research:

The results of this research, will generate the 'Theory of Disoriented Learning'. This has been validated in the research conducted with both children and the groups studied.

In all the schools visited during this research, it was found that there is no remedial bridge course provided to children who have internalised misconceptions. The schools expected the parents to help children to bridge the gaps in conceptual understanding on their own. The parents resorted to private tutors to bridge the gaps in their child's acquired knowledge. The tutors on the other hand resorted to passive teaching and skipping curricular content. This further increased the gap. It did not help these tuition classes often take place during summer breaks and school holidays. An overview of the responses of 'subjects in this research is given in table 6.5

Fig 6.5.a gives overview and the recommended structure of a bridge course in the spiralling curriculum to build conceptual understanding in school children.

The use of 'bridge curriculum' facilitating 'bridge classes' could be introduced in schools to eliminate the necessity of private tuitions. This can be taken up for research in future.

Skill development in schools needs to be studied in depth to introduce it in a manner that does not relate to the real-life unpleasant experiences of a child.

Fig 6.5.a gives overview and the recommended structure of a bridge course in the spiralling curriculum to build conceptual understanding in school children. This idea is conceived because

the students in the experiment of 'Role reversal'[56] were constantly stuck with the topic of numeracy and were asking for mediation by the instructor (researcher).

A data base of intermediaries for teachers as a resource must be made available. This would enable the teachers to adapt and adopt experiential activities in a meaningful manner.

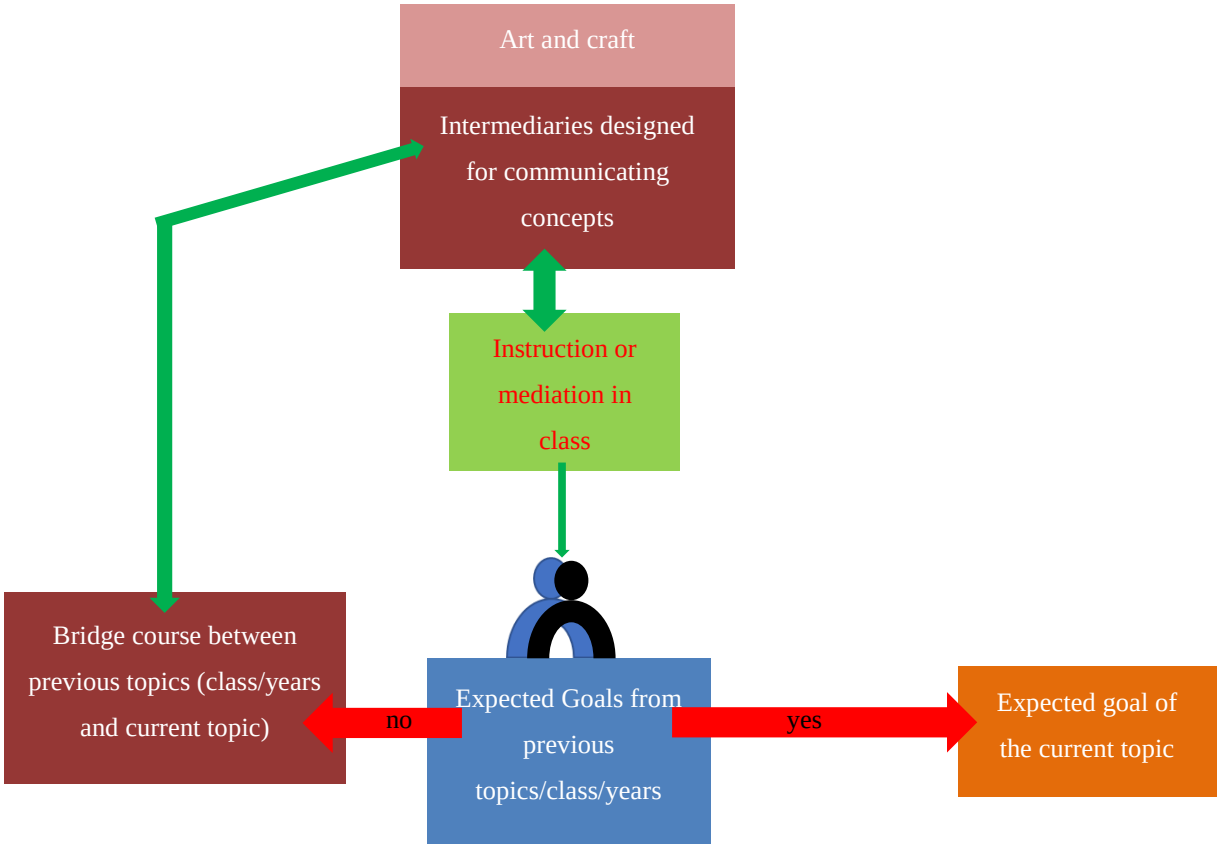

Fig 6.5.a: recommended bridge course for a learner with misconceptions

[56] Refer to 5.2.b.6 in this research.

Appendix I: Tables

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Table 4.2.1: Summary of the responses given by salespersons and owners of shops.

table 02_pg 171

table 02_pg 171

Table 4.3.3.b. Response of the one hundred domestic help (maids) who wanted to form a SHG.

table 02_pg 171

table 02_pg 171

table 02_pg 171

Table 4.3.1.b 1 Response of the Vegetable vendor

table 02_pg 171

Table 4.3.3.a.: Response of the educated domestic help.

table 02_pg 171

table 02_pg 171

table 02_pg 171

table 02_pg 171

Table 4.3.4. Comparing the responses of Student 1, Student 2, & Student 3

table 02_pg 171

Table 4.3.1 1: Response to questions by four Masons and three apprentices

table 02_pg 171

table 02_pg 171

Table 4.3.3: response of the farmers to the questions asked.

table 02_pg 171

Table 4.3.4: Response of bamboo craft persons from Maharashtra:

table 02_pg 171

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Table 5.1.a: Justifying the methods adopted in order to observe and study the subjects.

table 03_pg 187

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table 03_pg 187

table 03_pg 187

Table 5.2.b.4. table showing the grades obtained during and after the workshop 'doors of learning'

Grade Key									
Range of Marks	91%-100%	81%-90%	71%-80%	61%-70%	51%-60%	41%-50%	31%-40%	21%-30%	20%& below
Grade	A1	A2	B1	B2	C1	C2	D	E1	E2

No.	Students Name	Grades in mathematics 7th Standard18 end of weeks	Grades in mathematics 7th standard after 18 weeks
1	Student SM-C1	C2	C1
2	Student SP-C2	D	B2
3	Student SS-C3	D	C1
4	Student SHS-C4	B2	C1
5	Student KT-C5	A2	B1
6	Student SRG-C6	B2	B2
7	Student SAH-C7	**B2**	**C1**
8	Student SLR-C8	D	C2
9	Student ASS-C9	C1	B1
10	Student BBT-C10	B1	B1
11	Student MPK-DS1	Dropped out	Dropped out
12	Student SCK-DS2	B2	B2
13	Student SDM-DS3	Not available	Not available
14	Student PJK-DS4	A2	A1
15	Student RGU-DS5	A2	A1
16	Student RBP-T1	B1	B1
17	Student RVD-T2	Not available	Not available
18	Student PST-T3	C1	B1
19	Student SAS-T4	E1	Dropped out
20	Student TRM-T5	E1	Dropped out
21	Student P-T6	Dropped out	Dropped out

Table 5.1.a.1 Paper and Pen Exercises as pre-test:

Sl No	Questions Asked	Explanation to the questions asked
1	Does a Saree have surface area? 1) yes 2) no3) don't know	Saree is measured in yards or meters not square meters To study the response of the students.
2	Does a floor tile have surface area? 1) yes 2) no3) don't know	Tile is a rectanglar object. So how would they respond?
3	Does a Chapati (Indian Bread) have surface area? 1) yes 2) no3) don't know	To check if they believe that food they encounter every day has surface area. Chapathi is normally round in shape and it is consumed. What would be the response of the students ?
4	Does the paper in a note book have surface area? 1) yes 2) no3) don't know	Paper is athin and rectanglar object. To check what their response would be.
5	Does a one Rupee coin have surface area? 1) yes 2) no3) don't know	It was observed that students think small objects don't have surface area and only big objects have surface area. Common understanding is that very thin, small, transparent objects do not have surface area Eg: saree, paper, ear rings and transparent bottles.
6	Does a 10 Rupee coin have surface area? 1) yes 2) no3) don't know	These questions were asked to see if they have the misconception that only large objects have surface area and smaller objects don't have surface area.
7	Does a 10 Rupee note have surface area?	

	1) yes 2) no3) don't know	
8	Does a 100 Rupee note have surface area? 1) yes 2) no3) don't know	
9	Does a 500 Rupee note have surface area? 1) yes 2) no3) don't know	
10	Does a 1000 Rupee note have surface area? 1) yes 2) no3) don't know	
11	Is there any object in your house that you think does not have surface area?	To understand if they see surface area as a property of the surface.
12	Name five things in your house that have surface area	
13	Point out the surface area in the following objects Tiffin box , Transparent glass bottle, Opaque plastic, PVC pipe bit Piece of card board, Piece of tile that is irregular, Piece of cloth, Towel, Bed sheet.	

Continued on next two pages

Sl No	Questions Asked	Explanation to the questions asked
14	Can mathematical operators be used to manipulate and measure area of a field using basic addition? (adding one area of field to area of another field) 1) yes 2) no3) don't know	If they have land in their village, it is common for the family to discuss about division of land at home. If their parents acquire land in their village they would perform mathematical operators for measuring the land.
15	Can mathematical operators be used to measure or manipulate the area of a field using basic subtraction? (subtracting one area of field from a bigger area of another field) 1) yes 2) no3) don't know	
16	Can mathematical operators be used to measure area of several fields of equal area using basic 'multiplication' 1) yes 2) no3) don't know	
17	Can mathematical operators be used to measure and manipulate the area of field using basic Division' (like dividing the area amongst 4 people etc). 1) yes 2) no3) don't know	
18	A plot of land 75.5 m long and 30.5 m broad was sold at the rate of 550 per Sq.mts. what is the selling price? Text book question (page 121 class seven math book)	If students can solve textual problems and observe how they solve the problems. The strategies used and why they use the strategies.
19	A pit 2 m long and 2 m broad is to be dug in a place which is 12.4 m	

	long and 10.3 m broad. Find the area of the plot left after the pit is dug.	What the problems in the text mean to them and if they can visualise the problem.
20	Identify the shapes in question 19.	
21	Can two rectangles have same area and different perimeters? 1) yes 2) no3) don't know	To understand if they have conceptual understanding of the area and perimeter of the rectangle
22	Can two rectangles have same perimeters and different area? 1) yes 2) no3) don't know	
23	Given a square to divide into shapes	If they can figure out more than one way to manipulate shapes.
24	Given a rhombus to divide into shapes	
25	Given right angled triangles to join and form shapes.	
26	Cut the given rectangle into half	
27	Cut the given square into half	

Table 5.3.1: Questions and remarks as to the importance of questionnaire design

Sl	Question	Intent of the questions asked along with Comment/ remarks
1	Does saree have surface area?	Saree is rectangular in shape but hung on a clothes line for drying. Since the saree is hung for drying and never put on the floor like a carpet, there is a misconception that it has no area. Cloth is measured in meters as a length. This is very confusing to people who were questioned in the earlier study. Mothers of the children questioned said they did not know. Floor, field, ground, garden was strongly associated with the concept of area and perimeter.
2	Does a tile have surface area?	Tile is rectangular or Square in shape. It is placed on the floor to decorate the floor. Since the area is studied as "area of a particular shape" in the text book
3	Does a chapati have surface area?	Chapati is round and usually divided during meal time. It occupies space on a plate. In the uncooked state during rolling it occupies space on the rolling board.

		While in a box it occupies space. But it is stacked inside the box. It was important to understand the response of students
4	Does a paper in your book have surface area?	Paper is again rectangular and looks like the example given in the book
5	Does one-rupee coin have surface area?	One-rupee coin is tiny and round. Shape is similar to chapati. One-rupee coin is a perfect circle. The value of the coin is very little. Only to see if they equate surface area to high value currency
6	Does ten-rupee note have surface area?	Ten-rupee note is a perfect rectangle
7	Does one hundred-rupee note have surface area?	Value of the currency is higher than 10 rupees, in the shape of rectangle
8	Does five hundred-rupee note have surface area?	Higher value of Currency than 100 rupee, in the shape of rectangle
9	Does One thousand-rupee note have surface area?	Highest value of Currency in the shape of rectangle
10	Is there any object in your house that does not have area?	Objects hung, in the shape of spheres, the general misconception in subjects examined is that objects with spherical shape have no surface area and objects in the shape of square or rectangle placed on floor have surface area.
11	Is there any object in your house that has surface area? If yes mention it	Objects in the shape of rectangle or square are mentioned as having surface area.

12	Can you perform mathematical operation of subtraction to area of a field? Can you Subtract Area of a small piece of land from a bigger field	Whether they can extend the concept of numeracy to plane geometry. The concept of landed property is ingrained in all children as they go to their village during vacation. They witness land partition. They talk about land grabbing, area of house etc. It was important to find out if they could relate the concepts on to textual problems
13	Can you perform mathematical operation of addition to area of a field? Add Area of a field to an adjacent area of the field	
14	Can you perform mathematical operation of multiplication to the area of a field? Can you multiply Area of a field by a number and have a bigger field with bigger area?	
15	Can you perform mathematical operation of division to the area of a field? Can you divide Area of a field into parts	
16	A plot of Land 75.5 m long and 30.5 m broad was sold at the rate of Rupees 550/Sq m what is the selling Price? (question from the text book- class 7 math text book)	Problem from the class text book. To check how they attempt to solve the problem.
17	Divide the given square into half.	There are many ways to divide a square in half. To see if students can divide the square into half in more than one way.

	Problem from the text book: A rectangular piece of land has an area of 1800 sqm. If its length is 60 m what is its breadth? (Page 122 class 7 math book)	To check how they respond to questions from the text book.
	Problem from the text book: The length of a rectangular garden is 70m and its breadth is 30 m. There is a 3 m broad road around this garden. What is the area of the road? (Page 123 class 7 math book).	
	Draw a 6X6 cms square and find the area of the square and its perimeter.	This question is given to check if the students can represent the scenario and compute. if they could find it to be simpler to draw and figure out the solution.
	Draw a rectangle of 3cm X 6cms compute the area and perimeter.	

Table 5.3.2 1 Table given to students to compare area and perimeter

Divide the given square and compute the area and perimeter of the Square, and the rectangles obtained after dividing. Divide square in half joining the mid- point of the opposite sides. Two rectangles are obtained as a result of dividing the square by joining the mid points of the opposite sides. The area and perimeter is computed for the square and one of the rectangles.		
	Square 6X6 cms.	After dividing the square in half by joining the mid points of the opp sides: rectangle 3X6 cms.
Area	(s X s)	(s/2) X s
Observation of the area after comparing.		
Perimeter		
Observation of the perimeter after comparing.		

Table 5.3.2.b 1 Design intervention in class in which five children were observed.

table 04_pg 201

table 04

table 04

Table 5.3.2.a Revisiting the research questions framed through a new lens using focussed critical approach:

table 04

table 04

table 04

table 04

Table 5.4: Behaviour analysis of the students in class.

table 04

Table 5.4.I.: Overview of the research questions, experiments conducted, claims and findings in a classroom set up

table 05_pg209

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Table 6.5: response of subjects /expectations of the subjects.

table 06_pg 211

table 06

table 06

table 06

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Appendix II: sample of data collected

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Examples of the Data collected during workshop

Data was collected in detail. The process that children used, to solve problems was documented at every step.

Data collected from an educated maid

Where 'Q' is the question asked. 'R' is her response.

Q1: *10 mangoes are divided among 5 children how many mangoes will each child get?*

R: *2 mangoes per child*

Q2: *how can you divide 11 mangoes among 5 children? how many mangoes will each child get?*

R: *2 mangoes per child and one mango will remain. She says cannot divide 1 mango among 5 children*

Q2a: *Why? How can the remaining mango be divided?*

R: *How to cut 1 mango and give five children.*

She also said only four children will get one will be left out

Q2b: *Show how*

R: *"think of one Rupee divide into smallest part"*

R: *"it is 25ps" "so only four will get quarter of rupee"*

Q2c: *"how many Paise in a rupee?"*

R: *"100 Paise in a Rupee but there is no Paise below 25"*

She rejects the analogy of rupee and goes on to draw the mangoes.

She draws the mango and makes cuts on them to graphically represent the pieces.

After about 5 minutes

R: "*cut the mango into 5 parts and distribute".*

After drawing, she responded: "cutting it will be difficult".

Q3:*If there are 222 mangoes and 5 children, how many mangoes will each child get?*

Q*:On asking her the process*

R: *it is ' BHAGAKAR' (process of division) she studied in vernacular medium.*

She split 222 mangoes into 10+10+10+10+10 .....till she distributed 200. That is 40 mangoes per child

Then she divided 22 into 4+4+4+4+4 and remainder of 2 mangoes

Then she said each child will get 44 mangoes and 2 mangoes will remain

She asked how to make 2 mangoes 'SAMASAM'? (how to make it into equal parts?).

She was finding this very difficult to solve as the 2 mangoes that remained had to be divided equallly among 5 children.

Excerpts from the Doors of Learning workshop on misconception among the three students that were shadowed: Some of the procedural observations that revealed the misconceptions that are internalised, are documented herein.

Observing Student S1-S computing while testing numeracy: She overgeneralises the concept of addition. She skips numbers in between the augend and addend. On further questioning her it is understood she wants to complete the answer quickly and in the haste, she overgeneralises. 15+3=20 is her answer. She justified "5 is there". "Means the sum has to be a multiple of 5". On asking to count again she was verbally saying "15,16,17,18". She finds the difference between the minuend and subtrahend digit by digit and sees addition and subtraction as two unique, discrete and separate processes.

Multiplication and Division: Children do not know when to multiply or divide. They cannot explain why. In the process of multiplication they make computational errors of a carryover while adding to obtain the product. They also ignore the place value.

Under-generalising the process of multiplication by S1-S When multiplying with powers of ten she works out a long process to compute the product, for example: 2X200=400 for S1-S is

```
  2    X
     200
     ———
   0 +
  00
 400
 ———
 400
 ———
```

The children misinterpret place value. In the case of S3-R a student from the municipal school, multiplying 15 X 16 was attempted as follows

```
   15  X
   16
----------
  900
  150
----------
1050
----------
```

When student S1-R was asked why he wrote 900 he said he saw the 0 and then assumed he had to put another 0 after 9. Any amount of 0's would not make a difference.

Students do not apply the properties of multiplication but they know the properties of multiplication.

When student S1-R encountered Multiplying 8X16 he did the following (this method is used by S1-S, S2-T) student S1-R is well versed with 8 times table but he did not figure out that 8X16 is also 16X8

```
  8  X
  16
---------
  48
  80
---------
128
---------
```

Observing Student S3-R while computing: The children misinterpret place value. In the case of S3-R a student from the municipal school multiplying 15 X 16 was attempted as follows:

```
   15  X
   16
----------
  900
  150
----------
1050
----------
```

When student S1-R was asked why he wrote 900 he said he saw the 0 and then assumed he had to put another 0 after 9. Any amount of 0's would not make a difference.

Students do not apply the properties of multiplication but they know the properties of multiplication.

When student S1-R encountered Multiplying 8 X16 he did the following (this method is used by students S1-S, S4-P, S2-T) student S1-R is well versed with 8 times table but he did not figure out that 8X16 is also 16X8

```
   8  X
  16
---------
  48
  80
---------
128
```

This is process is observed in S1-R when he tries to compute in haste.

Observing misconceptions in topics of Angles& fractions: During the workshop session a game of angles was played, a clock was set up on the board, and the children were asked to compute the degrees based on the time. For practical purposes whole numbers were used to represent the

hour and minute hands. They could figure out the number of degrees that one unit of the clock represented. They knew that if the hour hand was on 3 and the minute hand was on 12 the angle between the hour and minute hand was 90° but if the hour hand was on 1 and the minute hand was on 12 then they could not compute the angle between the hands. Prerequisite for learning angular measurements is to understand the meaning of Angle. The students say angle is “90 degrees”.

Misconceptions in fractions are observed. Except 4 students, all other children treated the numerators and denominators as separate whole numbers. S1-S, and two others, had developed one concept of their own when they see the denominators are same numbers they perform addition (or subtraction) of the numerators and write the answer but if the fractions have different denominators then they add (or subtract the numerators) and then add (or subtract) the denominators and write the answers. The rule adopted by them is : when fractions to be added (or subtracted) have different denominators they simply treat the numerator as an integer and the denominator as a separate integer.

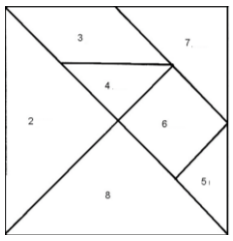
Eg: $\frac{1}{2}+\frac{1}{2}=\frac{2}{2}$

$\frac{1}{4}+\frac{13}{4}=\frac{14}{4}$ alternatively $\frac{1}{2}+\frac{1}{4}=\frac{2}{6}$

Stage I and II: Photographs from primary research

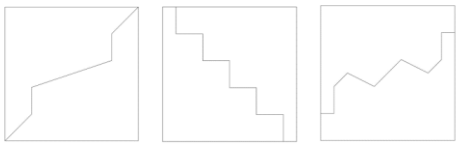
<table>
<tr>
<td>  
Children from marginalised section of society playing with toys</td>
<td> 
child playing with designed intermediaries</td>
<td> 
Experiencing floor area is not enjoyable activity- Bhambarde School.</td>
</tr>
<tr>
<td>  
Art is a mundane activity in school limited to colouring for pre-schoolers</td>
<td colspan="2">  
People believe that vertical surfaces have no surface area</td>
</tr>
<tr>
<td> 
Right angle used by masons. This made using the edge of a plywood sheet assuming the corner of the sheet is a perfect right angle</td>
<td colspan="2">   </td>
</tr>
</table>

Stage III : Intermediaries designed and used

<table>
<tr>
<td>  

Tangram designed with denim for children to deduce that cloth has surface area</td>
<td>  

Unit square blocks designed with Velcro to make children understand the concept of ‘units of Area’</td>
</tr>
<tr>
<td> 

Intermediaries made with paper
 </td>
<td>  

Blocks to manipulate made with bamboo using natural dyes.</td>
</tr>
</table>

Stage III: Students from focussed study in class

<table>
<tr>
<td>   
Children from marginalised section of society distracted during classroom instruction</td>
<td>Eating a fruit  plucked from a tree to skip mid-day meals</td>
</tr>
</table>

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Received 10.04.08; revised 13.06.08 referred on Feb 20 2013

Publications

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1: Conference IHope, Sapparo Japan, 29, June 2016. Published in conference proceedings.

Title: Sociological Aspect to education: Experiential Education field trial in Mumbai

ABSTRACT

It was observed that Children studying in municipal schools' lack conceptual understanding in Mathematics. Children drop out of school after Class 7. The dropout rate in Mumbai amongst the Scheduled Caste and Other Backward Caste categories has increased according to the survey for assessment of dropout rates at Elementary level in twenty-one states (January 2013). In order to investigate the misconceptions developed, Experiential Learning sessions were designed and tested for eighteen Saturdays after school hours and compared with sessions conducted in formal school during school hours. Activities were designed to ease the cognitive load in children. The sessions were planned and activities designed around the curriculum were meant to be de-stressing. The learning output was recorded. The study was based on the premise that children would understand concepts in Mathematics if they were related to real life experience and that they would be comfortable in an "out of school" environment. The paper examines the sociological factors if any, which affect children's conceptual understanding. The study is centered on children belonging to lower economic strata of the society and belonging to Scheduled and Other Backward Caste attending municipal schools in Mumbai.

Keyword: Untouchability, education, caste, Hindu, education,

2: Conference IESTL 2017 Hiroshima Japan, 5, July 2017. Published in conference proceedings.

Title: Design education and training: Developing curriculum for Undergraduate Design Education

ABSTRACT

Undergraduate study in design is taken up by students after Class 12. the students of undergraduate studies in Design have diverse backgrounds, interests and views. They have pre-conceived notions of the course. One hundred students of Product Design from the second year Bachelor of Design course, were tested on conceptual understanding in plane euclidian geometry and their capability to understand the course study of forms. This study was conducted on two batches of 60 and 40 students of the second year. students tried to visualise

forms and their process was documented. The course output gave pointers to develop the course further. The output of the tests conducted sets guidelines to the instructors to effectively develop curriculum and the mode of communication to students.

Keywords: Curriculum, Undergraduate Design, Conceptual Understanding, School Children.

3: Poster Publication National Institute for Mathematics Education-HBCSE 2010, Mumbai

ABSTRACT

This paper aims to compare solutions given by farmers and students to problems posed on area and perimeter of a rectangle. The study is made in an Indian context. Unschooled practising farmers were able to figure out solutions for complex geometrical configurations which occur in real life. It is observed that students have difficulty to solve problems in real life situations. Meaning associated with the process of problem solving is studied. This paper elucidates the meaning associated by students and farmers in solving problems. Mathematical ability herein is conceptual understanding, application of the concept in problem solving and computation. The need for mediation in math education is highlighted as an outcome of the study.

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Acknowledgements

I thank my son **Akshar** for highlighting the misconceptions and igniting the thought of this topic. **This work is dedicated to Akshar Nair**.

Sajive (my husband), I still miss you. Thank you for letting me peruse education after marriage.

I profusely thank my father **Sri K G Shenoy** and my Sister **Dr Parimala** for sitting up late nights to motivate me in writing. I also am indebted to my mother who died in 2010 and was a great help till her end.

I thank **Prof A G Rao** who initiated the workshop 'Doors of Learning' and permitted me to use the knowledge gained out of this experience. Rao sir, I thank you for letting me participate actively in the workshop as a resource person, designer and to communicate concepts during the workshop. I profusely thank **Dr B K Chakravarthy** for believing in my work and guiding. Without the help of Prof Rao and Prof Charavarthy this research would not have been possible.

I thank **Prof Ramesh Bairy** for the critical reviews provided and examining the research. I thank **Prof V P Bapat** for taking interest in this research and providing valuable feedback.

I Thank **Dr Gabriela Goldschmidt** for the encouragement, doing a quick review of the research and providing valuable feedback. This was surely motivating. I thank all the subjects in this study who willingly participated in the research.

I thank **Ms Annie Thomas** whose valuable experience in international Montessori training and love for English helped me edit my work.

I thank **Prof Kirti Trivedi** for permitting me use his private collection of books and giving me inputs at various stages of this journey. Sir, thank you for believing in this work. I thank **Sensei Kohei Sugiura** for patiently listening and discussing my research. The feedback and encouragement are very valuable.

I thank **Jo Boaler, Keith Devlin, Dr Sternberg** and **Dr Srinivas Kota** for permitting me to use and quote from their work. I thank **Prof Shreekumar** (HOD), **all faculty** at IDC and in the Academic section IIT-B for constant support.

Thank you **Sudhakar Shenoy** you triggered the thought of taking up research.

I specially thank my friends

Dear **Dr Nandini** (KMC Manipal) my childhood friend ..thank you. You always picked me up in all my personal tragedies and losses till date.

Dear **Roshan Taneja ma'am** thanks for the constant support during this research and support during my personal tragedies.

Smita Mahale and **Kumar** my cousins thanks a ton for everything. You are my favourite family members … My Aunt late **Mrs Vinay Shorey** was a constant support till her end.

Thank you **Prof A K Das**. I will be ever indebted to you **Manjari** for being forthcoming to help me in the research when I needed help the most.

Dr Sushmita a constant motivation throughout my research. Thank you, Dr Sushmita. **Vineeta** how can I ever thank you? you spent countless nights when I was analysing data ….those post-its gives me jitters now but …..then,…. they eventually helped me sort data. Thank you.

I could not have completed this work without the help of **Prashant Patekar**, **Vinay Adhikari** and **Anupama Shimge**. A special thank you to you all.

I profusely thank **Rudrapal**, **Gangamma**, **Mr Praksah**, **Mr Kini, Mr Patil, Mr George, Mr Diwekar, Mr Patkar, Mr Prajapati, Mr Navle, Mr Nandu Sawant, Ms Pragati, Ms Shubhangi. Rajan sir**, thank you for solving all computer related issues.

Special thanks to **Samarth** for helping me make the intermediaries at very short notice, understanding my cryptic instructions and understanding my sketches. Thank you **Prof Udaykumar, Prof Satyaki** and **Prof Avinash**

A very special thank you to **Ranjana** who patiently handled the correspondence and ever kind to complete the paper work on time. Thank you **Nancy** at the security ID card issuing office and **Nancy** at the IDC office.

When I needed a hand most, I always found a paw at IDC thank you to all the stray dogs who cheered me up when I was feeling low. I will always cherish this experience. Thank you.

……the end

Table 3.4: framework of Inquiry		
	Theoretical framework to base the research (ELT, MLT and action research)	Conceptual frame work using experience-based activities outlining possible courses of action or a preferred approach to an idea. And possible design intervention.
Research problems	Literature review indicated that with in the purview of Experiential learning Theory the Experience based pedagogy is **not structured** with respect to the academic system prevalent in the country. There is no empirical study on the (intermediaries) experience-based activities, effectiveness of experience-based activities and their impact on learners in primary schools, as an established mode of communication of concepts in school.	Experience based activities are not developed with in the tenets of 'experience-based pedagogy'. Experience based activities are not used in schools to communicate and facilitate conceptual understanding. There is no recorded database of activities from where a teacher can refer/pick/take/modify and use the activities, to facilitate class room instruction that suits the needs of the learners. Examining curriculum to design intermediaries for class room instruction
Research Questions	Effectiveness of experience-based activities in the preview of ELT: Will attending experiential learning sessions enable children from municipal schools to develop cognitive/metacognitive strategies to link experience to formal school problems? Will experience based pedagogy decrease the dropout rate in municipal schools?	Can experience based activities be used effectively in school to communicate concepts and facilitate conceptual understanding in primary schoolchildren? Necessity to design a questionnaire to examine there are any other factors affecting learners by which they develop misconceptions and deter them from conceptual understanding

	Within the frame work of Motivational Theory and the ELT it is required to be examined if the children attending municipal schools be motivated to attend formal school after attending Saturday school (out of school) experiential sessions	Should the curriculum facilitate experience-based pedagogy inclusive of hands-on-experience (art-craft) linked to academics with mediation, to be effective with primary schoolchildren from an economically underprivileged background? Proposing to design activities for a children to generate interest in class room instruction.
	ELT and connection with real life experience for conceptual understanding.	Should the experience-based pedagogy inclusive of real-life experience linked to academics with mediation, to be effective with children from an economically underprivileged background? Children would have a conceptual understanding if they learnt concepts connected to their real-life experience.Designing activities linking real-life experience and concepts in school.
Theories to base the research on	Experiential Learning Theory, Mediated Learning Theory Action Research,	Experience based activities used to help children understand concepts. Instructor without misconception to mediate with intermediaries. To observe the class in its natural setting. Instructor of the school being given the intermediaries. Testing the class after the experiential setting.
Necessity of this knowledge	Within the theoretical framework of ELT in the Indian context to determine effectiveness of ELT in class room communication in India.	Within the conceptual framework it is important to design classroom instruction that is effective for learner to learn with conceptual understanding by decoding how they learn and equip/direct the learner to develop metacognitive abilities.
Basis of the Hypothesis	**Experience based activities can generate interest in children for developing conceptual understanding.** (Bruner, 1960,	**If 'hands on' experience of a learner or real life (Gandhiji – Nai Talim) experiences are connected to concepts in school, it would help a student to understand abstract concepts and facilitate learning with**

	1977)**. Experiential Activities can be designed.** (Krippendorff, 2007)	**understanding. It can motivate children to attend school and in turn prevent dropout rate in school.**
Quality of Data that is needed to answer the questions	The theoretical framework rests on Action research used as a methodology to determine the measurable outcome mode and effectiveness of Communication and obtaining data (Recoding data)	Classroom studies observe students in their natural environment. To deduce the behaviour/attitude of the (subjects) students to class room learning. Classroom observation would determine the effectiveness of classroom communication by observing teachers conducting a formal class. Recoding data in a closed out of class room setting would deduce the behaviour of the students in a controlled environment. Study of classroom observations to probably help to decode learning among students and the root cause of internalising misconceptions.
What is the source of Data	Based on Action research and questionnaire	Primary data is obtained from the groups observed and children in various settings. Primary data by shadowing children and participating with their peers and activities with no formal inputs. Primary Data obtained from the teachers conducting class and attitude in an 'out of class' setting.
What are the methods to collect the data needed for the research	Action research as a methodology to observe both in class sessions in person and on a one-on-one basis.	Classroom observation entails behaviour and response to instruction by observing subjects respond in their natural surroundings.Creating environments that are conducive for a learner and conducive for a researcher to observe.
Mode by which data would answer the research	Interpretative mode of analysis based on Strauss and Corbin (Strauss, 1990.)	Interpretation based on a phenomenon would be based on qualitative studies to observe pattern in data obtained.

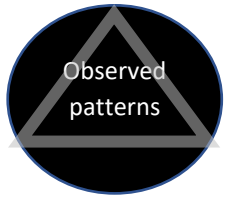
questions- data analysis		Insights could shed light into the manner in experience-based activities that can be used in communicating concepts to schoolchildren. Design of structured questionnaire and formulating probable questions for an unstructured questionnaire if the response is deviant.
Plausible Research contribution	Experience based pedagogy along with Mediated Learning Theory to assist in decoding learning among children.	Conceptual learning among children of lower Economic stratum would be understood giving a new direction to design effective curriculum Testing and evaluation of criteria developed, to encompass the misconceptions.
Validity and data analysis	Action research is carried out in various modes. Participant, non-participant, Data to be collected and analysed.	Interpretative so it is self-validating. Exploratory research Data collected from various geographic area from a heterogeneous group of people to understand their aspirations for their children and their views on education and experience-based pedagogy. 
Generalisability	Based on Grounded theory to see if the findings are generalisable. (Strauss, 1990.)	Solutions can be formulated on a need and case-to-case basis to improve conceptual understanding amongst children.If the learning amongst this section of students is decoded, then it can be generalised and extended to Learning amongst the children from the lower economic stratum of the society. An effective curriculum can be developed based on intermediaries that are designed to communicate concepts in classroom. Developing a grading system to evaluate learning.

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Table 4.2.1: Summary of the responses given by salespersons and owners of shops.

	Description of the place	Questions asked by this researcher posing as customer	Criteria for framing questions	Response to the Questions	Remarks
GROCERY SHOPS	**SHOP1:** Selling cake mixes. The shop was packed with people. Customers in the shop were purchasing greater than 1 Kg.	Asked to purchase 105 grams of flour.	Odd quantity of commodity was asked to check if the sales man could weigh and compute for odd quantities.	The shopkeeper wanted to check the recipe as there was no other customer asking for an absurd quantity. The shop keeper decided to not sell flour	(1) Shop keeper did not want to sell small quantities when he had other customers buying more than one kilogram **He found it a waste of productive business time and a meaningless activity** **Found no meaning in selling. Avoided rare and unusual circumstances.**
	SHOP2 AND SHOP3 There were not many customers. (Three to four people in the shops).	Asked to purchase 260 Grams of rice priced at Rs.24 per kilogram.	Other customers do not buy 260 Grams. Quantities of rice sold are in multiples of 250 Grams. 260 Grams Was chosen to check the math ability and the reaction to a different and unusual situation encountered while on job.	Salespersons weighed the exact amount of rice. They used a calculator and used the formula 0.001 X cost per Kg (24 Rupees.). X Quantity in grams (260 Grams.). To arrive at 6.24Rs. Rounded off to Rupees. 7 instead of Rupees. 6.50. Owners of the shop have taught them the above formula. **They could not explain why and how the formula was derived.**	(1) (2) **Internalised and applied 'on job' learnt skill to solve a given task.** **They used the formula taught by owner without understanding.**
		The price of 250Gms. of rice was asked.	To check how they calculate the price for standard quantity that they usually sell and familiar with.	The reply was Rs.6 They obtained this number by dividing the price of a Kilogram by four.	(4) **Simple math operation of division is applied.**
		Take on education	They love to attend formal schools.	Everything about formal schooling is intriguing. The aspect to wearing uniform and sitting on tables and chairs. Not having to work with hands.	**Prefer formal school to experiential learning.**

	SHOP4	Asked to buy 260 Grams of rice that was priced at Rs.24 per kilogram.		He calculated the price for rice correctly. He did not use the calculator.	(1) (2) (4)
					(2)
	SHOP 4 Salesman Since he was able to perform complex calculations he was quizzed further	Was asked if a saree hung on a clothesline has surface area.	Everything that is a rectangle has area.	.	The **concept of only rectangles or rectangular surfaces** having area. Is a misconception internalised and harboured.
		Does a ball have surface area?	Ball does not have surface area	The point of contact of a ball to ground or cupboard is negligible so it does not have area.	Their concept of objects having area is limited to rectangles whose surface touches a flat surface.
		Take on education	He loved the Local municipal school that he had attended.	After doing household chores, he did his school work. He likes ‘pen and paper’ learning. He loves mathematics and likes to compute. In school he used logic to solve math problems. He thinks of the problem ‘as it is’ and there is no analogy of real life that he relates to the problem.	**Prefers formal school to experiential school as one should learn from textbooks.**

Table 4.3.3.b. Response of the one hundred domestic help (maids) who wanted to form a SHG.

Sl. no	Questions asked	Responses			Remarks on why the questions were asked.
1	Counting: Small Two digits.	75 maids can count	25 maids could not count		To understand if they had knowledge /skills of numeracy, as it is the prerequisite to the topic of Area and Perimeter of a Rectangle.
2	Do you measure the length of the string used to dry the washed wet clothes?	100 maids replied in negative.			Posing the question helps find out if lengths are measured. String to hang clothes is measured by them in metres and is available in the desired length.
3	How do you buy string to dry your wet clothes after washing?	20 maids said they buy small Bundle of the string. (one small bundle is sold in shops of a standard length 7 metres.)	58 maids said they buy a Medium sized bundle of String (Medium bundle is double the length of small bundle 14 metres)	22 maids did not purchase the string. Their husband bought it. They had no idea of the length of the string.	This question was asked to see if anyone in the house actually understands length as a measure and find out their acquired knowledge of lengths and measures.
4	What do you understand by Area (‘Kshetra Phal’)	100 maids replied that Area is the space of room			To find out if they have any previous knowledge on Area and Perimeter of a Rectangle.
5	What is the Area Of this Room (where they had gathered for the meeting).	100 maids replied it is 150 Square feet.			Based on the previous answer, if they could visually estimate the area of the hall they had gathered in which was approximately 1000 square feet.
6	Why Square Feet and not Square metres.?	100 maids replied in the city, Estate Agents use square feet as a measure.			This was asked to test the knowledge of the metric system. As the MKS system is followed, but the area in villages is measured by a local unit called “GUNTA”, Acres and Square Feet.
7	How do they charge for Domestic work? Is it By Square feet Of the House? Or Do they have a unique way of charging for their labour?	71 maids said they charge their labour by the Number of Rooms in a house & not by the square feet of the rooms.	8 maids said they compare old buildings to Newer Buildings and visually determine if the newer building is bigger or smaller than the older building that they were familiar with. Then charge (visual estimation)	21 maids that one ‘leader’ (dominant female who sets standards in their community) gives them an idea in case they don’t know.	Since all the people who had gathered worked as domestic help in houses, it was important to know how they charge for their work. Some of the builtup areas of the flat are ‘big’ and some are ‘small’. Built up area ranging from 550 Square Feet to 4000 Square Feet
8	What is the surface area of the saree	100 maids replied that saree has no surface area			Saree is a draping fabric which is five meters long and width 3 feet or 3.5 feet depending on the loom. It is hung vertically to dry. This question was asked to find out if they could relate to area of objects placed vertically and as the property of the object.

l. no	Questions asked	Responses			Remarks on why the questions were asked.
9	Why is saree measured in Metres	100 maids replied that shop keeper measures in meters so they do not question but accept that saree is measured in metres.			Saree is often measured in metres. Not in “square units” wanted to know if there was general awareness.
10	Point to objects in this room that have ‘surface area’	99 maids pointed to the floor as the object with area.	1 maid: did not respond		To check if they knew if the walls had areas.
11	Which is greater ¼ or 1/8?	99 maids responded 1/8 is greater than ¼	1 maid said ¼ is greater than 1/8		To find out if they divide food and use the concept of fractions while dividing food?
12	Do you cut roti in Half? and ‘Paav’ (1/4)	100 maids said they cut roti in Half (Aadhi)			
13	Can we divide roti into 8 parts?	100 maid Concept dividing roti 8 parts is non-existent			
14	Find a way to divide five mangoes amongst five children	100 maids replied each child would get One mango.			
15	How do you divide Eleven Mangoes between 5 children?	100 maids replied that each child would get two. The remaining would be cut up into random bits			
16	Do you divide food equally among all?	100 maids said it would be meaningless to divide food equally among all family members.			
17	how will he give 4 litres of milk to a customer?	6 maids replied: Two Litre Twice. Take five litres pour from the five litre can to the three litres. In the five litre can two litres would remain. Give this to the customer. Repeat this process and the customer will get 4 litres.	94 maids said they did not Know how to do it.		They buy milk from the milk man. To find out if they observe how he measures the required quantity and also find out if they know how to divide liquids by using measures

Sl. no	Questions asked	Responses			Remarks on why the questions were asked.
18	If you are in the milkman's situation how would you keep 4 litres of milk ready for the customer if you have 5 litre and 3 litre measuring containers?	94 maids replied that they did not know.	6 maids identified it is the same problem and that one maid had solved earlier. They felt that the Right solution is already obtained and futile exercise to repeate.		This was to see if they accept role reversal and figure out the above problem if it concerns their house and they have to keep 4 litres ready for their family.
19	If two parts of water are added to one part of milk (Water **:** Milk ratio is 2:1) and the resultant liquid is 60 litres. How much milk and how much water is there in the resultant liquid?	17 maids answered, that 40 litres of water and 20 litres of milk are present in the resultant liquid.	79 maids Did not Know	4 maids randomly said numbers without thinking. Response was incorrect.	The measures are related to physical solid objects in everyday life. People use liquid measured very tacitly. Since they were going to start a SHG to make food, it was important if they understand liquid measures and if they had any knowledge how to estimate quantities using ratio and proportion.
20	If there are 11 parts of water and two parts of milk in 60 litres of solution (water: milk ratio is 11:2). How much milk and how much water is there in the resultant liquid?	83 maids could not answer and said they did not know.	1 maid said that the question was erroneous.	16 maids Answered 110 parts of water and 20 parts of milk. They added a '0' To 11 and 2 and said 110 and 20.	
21	If you consume 12 litres of water per day how much water will you consume in16 days?	17 maids computed erroneously.	2 maids computed correctly	70 maids said "forget it" 5 maids Gave up	Water is scarce in slums. Consumption of water is a serious issue in households. They stock water in drums around 50-75 litres every day. They did not find meaning in computing. They only knew that they had to replenish water that was consumed.
22	Is it good to have Experiential education in school? Learning from experience and learning by doing?	100 maids replied that NO experiential activities be included in curriculum	1 maid said skill development is ideal	100 maids: skill development should be tailoring or cooking and must be introduced in schools.	Meaning to learning is to earn more money an additional income supplements the joint income of the household.

Table 4.3.1.b 1 Response of the Vegetable vendor

	Questions asked	Criteria for the questions asked	Response to the Questions	Remarks
VEGETABLE VENDOR	What is the cost of ¼ kilograms of carrots.	She was not selling odd quantity of vegetables. But in multiples of ¼ kilograms, 100 gms. and 50 gms.	She calculated with ease the cost of 250Gms 100Gms and 50Gms. She consulted a fellow vendor selling fruits for validating the amount she calculated. Upon enquiry, it was found that the fellow vendor uses price for 100 Gms as a base for all other calculations.	(1) (5) She had to sell vegetables for a living. This was the meaning to her activity of selling vegetables She has to device her own methods to compute costs and concludes by taking help of the fellow fruit vendor She has to please customer
	This researcher asked to purchase 5 Gms. Green chillies.	To check how she weighs and computes small and unusual quantity	For weighing 5 Gms. chillies, she used a small stone as a weight. She charged Rs. 2 (randomly) without computing. She said the weight of stone was 5 gms because it was less than 50 gms. Weighing stone	(6) Ability to develop tacit knowledge **from previous experience** She sells so that she **always profits from the sale** and the customer feels that she has not overcharged.
		Leafy condiments are not quantified but asked as 'little'. To check how she calculates and the quantity of leafy vegetables she gives.	A rupee was charged for sprig picked by hand. There was no basis for calculation	
	Identification of colours in terms of the freshness of the vegetable.	She could identify how green should the green chilli to be called mature		Tacit knowledge of the colours. She could visually tell by the colour if a vegetable is stale.
	Whether saree hung on a clothesline has surface area.	She said 'No' as it hangs vertically. Saree is not 'floor' therefore saree does not have area.	.	Only floor has area. The concept of only floor having area as the meaning of area applies to only floor area. This is because the cost of housing in city is not comparable to that in villages. and the meaning of losing floor area is significant.
	Do vegetables stacked (upwards) have area?	She said 'No' because they are not on the ground	Only things kept on the ground have area. Like area of room.	
	Does the vegetable basket have area?	She said 'No'	When it is kept on the ground the floor area is lost	
	Take on education	She was sceptical if she could study if she had an opportunity. But she loves the idea of going to school	She was old and if given an opportunity she would have formally schooled her children. They would have loved the idea of formal school. When asked why? She said the job of selling vegetables was only thing she did and going to school is something unimaginable and elite.	Advocates formal schooling. Why should children do experiential activities? They have to 'study' was her response.

Table 4.3.3.a.: Response of the educated domestic help.

Subject	**Questions asked**	**Criteria for the questions asked**	**Response to the Questions**	**Remarks**
Educated Domestic help aged 26 (passed Class 10 exams) Willing to participate in the experiment. She divides food in the house among her children and her sister's children.	10 mangoes are to be divided among 5 children How many mangoes will each child get?	This is a simple text book question. she has 5 children at home.	2 mangoes per child	(1) (4) She wanted to prove academic competence. She was constantly stressed of her educational background. She applied the process of division
	11 mangoes are divided among 5 children how many mangoes will each child get?	Simple text book question To see how she would handle the remainder of one	2 mangoes per child and one mango will be surplus. She says cannot divide 1 mango among 5 children	(1) She has given 2 mangoes per child if there is one mango surplus its OK. She finds no meaning in dividing the surplus mango.
	Why can you not divide the mango? How can the remaining one mango be divided?	To probe and understand her response.	How to cut 1 mango and give five children. She also said only four children will get one piece of the mango and one child will get left out	To her if mango remains with her it is not an issue as long as the children get equal whole mangoes.
	She was asked to explain how.	To probe and understand her response.	She took the analogy of the rupee her response was: "think of one Rupee divide into smallest part" "it is 25ps" "so only four will get quarter of rupee"	(5) Drawing own conclusions using known analogies and trying to find a method of solving the problem.
	She was asked: "how many Paise in a rupee?"	To understand if she knows or not the currency.	Her response: "100 Paise in a Rupee but there is no Paise below 25" She rejects the analogy of rupee and goes on to draw the mangoes. She draws the mango and makes cuts on them to represent graphically the pieces. Cut the mango into 5 parts and distribute. "Cutting it will be difficult".	(1) (5) Coins below 25 Paise are out of circulation. Drawing the object to represent graphically the physical situation.

Subject	**Questions asked**	**Criteria for the questions asked**	**Response to the Questions**	**Remarks**
	222 mangoes are to be divided among 5 children how many mangoes will each child get?	Text book problem was asked to check her computational skills and techniques used by her	She said it is 'BHAGAKAR' (process of division). She split 222 mangoes into 10+10+10+10+10 …..Till she distributed 200. That is 40 mangoes per child. Then she divided 22 into 4+4+4+4+4 and remainder of 2 mangoes Then she said each child will get 44 mangoes and 2 are surplus	(4) She applies simple mathematical principles of dividing in parts by grouping
	She asked how to divide 2 mangoes in equal parts for 5 children 'SAMASAM'?	Testing to see if she remembered the previous solution and applied it or how she would tackle this situation To physically visualise cutting ⅕ of 2 mangoes is unusual and complex.	She was finding this very difficult to solve the remainder 2 mangoes to be divided among 5 children was very taxing to her	(1) (5) In real life situation problem, solving becomes main criteria. She drew mangoes, made cuts, and figured out by trial and error method.
	Question from 'bamboo dyeing' manual (training manual for trainers): 50 Gms. Haldi is dissolved in 5 litres of water How much Haldi should be added to 7 lts of water?	How she responds to other situations. Haldi (turmeric) is used in cooking. Cooking involves liquids. This situation is very much like a kitchen activity. Not complex.	She tried using the rupee as an analogy and commented "it is water not mango" Concept of liquid caused confusion. .	(5) Drawing as a tool to visualise the solution in real life situation. Drawing was an aid/tool to computing.
	Asked her if saree has surface area	She said when drying it does not have Surface area but when folded it has surface area	Concept of saree occupying area in the horizontal plane only.	This question was asked to investigate her understanding of the concept of area of a fabric. Since fabric is measured in units not square units
	What is the length and breadth of your saree?	It is 5 metres It has no breadth		To see if she knows that Area of a Rectangle has length and breadth
	Can area have only length?	No		

Subject	**Questions asked**	**Criteria for the questions asked**	**Response to the Questions**	**Remarks**
	When you fold a saree, you said it occupies area. How can you have area without breadth	Folded saree has breadth. Open saree does not have breadth. When it is hung, the breadth goes away.	It has been observed most subjects say that cloth does not have area while hanging.	To check if she knows if saree has surface area.
	Where does the breadth go?	When you open it and hang on the clothesline, it goes away and again when you fold it comes back. Somethings just happen in life. Like 'GOD'. You know that god exists but you cannot see and you can feel therefore one know he exists.		
	Make a square with the following plastic pieces. Three triangles from the tangram puzzle were given.	She quickly arranged the pieces and made a square.		
	Given a cloth tangram pieces and asked to make a square	She replicates the above procedure.		
	Does this cloth square have length and breadth which are equal	Yes. For a square the length and breadth are equal		
	The square cloth is taped to book. The book on which the square is kept is tilted to 90° Now does it have the length and breadth	Yes		
	This square is cloth piece and single layer and when it is vertical how come the breadth did not disappear? Can you now see the saree and identify the length and breadth while hanging?	She maps the sides of the square with her fingers and feels the saree. And identifies the breadth. And giggles.		

Subject	**Questions asked**	**Criteria for the questions asked**	**Response to the Questions**	**Remarks**
	With reference to the above exercise, Did you find it? Did it go anywhere?	Ohh…. yes, I found it. I was always there but we can see only one side of the breadth not two when hanging.		
	She was asked of her views on Education and how children should be educated.	She commented that the questions asked were “hard” and it is not the way the school asks the questions	She said her children should be formally schooled. She also said that experiential education is inappropriate as the children face tough life at home and it is unfair to have work experience in school. Having said that she also said if they are trained in a skill like tailoring it would help them in addition to academics	She advocated formal schooling and skill incorporation in curriculum as to enable them to earn and help the family financially.

Table 4.3.4. Comparison of the responses of Student 1, student 2, and student 3

	Questions asked	Criteria for the line of questioning.	Response to the Questions	Remarks
STUDENT1 Boy from Class 9 SSC board English medium school.	1) Design a label for a perfume can with no overlapping edges or gaps. It should envelope the container surface only once. To calculate length of paper needed & verify the radius. (Steel rule, string and stiff paper were given to be used as tools to measure.) 2) questioned on the concepts of Area and Perimeter of a Rectangle 3) Does a saree that is hung to dry have surface area? 4) does a note (money) have surface area? why? 5) does a coin have surface area? why?	To find out how children in work situations apply their acquired knowledge. To find out if they had any misconceptions on Area and perimeter of a rectangle.	Student 1 did not remember the formula and had forgotten all about circle He did not want to continue with the given task.	Student 1 did not find meaning in this activity He was familiar to the researcher of this study. He did not want to be ridiculed or compared to another child. He 'hated' mathematics.
STUDENT 2			Student 2 took the string and enveloped it around the surface of the can. He marked the string with pen. Then he cut the string with reference to the marking. He placed the string on the steel ruler and measured its length. He placed the ruler on the paper and cut off the length (L) required for the label (L=15.9cms) He placed the label on the surface and found a gap. He verified the radius using the formula C= 4/3 πr^2 (incorrect) He measured the radius with the steel ruler and said it is '2.4 something' He managed to make a label but had a 4mm gap at the between the ends of the label. He completed the given task and exclaimed that taking paper would have helped instead of the string. He liked doing this activity and learning rather than learning passively. He had not done such work in school or anywhere else. Knew that saree had surface area Notes have surface area Coins don't have surface area	Student 2 believed rectangles have area and any circular object that is not kept flat on the ground, does not have surface area
STUDETNT3 Class 10 Marathi medium boy			Student 3 cut a long piece of paper of required breadth and enveloped it around the surface of the can. He measured the circumference of the given can. Finally he measured the piece of paper that was cut to design the label for the can (L=16.2 cm) He went on to verify the radius using the formula C=$\pi r/2$ Had forgotten the formula. He measured the radius as 2.5. There was no gap between the ends of the label. He knew that saree had surface area Notes have surface area and Coins don't have surface area	Student 3 felt proud to design a label for the can. He liked this activity and wished this was a school activity. He gave up watching a cricket match to do this activity. No one else had given the student an activity before. No fear of being judged as it was not an exam. He felt proud to be attended individually Believed rectangles have area any circular object that is not kept flat on the ground, does not have surface area

Table 4.3.1 1: Response to questions by four Masons and three apprentices

Sl. no	Questions asked	Responses	Remarks on why the questions are designed.
1	If they could count two small digits	All seven masons could compute	To understand if they had knowledge /skills of numeracy, as it is the prerequisite to the topic of Area and Perimeter of a Rectangle.
2	Do you measure the length of the string used to dry the wet clothes?	All seven did not measure the string. They just bought a bundle of string as sold in the shop.	This was posed to find out if they measured lengths. String to hang clothes for drying wet washed clothes, is measured in metres and is available in the desired length. Since a pre-determined length is available, they did not find the necessity to measure.
3	How do you buy string to hang clothes?	All seven said they buy a small bundle and share with neighbours	This question was asked to see if anyone in the house actually understands length as a measure and find out
4	What do you understand by Area (Kshetra Phal)	All seven masons said that Area is the area of floor, tiles and wall	To find out if they have any previous knowledge on Area and Perimeter.
5	What is the Area of this bathroom (the bathroom in question- where the study was conducted and they had to tile it)	All seven said 140 Sq. feet	This question was posed to gauge if they could visually estimate the area of the bathroom that they had to tile. They estimated it by the number of 2' X 2' tiles
6	How do you know the area?	Based on the number of tiles needed	
7	Why do you measure area in Square Feet and not Square metres.?	We don't know and don't want to know	This was asked to test the knowledge of the metric system. As the MKS system is followed, but the area in villages is measured by a local unit called "GUNTA", acres and square feet.
8	How do they charge for tiling work? By square feet of the house?	All seven said that they agree to the terms of the contractor. They do not compute the costs.	All masons find it difficult to find jobs and have to depend on the contractor for making a judgement of paying them. It was important to know how they charge for their work. Some of the areas of the flat are big and some are small.
9	What is the area of the saree	All seven said that saree has no surface area	Saree is a draping fabric which is five meters long and width 3 feet or 3.5 feet depending on the loom. It is hung vertically to dry. This question was asked to find out if they could relate to area of objects placed vertically and as the property of the object.
10	Why is saree measured in metres	All seven responded that sometimes saree is measured in metres	Saree is often measured in metres. Not in "square units" wanted to know if there was general awareness.
11	Which is greater 1/4 or 1/8 ?	Six masons said One eighth One mason said ¼	To find out if they divide food and use the concept of fractions while dividing food.
12	Do you cut roti in half and 'paav' (one fourth) by cutting	All seven masons cut roti in half and ¼	

Sl. no	Questions asked	Responses	Remarks on why the questions are designed.
13	Can we divide roti into 8 parts	All seven said roti is never divided into 8 parts.	
14	Five mangoes to divided between 5 children. How many mangoes will each child get?	All seven said one each	
15	Divide Eleven mangoes between 5 children. How many mangoes will each child get?	All seven said two Each. The surplus one is divided in randomly.	
16	Do you divide food equally among all?	All seven said it was meaningless to divide food. As food taken/served depending on how hungry a person is.	
17	A milk man has milk and two measuring jars of capacity, 5 litres and 3 litres. How will he give 4 litres of milk to a customer?	All seven said Two Litre Twice Transfer to three-litre container from five-litre container. Two litres remain in the five-litre container. Repeat for another two litres to obtain 5 litres.	They buy milk from the milk man. In order to find out if they observe how he measures the required quantity and also find out if they know how to divide liquids by using measures
18	How would you keep ready 4 litres of milk if you are in the milkman's situation?	All seven found it meaningless to answer this question	This was to see if they accept role reversal and figure out the above problem. If it concerns their house and if they have to keep 4 litres ready. They buy from the milkman and rely on the milkman's knowledge of giving milk. They accept any quantity.
19	How much milk and how much water is present in 60 litres of the solution where the water : milk ratio of 2:1.	All seven meaningless as it is tacit	
20	To make water: milk ration of 11:2 in 60 litres. How much milk and how much water?	All seven asked if this was a joke.	
21	What is the water consumption for 16 days at the rate of 12Litres per day	All of them computed wrongly	
22	Experiential education: is it good to have it in school. Learning from experience and learning by doing	All said no to experience based activities in a class room.	Meaning to learning is for additional income. They prefer formal (passive) education for their children.

Table 4.3.3: response of the farmers to the questions asked.

Description of the geographic area.	Questions asked	Criteria for the questions asked to Farmers	Response to the Questions	Remarks
Twenty-five farmers from Rajasthan were interviewed. Three dropped out from class 5 one dropped out from class 6 and one dropped out after class 8 Rest twenty farmers are not formally schooled or uneducated	Simple task to calculate the perimeter of the given objects.	To check if they know to calculate the perimeter of the field.	They added the sides of the diagram given and calculated the perimeter	(1) (2) (4) They applied traditionally learnt concepts. They used simple mathematical operation of addition to calculate. They have sense of numeracy and knowledge on Perimeter.
	Calculating area when sides were given.	To check if they know how to calculate the area of a flat rectangular surface. and relate it to the area of field.	They could not calculate area by knowing the length of sides. They could not figure out. They responded that this problem is not encountered by them as they already knew the area of their plot.	
	Interdependency of Area on Perimeter and Perimeter on Area of a rectangle.			They know area as a fixed measure. As they possess land with fixed area. They could not be tested on this concept.
	They were asked if a saree hanging on a clothes line has surface area?	To test if they had knowledge of objects having surface area.	All 25 responded in negative. Because saree is not a field.	What matters to them is land and area of land.
	Their views on education	To check their attitude on learning and their reaction to experience based activities in school	They want their children to attend formal school. They are working (practicing profession) at home so why should they work in school? They consider experiential activities as a waste of time.	All farmers advocate formal schooling

Table 4.3.4: Response of bamboo craft persons from Maharashtra:

Sl. no	Questions asked	Responses	Intention of asking the questions
1	If they could count two digits between 20 and 50	52 subjects could count 2 subjects could not count	To understand if they had knowledge /skills of numeracy As it is the prerequisite to the topic of area and perimeter. They use numeracy to count baskets, money spent and received.
2	Do you measure the length of the string used to dry the wet washed clothes?	54 subjects replied ‘ NO ‘	To find out if lengths are measured. String to dry clothes is sold in metres. Desired lengths of string are available in shops. To see if anyone in the house actually understands linear measures.
3	How do you buy string to dry the washed clothes?	Response of **25females**: males in the house buy it **22 males**: whatever the shop sell we buy. **7 subjects**: we do not bother to get. Someone from the house gets it.	
4	What do you understand by Area (Kshetra Phal)	54 subjects: Area is the space of room	To find out if they have any previous knowledge on Area and Perimeter.
5	Area of this Room (where they are gathered)	**50 subjects:** 150 Sq. feet **4 women:** did not answer	If they could visually estimate the area of their own home.
6	Why is area of the room measured in Square Feet and not Square metres?	**47 subjects:** don’t know **7 adults:** it has come from years back.	To test the knowledge of the metric system. MKS system is followed currently. Area of land in villages is measured by a local unit called “GUNTA”. In addition to GUNTA, people also measure land by acres and square-feet
8	How do they charge for baskets they weave with bamboo?	**54 subjects:** Rupees 60 for one big basket	They do not plan and estimate the cost. They earn 60 rupees per basket when they sell it to the people for packaging fish.
9	What is the surface area of the saree?	**54 subjects:** Saree has no surface area	Saree is a draping fabric, which is five meters long and width 3 feet or 3.5 feet depending on the loom. Saree is hung vertically to dry. Answer to this question would determine if they could relate to area of objects placed vertically and as the property of the object.
10	Why is saree measured in metres?	**54 subjects:** “because you can pick it up in hand and measure it with the tape”.	Saree is often measured in metres. Not in “square units” to investigate if, there was general awareness among the subjects.
11	Point out objects having area in this room	**53 subjects:** pointed to the floor **1female:** did not respond	To check if they had acquired knowledge that walls and other objects had area.

12	Which is greater 1/4 or 1/8 ?	**53 subjects:** 1/4 is greater **1 subject:** 1/8 is greater	To find out if they divide food and use the concept of fractions while dividing food?
Sl. no	**Questions asked**	**Responses**	**Intention of asking the questions**
13	Do you cut roti in Half? And Paav (one fourth)	54 subjects: Aadhi (Half) and Paav (One fourth)	They divide the roti into half and one fourth and they know that more parts mean smaller the piece.
14	Can we divide roti into 8 parts	**54 subjects:** yes	They make huge rotis of diameter one foot. The roti is folded and cut into half. The half roti is folded and cut into a fourth to store in a roti container. The one fourth roti is cut into a one eighth when they have to feed small children
15	How do you divide Five mangoes to amongst 5 children	**54 subjects:** One each	This question gave an insight of the personal knowledge used to divide food. Mangoes are seasonal and subjects are familiar with the fruit.
16	How do you divide eleven mangoes amongst 5 children	**54 subjects:** two Each The remaining mangoes cut in random bits and distributed.	
17	Do you divide food equally among all?	**54 subjects:** meaningless to divide food	If they find meaning to divide food equally among people.
18	How to obtain 4 litres of milk? Using measuring jars of 5and 3 litres.A milkman has milk and two measuring jars o f 5 litres and 3 litres how will he give 4 litres of milk to a customer?	**50 subjects:** don't know **1 female:** did not answer **3 adults** (children of the workers): 2 litres twice (pour from five litres can to the three litres can resultant is two litres in the five litres can. repeat this process twice)	They buy milk from the milkman. To find out if they observe how he measures the required quantity and find out if they know how to divide liquids by using measures.
19	Retain 4 litres of milk, if you are in the milkman's situation?	This question was not asked to this group.	
20	How much milk and how much water is present in 60 litres of the solution where the water : milk ratio of 2:1.	**53 subjects**: 30 water 30 milk **1 female**: did not answer	The measures are related to physical solid objects in everyday life. People use liquid measured very tacitly.
21	water : milk is in the ratio of 11:2 In 60 litres. How many litres of milk and how many litres of water are there in the resultant dilute milk ?	This question was not asked.	
22	What is the consumption of water for 16 days if you need 12 litres of water at the rate of 12L per day	This question was not asked, as they get enough water in drums and they said they do not know exactly how much water a bucket can contain. They fill water into plastic drums with a steel vessel	
23	Experiential education: is it good to have it in school. Learning from experience and learning by doing	**54 subjects:** no	
24	Do you think learning skill in school would help a child in future?	**54 subjects:** no	They reiterated that skill was mundane like the work they were doing. They want their children to attend a formal school

Table 5.1.a 1: Justifying the methods adopted in order to observe and study the subjects.

	Approach towards Research- Tests	Reasons for testing & methodology
5.2.b. 1	Pre-test was conducted on a) 85 children of class 8th SSC Board b) 60 students of class 7 SSC Board (total subjects studied are: 145)	The group from class 7 and class 8 were chosen to determine if: • if the students have conceptual understanding. • if the (knowledge acquired) concepts learnt in class 7 are used in solving problems in class 8
5.2.b. 2	**Initial research question and hypothesis was conceived by advocating the use of learning from experience and experience-based pedagogy. The outcome of this was undesirable and the test failed.** **The outcome of the initial study necessitated further extending the need to Inquire in depth.** **Social factors from local and Phenomenograpy studies of the research are taken into consideration to build the hypothesis**	
5.2.b. 3	Intermediaries were to be designed for use in classroom observation. The same intermediaries needed to be used after 6 months (after conducting the 18-week workshop)	From references, Frobel Occupations and Fraudenthal (Fraudenthal, 1972), it is evident that concrete

		intermediaries help in visualising abstract concepts. **…** contd on next page From the pre-test it was observed that misconceptions developed during primary school were harboured in adulthood. •
5.2.b.4	Studying a group of 20 students of the same socio-economic stratum of the society over 18 weeks in a workshop. Experience-based pedagogy and experience-based activities were used to communicate concepts. 15 students in the group were underperformers they were re-tested for conceptual understanding after a gap of 6 months. This was to test if conceptual understanding actually took place and if they recalled and understood concepts.	• Out of 20 students studied, 10 children were from an SSC Board, government aided school. • 5 children were from the SSC Board. their school was funded partially by government and partially funded and administered by private management. These children were high performers and were eliminated from the later study as studies on high performers was out of the scope of this study. The intent/focus of this study is to decode how children learn and develop misconceptions. • 5 children were from the SCC Board government school. As underperformers they were subjects of interest for this study. Four of these children

		dropped out from the 18-week workshop. **……..** contd on next page
5.2.b.5	Failure of the initial Hypothesis	The earlier Hypothesis was based on experience-based pedagogy creating conceptual understanding. The hypothesis failed because students dropped out of the session.
5.2.b.6a	Studying the children on the topic of fractions, area and perimeter of a rectangle in their schools after six months (post the 18-week workshop). (15 underperformers were tested in this study as the other five students were high performers and had access to help from school teachers and professional guidance).	To check if the students continue to harbour misconceptions after participating in sessions based on experiential activities.

5.2.b.6b	Studying the learning abilities in the students who dropped out of the 18- week sessions.	The four children who dropped out from the experiential session were underperformers in school. They however attended formal school. It was necessary to find out the effect of experiential sessions on these children.
5.2.b.6c	Understanding how the students develop misconceptions in mathematics	
5.2.b.7	**Determining why the hypothesis has failed**	Understanding how students develop misconceptions gave a clear picture as to why the initial Hypothesis failed.
5.2.b. 8	**Designing an effective assessment system to address remedial education that will aid students who harbour misconceptions to bridge the gap in academics.** **The cue to assessment was drawn from the Van-Heilie method of geometric learning.**	The current assessment system is based on the recall of knowledge. It does not give a measure of misconceptions. This was discussed with teachers and then a plan was drawn up to study the evaluation scheme.

Table 5.3.2.b 1 Design intervention in class, in which five children were observed.

Sl no	Exercises given and description of the intermediaries given to children.	Before design intervention	After design intervention
1	**Card-board bending exercise:** A card board was cut into half in various ways. The back of the card board was taped on the cut so that tape acted as a hinge and the card board could be folded over the cut. The folds were planned so that pre-determined shapes are obtained on folding. This was given to the students to feel and fold in several ways, they could fold in more than one ways.	They knew only one way to divide the square into half. They divided the square into half along the diagonal. Square craft papers were given to students. They folded them along the diagonal to make into half.	They explored other ways to divide a square by folding the card board. Some of the cuts did not yield a half but they tried. They could explore successfully with paper by cutting in more than one way.
2	**Playing with blocks to understand if there is interdependence of area and perimeter of a rectangle:** one-inch square blocks were cut from full-bamboo, these blocks were used as intermediaries.	They had to make shapes and compute area and perimeter of the shapes with one-unit square blocks. They had a problem to compute the perimeter and assumed the Perimeter and Area are the same.	The problem of understanding continued. On rearranging blocks, they still had the misconception of Area and Perimeter being interdependent on each other.
3	**Computing area of irregular shapes from the known areas. Then computing perimeters.** The students were given irregular cut-outs. They had to draw a one-centimetre grid on the irregular shape and compute the area of the given shape. They were given a string to measure the perimeter of the shape.	Students could not compute the area or the perimeter as they could not approximate the half or one-fourth of a square on the square grid. While finding the perimeter the thread was slipping out of their hands	This task was found too difficult for children.
4	Students were given1000 rupee notes and one- rupee notes to determine the area of the notes	Prior to this task they all believed that smaller denomination currency does not have surface area and higher denomination currency has surface area. The significance in the value of the currency led to this belief.	Students computed the area of both notes and deduced that irrespective of the denomination value both possessed surface area.
5	Students were given a cuboidal box and were asked to determine the surface area of a box.	This task was not tried earlier.	This problem was not solved by the whole class they just did not find the meaning to this problem and when packaging of soap in box was shown and erasers in a box were shown, they ridiculed the exercise and did not want to do this task.
6	Students were encouraged to frame a question on surface area and perimeter of rectangle for fellow student to solve.	This was not tried earlier	They were shy and after much coaxing asked questions. All questions they framed were recalled from memory by rote learning.
7	Blocks made with bamboo that were used in the earlier studies (with farmers and bamboo workers) were given to students they had to manipulate these blocks to find area of irregular shapes and computing the perimeter	They had failed to compute the perimeter and area of the resultant pattern.	They made patterns but could not compute the area of the resultant figure. The overlapping edges of the blocks had posed the problem.

Sl no	Exercises given and description of the intermediaries given to children.	Before design intervention	After design intervention
8	Discussion on dividing the square into half. Extending the principle of dividing the area to other scenario like field, blackboard and food (chocolate and roti)	They did not find meaning in dividing food.	From the example of cardboard, they tried cutting food items in many different cuts. Cadbury's chocolate and roti were given to them.
9	They were given a square piece of paper 6" X 6". They had to make a tangram with the square paper. They were asked to draw it in their book. They were asked to calculate the area of the square they made.	They could not make the tangram pieces. Their inability to cut precisely yielded poor quality shapes. They found it craft like activity.	One child cut the shapes of the tangram fairly well. All except one child computed erroneously as they could not calculate the side of the triangle. The area of the square (whole tangram) was calculated using the formula Side X Side.
10	Does saree have surface area? Does your face towel have surface area? This was verbally asked and not given as a task.	To this the entire class had replied in negative.	Three students were unsure. Mixed reactions were obtained from the rest of the class, some said saree has surface area, some said saree does not have surface area. This was verbally asked hence the answers could not be documented.
11	Playing with cloth tangram: tangram was designed using denim cloth. The cloth is stiff and resistant to wear and tear. This puzzle was given in class to all forty students including the five children who knew the puzzle as they were exposed during the 'out of school' workshop.	They made shapes using the tangrams by seeing the shapes on paper. They computed the area of square shapes. They found it difficult to compute the area of other shapes.	They tried to make the given figures. As children (except 5 who attended the workshop) had not played with the puzzle earlier, they took time to figure out the puzzle.
12	Cloth tangram that was designed as an intermediary was given to students	In Question 3 they were confused and some students said that saree (cloth) has no surface area.	They were asked to comment on the material of the tangram. They said it is cloth. They discovered that they can compute area of cloth tangram and deduced that cloth has surface area and hence saree has surface area even if it hung on a clothes line.
13	**Making squares with pieces of tangram:** tangram has seven pieces. The task was to make squares with two pieces, three pieces, four pieces, five pieces, six pieces, seven pieces. Freedom of choosing the shapes was given to the students. (combination of making a square with six pieces is an impossible task). After making these squares they were asked to compute the area and perimeter of the squares and tabulate the result, they were encouraged to infer from the exercise what they observe, they were asked to dismantle the square and compute the area and perimeter of individual pieces that constitute the shape and compare with the area and perimeter of the whole shape,	All students could manage to pick two shapes (two triangles) with pieces 4, 5 and 2, 8 to make two squares. The three students who dropped from the workshop and who were studied in detail, could create squares with triangles. They could not create other shapes with other pieces.	They could make the shape but when asked to compute perimeter of individual pieces, they still showed the misconception of believing that area and perimeter of a rectangle are interdependent. The children who attended the workshop were unable to compute and infer,

Sl no	Exercises given and description of the intermediaries given to children.	Before design intervention	After design intervention
14	**Applying the concepts of area and perimeter to other situations:** a text like question was given. Problem of digging a well in a square area. The problem given to student states that the circular well of 7 feet is to be dug in a square field of side 7feet. Draw the situation and compute the area to determine if a path of garden can be made in the plot of square land after the well is dug. Deliberately the radius of the circular well was given as 7 cms. and the side of the square were given as 7 cms. This was done so to see how the students react to the exercise.	One student from the class could figure out after questioning the answer and subsequently questioned the task. She was not among the students that are being observed and she had not attended the workshop sessions. All students constructed a square 7cmsX 7 centimetres. Found the mid-point as the intersection of the diagonals of the square and drew a circle with the radius equal to the distance between the mid-point and the side of the square. The resultant figure was the well. It was inside the square.	This problem was not attempted by all three students who were being observed and who had earlier attended the “out of school” experiential activities. After computation one girl was able to sense that the area she obtained was negative then she re- drew the problem and found out that the well engulfed the plot and went on into the next plot of land. She laughed and commented that the area is negative because it eats the neighbours plot of land. After quizzing individually, it is found that all students understood this problem Rest of the class (including the girl who answered correctly). The drawing was still incorrect with the well inside the garden. This is because of the fact that they see a well only inside a plot of land and never imagine the situation posed to them.
15	**The students were asked to make a photo frame and calculate the area of frame**. They made the frame but were not able to calculate the area as the frame was small and scaling the task would enable them to comprehend the task. The task was changed in class during the classroom observation to find the area of the frame of the black board in class and the area of the black board Deducting area of the black board from the total area inclusive of the frame to determine the area of the frame of the black board	Three students could relate to the problem and computed correctly. The other two children could relate to the problem and could not compute. Rest of the class did not relate to the problem. Out of these three students being observed, one student continued to do other work in class and did not perform the task.	All three students (from the workshop who were earlier exposed to the same problem) could not relate to the concept of area of the blackboard. From the rest of the class only one student could relate to subtraction of area. Even on scaling the problem, the students found it difficult to visualise
16	**Role Reversal:** The two students were asked to explain area of square on black board (one by one).	They could not explain. They starred at the board. The three students who dropped out were addressed individually and then asked to teach the concept of area and perimeter to the class. The other two girls teamed up and were clearing their doubts on numeracy. The boy did not participate in this experiment.	They did not care about the activities as the exams were approaching. They were constantly asking for solutions to problems in the exercise of the text book. This was again tried after class only with the three students that are being observed. Initially they were shy. Then all three took turns and explained. It was observed that they did not have the pre-requisite of numeracy and mathematical operations. At every stage they were They were seeking for mediation.

Table 5.3.2.a Revisiting the research questions framed through a new lens using focussed critical approach:

Revisiting the research questions	**Experiment:**	**Claim**	**Findings:**
Research Question 1: Should experiential activities be designed to communicate concepts effectively in schools? To answer the above question, experiments are conducted in school and the results are documented.	Standard activities listed in 'A' level curriculum were used and results were tested against the activities designed specifically. The 'A' level curriculum out of the scope of this study. The premise that 'A' level curriculum is better that SSC/CBSE/ICSE curriculum is accepted and current research is based on this premise. Questions administered to children are based on simple geometry, like cutting a square into half and determining the area of the half. Dividing a rectangle into half and the area of these halves had to be computed. Pre-cut square paper was given. While this session was going on, two children were writing Marathi Journals and they were not interested in the session. **One out of forty students could solve the problem by simply dividing the area by 2.** **Thirty-Five students divided the paper square into half along the diagonal of the square.** Students with the cut along the diagonal found it difficult to compute the area of the half as the resultant shape was a triangle. Roti was cut into two halves to demonstrate concept of 'full' and 'half' and that area of a surface can be divided into two halves. They could not connect with the concept that the area of the resultant shape obtained by dividing the original shape is half of the parent shape. They listed three objects that have no surface area. **The mathematics teacher was asked to evaluate their answers. The teacher evaluated that the objects mentioned by students as without area was in fact correct.** he had shown a clear misconception about "Area" but the concept of perimeter was clear. The teacher was confused with spherical objects. He said 'lemon' (fruit) did not have surface area. In class, the teachers prompted the answers to students while testing in class. They have a strong sense of right and wrong and are not analytical while judging the response of students. The teacher conformed to the solution in the answer key in the text. This attitude left no scope for a student to analyse the problem and solve it. Children had generalised the concept of cutting and computing. They could not relate the concept to other objects which could not be physically cut in to halves. They said coin had no surface area as they can't cut and calculate while notes had area because they can use the concept of 'cutting'. The premise was that you cannot cut a metal coin but you can cut a note. They also had a notion that small objects do not have surface area. The "petal of a small flower has no area but the leaf has area". Field has area but paper has no area. The concept of scaling was taken up using the intermediaries like 'roti' and 'poori'. 'Poori' is smaller than a roti. Pieces of 'poori' were smaller. Pieces of 'roti' were bigger both 'poori' and 'roti' were circular. They had to relate to their real life. They had to Calculate area and perimeter of whole roti/poori and calculating their half sizes obtained by cutting them into halves. Small circles made of Propylene sheets were cut into circles of different diameters. They were further cut into half. These intermediaries were used to teach children how they can be generalised for metal objects. The children could visualise the process of calculating the area of the objects but only with mediation and teaching with intermediaries, they could visualise how area can be divided. This circular object was compared with the rectangular object. In a circle the area and perimeter are interdependent and, in a rectangle, they are not.	**Standard activities do not help students to visualise & understand concepts.** **Students are not able to connect & generalise (laterally transfer) concepts to another situation.** The concept of area has to be explained in the terms they understand. Standard exercises listed in math lab as recommended in NCERT syllabus using paper cutting does not fulfil the objective of communicating the concept. The activities designed around the misconceptions will help to communicate the concepts effectively in a class.	**Activities designed were related to their life experiences but not central to their real life.** **They were able to connect and understand the concepts.** **Simplified activities reduce cognitive load in children**

Revisiting the research questions	**Experiment:**	**Claim**	**Findings:**
Research Question 2: Do children studying in municipal schools reflect on the instruction taken up in class at school on a day to day basis at home?	One on One interaction with the children was taken up. They were asked to redo the questions, which they answered wrong in the previous exercise. The students were individually observed while solving textual questions and during activities. During school hours all 40 children were individually interviewed. The children attending the workshop were also interviewed. The children committed errors in problem solving but were not able to figure out the errors. They had problems in memorising the multiplication tables, in determining the place value, and basic computation (addition). They did not know the algorithm to multiply. The children did not attempt to find out why they made errors. Once the papers were given to them they did not bother to even ask or interact as to why they were marked wrong. During personal interview, they revealed that they had not seen the answer and had too much workload after school hours. They also have to attend private tuitions. Home work to all 40 children was a routine 'job' or 'exercise'. These assignments as homework were either solved by the tuition teacher or just copied from peers or guided by their older siblings.	**They do not know if they have committed an error while solving a problem. Their thinking can and be directed towards the solution. Self-reflective practices are non-existent among all the children interviewed** After the post-test, this situation did not improve. They still did not bother to reflect on their own on the previous day's work. Upon mediating and when the children are calm they reflect on the problem and solution. This process helps them find out where they needed to change and why they need to change.	**Children studying in municipal schools do not reflect unless directed towards reflection. If the instructor mediates and assists in breaking down the problem, then they can think back or reflect. The children need to be composed and not be restless to address the reflective process**.

Revisiting the research questions	**Experiment:**	**Claim**	**Findings:**
Research Question 3*:* Do Children studying in Municipal schools find it difficult to concentrate in class due to spiralling curriculum? **Can children bridge the gap in the curriculum by experiential learning activities?**	A task was given to the students from their text book. The school requested that some topics in the mathematics text dealt with, in a formal manner from the current text book. Instructions were given in the class and the process was videotaped. The sessions were videotaped. The session was continued after changing the teachers. The first session was conducted by the school teacher after which the teacher left, so that students could solve problems on their own. Another teacher came to supervise the class and took over the class. This was a practice followed in school should one teacher have other classes to attend to. Finally, a one on one interaction by researcher (designer) with children revealed that previously learnt concepts were not clear. Children do not attend school for long periods of time. Problems at their home keep them away from school for many days at a stretch. They were given questions from the prescribed text book to solve. Only two children out of 40 students could answer all questions. There was a pattern that was observed among the children. Most gave blank sheets with “don’t know” as answer to the questions. Some children pretended to be ill every day. On checking their health record, it was found that they had no chronic ailment. On a one-on-one interaction they expressed their desire to re-learn some concepts they did not understand. On checking their attendance record it was found that they had not attended the particular session and were unable to make up for the lost instruction in class. Sessions for 15 minutes were conducted after class hours in school, for students who had remained absent to school and had difficulty to understand the concept of area and perimeter of a rectangle. The children were given the tangrams to explore and play with them. A test was conducted verbally on the concepts in the presence of the school teacher. They were able to overcome the misconceptions they internalised, by mediated learning using tangrams as intermediaries.	**Absence of students from school due to social activities or other necessities that demand children to stay at home were causes that children miss out instructions in class. The spiralling curriculum only compounds the issue. On its own the spiralling curriculum was not the cause of lack in concentration amongst children.** It was found that in this particular school, children do not attend classes due to several reasons. (1) Single parents (widows or divorcees) needed children’s assistance at home to enable them to take up extra jobs. (filling water, waiting for delivery of gas cylinder, sick younger sibling, illness of the single parent, child birth of older sibling and maintaining the house). (2) Ambedkar Jayanti preparations and (3) attending other social functions at the cost of missing lessons at school. The parents also encourage them to miss school. Social functions are used to introduce teenagers for a potential marital alliance. Children who have missed school were given the intermediaries and left to explore them and discover the concepts. They felt at ease when playing with the intermediaries and said they did not have the pressure to solve on paper.	**Bridging gaps in curriculum is possible with activities designed around the concept. The social problem faced by families is difficult to address and not within the purview of this study**

Revisiting the research questions	**Experiment:**	**Claim**	**Findings:**
Research question 4: Do teachers have conceptual understanding of the topic of area and perimeter of a rectangle? How does their understanding affect the mode of instruction?	**Experiment to check the teacher knowledge:** The math teacher was asked to correct the answers to the questions asked to the students. The teacher at one point in confusion asked "do spherical objects hanging in air had surface area?" he then said "no" and marked the student response as "correct". Children were asked to write objects they think that do not have surface area. All children had written ceiling fan as answer. The concerned subject teacher asked the researcher if objects hanging in air have surface area? He also marked the answer by students as correct. Objects on the ceiling have no surface area (according to the teacher)	**The study by Feuerstein and others show that there is a possibility that misconceptions internalised by the teachers are transferred to the students during classroom instruction.**	**The misconception internalised by teachers is a deterrent in classroom instruction. If the teachers do not have conceptual understanding, they resort to following the text book as the means of teaching. They are unable to take extra measures to research and relate to the teaching material.** Post the above intervention, the students are tested before their final exams to understand if the children have managed to gain conceptual understanding. The intervention is designed in such a way that students discover the properties of the material and shapes and figure out with very less mediation and least inputs.

Table 5.4: Behaviour analysis of the students in class.

Time	Observations during a class session	Behaviour of students and Analysis
9 am	Children were seated in class. Some of the children were late.	They help in house hold chores and get late to class.
9.10 am	Attendance was taken	Some children were absent due to illness.
9.15. am onwards	Instruction begins. Children were distracted. Two students were drawing on a book. Some were completing a homework assignment. Best friends sit side by side and chat. Topic of conversation is Bollywood film stars and dance. The 4 students	The children were not interested in listening to lecture from the teacher. They wanted to socialise They idolise film stars. They were tired of working at home and School was a place to socialise. One student was continuously drawing in his note book. This child was from a single parent home. He initially said his father was dead. On enquiring the cause of his father's death, he said that his father has walked out on his mother other siblings and therefore he considers him 'dead'.
9.45 am	Break	Children eat fallen fruits and tamarind. They buy cheap food and don't play with each other. They were constantly talking.
10 am - 10-45 am	Instruction begins One student (S2-T) was sleeping. The other student (S1-S) was distracted. Student (S3-R) was busy writing. Student (S4-P) stopped attending sessions after three sessions.	The student who was sleeping (dropped out from the workshop) was complaining that she had severe stomach pain The other student (S1-S) was complaining about head ache. On observing up close it was found that S3-R was copying material to complete his submission. His tuition teacher had written his homework and he was copying into the submission sheets.
11 am to 11.45 am	Instruction continues for another subject	The children continue their behaviour. They were talking to each other while the class was going on. **They had no motivation to listen to the teacher.**
11.45 am to 12.30 pm	Instruction for the last session before lunch break. lunch break	Children were given food by the school. They despised it and tried to eat taste enhancers. The food consisted of dry puffed rice with turmeric, broken wheat (rava-upama) preparation.
12.30 pm to 1.15 pm	Instruction of the post lunch session.	Most children were not responsive as they were sleepy
1.30		Time to disperse home.

Table 5.4.I 1: Overview of the research questions, experiments conducted, claims and findings in a classroom set up.

Research Questions	Experiment	Claim	findings
Experiential activities need to be designed to effectively communicate concepts in schools.	Standard activities listed in 'A' level curriculum were used and results were tested against the activities designed specifically.	Standard activities do not help students understand the concepts. Students are not able to connect and over generalise the concepts while applying to another situation.	Activities designed were related to their life experiences but not central to their real life. They were able to connect and understand the concepts. Simplified activities reduce the cognitive load in children
Children studying in municipal schools do not daily reflect classroom instruction at home.	One on One interaction with the children and they were asked to redo the questions which they answered wrong.	They do not know if they have made a mistake. Their thinking can and be directed towards the solution. Self-reflective practices are non-existent among all the children interviewed.	Children studying in municipal schools do not reflect classroom instruction unless directed towards reflection. If the instructor mediates and assists in breaking down the problem, then they can think back or reflect. The children need to be composed and not be restless to address the reflective process.
Children studying in Municipal schools cannot concentrate in class due to spiralling curriculum. The children can bridge the gap in the curriculum by experiential learning activities	Instructions were given in the class and the process was videotaped. The sessions were conducted by changing the teachers for the same subject. Finally, a one-on- one interaction by this researcher (designer) with children revealed that previously learnt concepts were not clear.	Absence of students from school due to social activities or other necessities that demand children to stay at home. Due to these factors, children miss out the classroom instructions.	Bridging gaps in curriculum is possible with activities designed around the concept. The social problem faced by families is difficult to address and not within the purview of this study
Research question: Do teachers have conceptual understanding of the topic of area and perimeter of a rectangle? How does their understanding affect the mode of instruction?	Experiment to check the teacher knowledge: The math teacher from the school was asked to correct the answers to the questions asked to the students. The teacher at one point in confusion asked if spherical objects hanging in air had surface area?	Claim: The study by Feuerstein (Feuerstein, 2010) and others show that there is a possibility that misconceptions internalised by the teachers are transferred to the students during classroom instruction.	Findings: The misconception internalised by teachers is deterrent in classroom instruction. Some teachers do not have conceptual understanding. They resort to following the text book as the means of teaching. They are unable to take extra measures to research and relate to the teaching material.

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Table 6.5: response of subjects /expectations of the subjects: The over view of all subjects interviewed and their response and expectations.

SL No	**Number of subjects interviewed**	**Subject and demographics**	**Response / expectations of the subjects.**
Stage I: Initial Studies.			
1	1	One student of class 7 from SSC board school who was a “failure” termed as “dumb” by the school, society and his parents	Was not interested in tangrams initially as he could not complete the tasks given. Role reversed and he was asked to teach the puzzle to other children. He managed to teach visually. He was not able to explain. This **motivated** the child he came with his math book for help.
2	3	3 farmers from Nepal	Can distinguish area and perimeter of a field. They show no misconception about the interdependence of area and perimeter. They believe that square (6x6) is the larger than rectangle (4x9)

			Mainly because more crop can be grown in the square plot and the water can be channelled according to the area that the crop is grown. They want their **children to be formally** educated in school. They consider activities of tangram as a part of art and craft in school and not as a part of academics.
3	4	Shop keep and salesmen from 4 shops in Mumbai	Selling was a meaningful activity for them. They could compute from learnt traditional procedures without understanding the process. Where they failed at numeracy, they used a calculator to compute.
4	1	Unschooled Vegetable vendor in Mumbai	She was asking a fellow vendor to compute. She could not weigh precisely or compute.
5	100	100 maids in Mumbai who were trying to set up Self Help Group.	The maids had no knowledge about area and perimeter. Since they were forming a SHG they were asking for help on estimation and computation of raw materials They want **children to be formally schooled**. Activities in school de-stress children and **do not see them as academic content.**

6	60	Students of class 9	Students of class 9 harboured misconceptions on area and perimeter of a rectangle. These study was conducted to establish that children internalise misconceptions and carry forward to higher classes.
7	4	I student who was attending regular school was given a task. And three other students were given a task based on experiential activity. 3 students who dropped out from school, working to supplement family income.	Children did not know the difference between area and perimeter. They were working to supplement the income for parents. They were able to make labels with geometric instruments. They had skills with no conceptual knowledge. They were not able to extend the concept of area and perimeter to tangram puzzles. They wanted to go back **to formalised school.** They **don't want activities** to be a part of curriculum.
8	3	Students of Waldorf school	The school advocates experiential learning amongst students. Students cannot connect theoretical knowledge to real life scaled situations.
Stage II Intermediate studies			
9	4	4 masons from Banaras	They had misconceptions about area and perimeter. But they had knowledge about area and perimeter.

			They use visual measures and estimations. They want **formal schooling** for their children. They **do not want activities** as a part of academics. They see activities as art and craft and do not link these with academics. They want their children **to have "good jobs in government".**
10	60	Undergraduate design students	The task given to masons was given to them. These students had internalised misconceptions from school and harboured this until this design intervention by giving the task on area and perimeter of a rectangle through the tiling problem given to masons.
11	25	25 farmers of Rajasthan	They did not know the difference between area and Perimeter
12	54	20 families of Bamboo workers who have migrated from Karnataka to Mumbai.	They had misconceptions about area and perimeter.
13	25	25 Bamboo workers from Assam	They did not know area but knew how to fence land. They did not know how to compute the length of wire needed to fence the land. The **want formal schooling.** They prefer **formal content in** school.
14	25	25 Bamboo workers from Chattisghar	
15	20	20 Bamboo workers from Nagaland.	

Final focussed study			
16	20	20 children from workshop	Discussed in detail in chapter 5
17	40	40 students from SSC board school.	Discussed in detail in chapter 5
18	3	Final 3 students shadowed from the 40	Discussed in chapter 5

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FINDING MATHEMATICAL ABILITY OF FARMERS AND STUDENTS WHEN SOLVING PROBLEMS

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ABSTRACT

This paper aims to compare solutions given by farmers and students to problems posed on area and perimeter of a rectangle The study is made in an Indian context. Unschooled practicing farmers were able to figure out solutions for complex geometrical configurations which occur in real life. It is observed that students have difficulty to solve problems in real life situation. Meaning associated with the process of problem solving is studied.

This paper elucidates the meaning associated by students and farmers in solving problems. Mathematical ability herein is conceptual understanding, application of the concept in problem solving and computation. The need for mediation in math education is highlighted as an outcome of the study.

FARMERS: Twenty five farmers form Baran, Rajasthan underwent training to make Bamboo Products. Farmers were making Bamboo products to earn additional income. They own Five to Ten Bhigas land . They cultivate their land and grow seasonal crops. Most of the cultivated crop is for sustenance. They partly sell the produce. The farmers belong to scheduled caste. They believe in supernatural phenomenon and believe elders. They also believe in people in power or authority. They do not question authority. One male farmer was a class 9 school dropout. One female farmer was a class 9 student wished to pursue further studies. Two male farmers were class 4 dropouts. Rest of them were not formally schooled.

STUDENTS: Pilot study: Forty One students (Class 7 CBSE) were interviewed as a part of a project. It was found that the students had their own understanding about area and perimeter of a rectangle.

One hundred students (class 7 CBSE) were interviewed during an independent study by MDes student as a part of product design project. Questions from both studies were posed to the farmers. All students interviewed said that they love to play.

One student from the Waldorf school was also poised with the same questions.

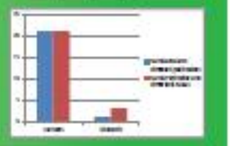
FENCING & AREA OF THE FIELD: Response given by Farmers and students to open ended and text book problems on Area and Perimeter of a Rectangle.

FARMERS: Fencing wire for field is not equal to perimeter of the field. "There are support posts to secure fencing wire so fencing wire required is more than the perimeter of the field". "What school books teach is not actually what happens in the field".
"Start measuring perimeter from 1 on a tape because 0 BEFORE ANY NUMBER HAS NO VALUE". "0 in between numbers has value".
"Productive / cultivatable area of the field is not actually the whole area".
"Path ways water ways or well take up some area and this area has to be deducted to find the actual usable area".

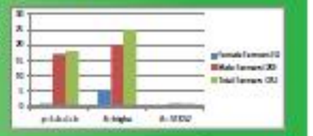
STUDENTS: Fencing wire for field is equal to perimeter of the field.
"Even if there are support posts to secure fencing wire it is not to taken into account to estimate fencing wire; Because: The text book says so".
"Start measuring perimeter from 1 on a tape as 0 before as NUMBER SYSTEM STARTS FROM 1".
Productive / cultivatable area of the field is actually the whole area. Field thought of as a rectangle drawn on paper.
Response of one Waldorf student: "Area was field was too big to see so I cannot relate to text book example".

Students	Yes	No	Not Sure
Knowledge of perimeter	39	2	0
Knowledge of Area	36	5	0
Solve text book problems	23	18	1

Existence of fields with	Male Farmers	Female Farmers	Male Students	Female Students
Same Area and different perimeters	17	8	0	1
Same Perimeters and different Area	17	6	2	1



Farmers	p-i-l-b-i-l-b	A- bhiga	A- SI M2
Female (13)	0	0	0
Male (20)	17	20	1
Total (25)	18	25	1



Teaching Aids designed and developed for mediation to teach area and perimeter of a rectangle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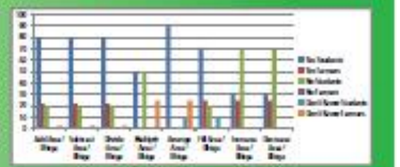
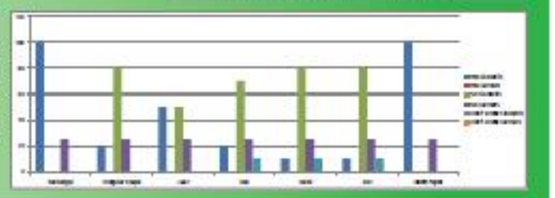
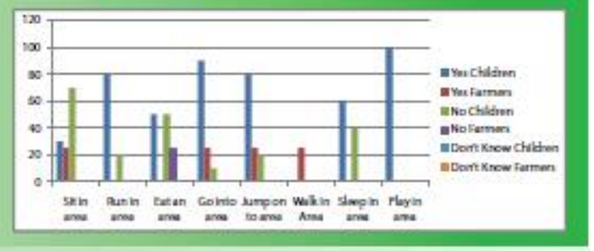
Can you	Yes Students	Yes Farmers	No Students	No Farmers	Dont Know Students	Dont Know Farmers
Add Area / Bhiga	80	22	20	0	0	3
Subtract Area / Bhiga	80	22	20	0	0	3
Divide Area / Bhiga	80	22	20	0	0	3
Multiply Area / Bhiga	50	0	50	0	0	25
Arrange Area / Bhiga	90	0	0	0	10	25
Fill Area / Bhiga	70	25	20	0	10	0
Increase Area / Bhiga	30	25	70	0	0	0
Decrease Area / Bhiga	30	25	70	0	0	0



Which of the following has area	Yes Students	Yes Farmers	No Students	No Farmers	Don't know Students	Don't know Farmers
Rectangle	100	0	0	25	0	0
Irregular shape	20	0	80	25	0	0
Leaf	50	0	50	25	0	0
Ball	30	0	70	25	10	0
Hand	10	0	90	25	10	0
Sun	10	0	90	25	10	0
Newspaper	100	0	0	25	0	0



Can You	Yes Students	Yes Farmers	No Students	No Farmers	Dont Know Students	Dont Know Farmers
Sit in area	90	25	10	0	0	0
Run in area	80	Not asked	20	Not asked	0	Not asked
Eat in area	50	0	50	25	0	0
Go into area	90	25	10	0	0	0
Jump on to area	80	25	20	0	0	0
Walk in Area	Not asked	25	Not asked	0	Not asked	0
Sleep in area	60	Not asked	40	Not asked	0	Not asked
Play in area	100	Not asked	0	Not asked	0	Not asked



CONCLUSION

It is observed from the study that farmers who, cultivate land though they have fair knowledge of perimeter; they are unable to estimate the fencing wire needed to fence the field. Meaning attached by farmers to the concept of area and perimeter is connected to livelihood. They do not see area as a surface property and consider area of any other object other than field to be non-exsistant. They seem to see division of area in terms of sharing or loosing land. Similarly increase in area is seen in terms acquisition of land.

From the response of the students it is observed that they rely on the formula as a tool to understand the concept of area and perimeter. The meaning attached by the students to the learning of the area and perimeter is to get through the annual examination by scoring 'good' marks or 'passing' the examination.

Mediation by a facilitator or teacher is required to bridge gap between experiential learning and formal learning. (TLP: Prof A G Rao)

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