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INTEGRATED-PEDAGOGY MODEL IN SCIENCE EDUCATION AT LOW-COST ENGLISH-MEDIUM MUNICIPAL SCHOOLS IN MUMBAI

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Integrated-Pedagogy Model in Science Education at Low-cost English-Medium Municipal Schools in Mumbai.

Abstract

Active-constructivist pedagogy and critical thinking has been of central focus in science learning at Muktangan since the academic year 2016-17. To develop critical thinking among students the department has initiated a paradigm shift in adopting an integrated pedagogical strategy that accommodates an **i)** integrated-pedagogy in-service teacher training, **ii)** interactive classroom design, **iii)** out-of-classroom learning and a **iv)** child-friendly pedagogical approach. This paper discusses the integrated-pedagogy strategy towards over 40 grades six and seven Muktangan trained teachers, across seven Municipal Public Schools with about 300 students in each grade, coupled with a monitoring-and-assessment mechanism.

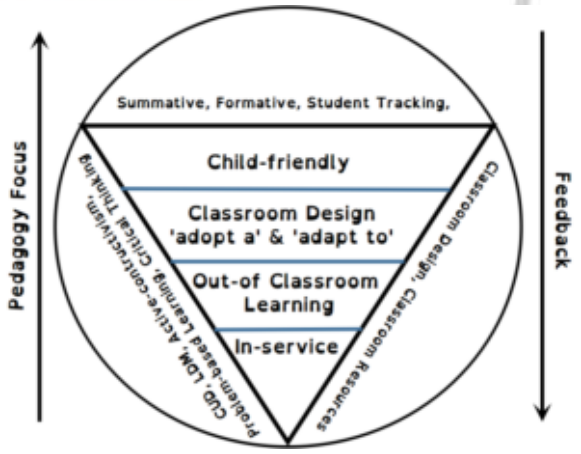

Figure: Integrated-pedagogy process

The aim is to develop a sustainable programme that could serve as a model across low-fee public schools in the city. The strategy integrates the active-constructivist

approach that is core to the organization's philosophy with activity or problem-based learning and critical thinking lesson-planning for in-service teacher training and students, while 'adopting a' and 'adapting to' a classroom design conducive to the integrated-pedagogy, initiating out-of-classroom learning strategies and developing a child-friendly curriculum. This strategy has resulted in the development of adaptable and evolving in-service lesson planning that integrates with the existing teacher appraisal system and professional development programme for teaching faculty, child-friendly lesson planning and classroom design, problem-based learning activities, effective evaluation mechanism for children with a customized tracking tool highlighting the developing domain as the child progresses over the years that integrates with the existing formative and summative assessment methods, thus closing the loop.

Key words: critical thinking, science education, active constructivism, activity-based learning.

1. Muktangan Integrated Teacher Education Programme

There are a number of public schools in India where children access an education that does not guarantee minimum level foundation skills. Despite the recommended constructivist approach (NCF, 2005), teaching methods continue on the premise of rote-memorisation. Pre-service and in-service teacher education centres in the country continue to remain isolated from schools, and fall short of providing opportunities to teachers to sharpen their practical skills and attitudes. The Muktangan Integrated Teacher Education Program (MITEP) comprising of pre- and in-service training, endeavors to bridge this vital gap in the curriculum, by introducing an active-constructivist learning methodology embedded with a rigorous school internship platform. Teachers who undergo this intervention are likely to be educational change-makers with the skills and attitudes to design and implement a relevant curriculum for the 21st century.

Muktangan and hence the science department follows a well-structured organisational culture that has evolved to work best with its educational philosophy and learner-centered approach. The teacher-trainees that graduate from the training programme join the schools as primary teachers and progress to higher grades with the students in each academic year. Teachers participate in weekly curriculum

understanding and development meetings led by subject experts and assisted by senior teachers who graduate into senior subject faculty, where key concepts are discussed to construct each teacher's understanding of the subject. Further, lesson development meetings are conducted by subject. assessments are planned and discussed here. Each teacher in each grade is also routinely observed during classroom sessions by the subject faculty. Teacher appraisals and professional development workshops that are planned based on the appraisal outcome, are conducted routinely thrice a year and work as a cyclic assessment-feedback- reinforcement system.

2. Muktangan vs Mainstream Education

2.1. - Apathy in our Education System

Research reflects that children from urban low-income families have access to schools with high student-teacher ratios that enforce rote-learning methods due to lack of integration between theory and practice in their classrooms. Unfortunately, over the years this long neglected, systematic anomaly has resulted about half of all children in standard five in India being unable to read even grade two level text books and 40% students unable to do simple math (ASER Report,2014). To add to this predicament close to 86% of parents in a metropolitan city like Mumbai whose children study in vernacular medium schools would prefer to access to English-medium schools (PRAJA Foundation Report, 2013). One must acknowledge that a mere rise in school enrollment is not the task at hand. Rather addressing the issues of curriculum and pedagogy require equal and critical attention; perhaps even special treatment for the socially under-privileged learners to help them achieve equality of outcome (National Focus Group Position Paper, 2006).

2.1.A Integration of Pedagogy

Every education institution aligns or adopts pedagogies with a foresight to influence cognition among their pupils to help them reach their potential. Cognition in an individual is defined by his/her thinking and is devoid of emotions, wishes and will. Cognition involves mental manipulation of ideas and processing of information. It is said that once cognition occurs, it leads to higher order thinking. Through the process

the individual uses the skill attained and his '*learnings*' to attempt to solve problems. Hence it is postulated by different philosophers that the set of experiences involved in this process could influence the ultimate outcome, i.e. 'learning' in the contemporary sense of terms and perhaps 'knowledge' in conventional terms.

According to Vygotsky, the effective learning is maximised through social interaction. His philosophy throws light on the importance of teacher or adult - child interaction. His theory of social interactions is based on his philosophy that when learners interact with others they build connections with the social world that enhances application of the concept learned. Dewey suggests that children learn by doing and hence education should be based on real-life situations. Dewey's proposition that parallels with Vygotsky suggests that children should be provided opportunities or experiences to develop their own interests and engage in activities that contribute to their understanding of the world.

Acknowledging the good practices in education world-wide and adapting them to the context of the unique niche of learners has been a challenge. The science department at Muktangan attempts to integrate the good practices while designing concept building plans for teachers who attend weekly CUD meetings. Being learner-centered, one must acknowledge that learners at this age group are in transition from being intuitive thinkers to rational thinkers and graduate from learning through early concrete operations to begin to learn abstract concepts. Notably, the CUD lesson plans for grade 6 and 7 provide number of approaches and experiences to explain concepts, while subject faculty and teachers sit together to devise classroom lesson plans to best suit their learners. Classroom plans stress the importance of using scientific vocabulary and develop reading and writing skills. Reinforcement is provided by using flash-cards of scientific concepts and terminology and audio-visuals. Activities included in the plans emphasise on experiencing, rather than mere completion of the task. Learners are provided opportunities to fabricate models, prepare charts, use scientific equipment,

plan and conduct experiments, gather data from varied sources, interact and a platform to work in collaboration and share their learning.

2.1.B Interactive Classrooms

Muktangan recognises the potential and strength of each child in lieu of their familial and economic backgrounds. Students come from economically underprivileged homes and underserved communities. Muktangan schools have about 12% differently-able students or those students who may be categorised as learning-disabled by the current system across all standards (1 - 10). The Muktangan school curriculum is based on 'emergent literacy', active constructivist philosophy, and inclusive collaborative pedagogy. Every Muktangan classroom is designed to cater to the active-constructivist pedagogical practices that the organisation's model strongly adheres to. Active-constructive learning is best delivered in small groups; hence each classroom has a maximum teacher-to-student ratio of 1:15. Muktangan classrooms are divided into three groups, each with a separate teacher and their own blackboard and resources. The teacher's role would be to provide a secure environment for students to express themselves and simultaneously interact with each other (National Focus Group Position Paper, 2006). To facilitate this, Muktangan teachers sit with their group of students, rather than tower over them, as Muktangan promotes a discussion-based model of learning unlike the conventional teacher-led sessions. Each classroom is equipped with stackable furniture that can be cleared for floor activities, resource cupboards hosting subject related resource material and books and display boards to reinforce visual augmentation. Stackable furniture is of immense importance in a science classroom. As a consequence, teachers are able to facilitate collaborative learning in small and large groups with the flexibility to switch to conventional classrooms if required during audio-visual sessions, or even a semi-circular set-up with students facing a demonstrator's podium on the head-side. This arrangement also facilitates teachers to use all parts of the classroom namely the floor to facilitate learning as against conventional chalk-and-board teaching practiced in other public schools.

Muktangan follows continuous comprehensive evaluation since its inception. The teachers are trained in observing children and give importance to formative assessment

over summative examinations. The student's observations are fed into review and planning of lessons every week.

2.1.C Out-of-Classroom Learning

Muktangan teachers work closely with the families through regular parent - teacher-meetings, home visits, and open day discussion of the students they teach, supporting their student's success in the classroom as well as making Muktangan an agent for more wide-reaching community change. Muktangan schools also organise routine field visits to the museums, industry, gardens, science centres, other public places and even promote learning through social interaction.

The science teachers plan lessons that facilitate students to formulate their own protocols and methods to gather, organise, analyze and present their data. As part of the integrated pedagogical approach, Muktangan has partnered with a private enterprise to facilitate problem-based-learning that gives grade 7 students an opportunity to think of a problem affecting their community, surrounding and the city at large. This half-year programme involves training teachers to facilitate grooming children to carry out a detailed research and submit their study outcomes in the form of a research paper for peer review to an anonymous panel of experts. Since the year 2016-17, all students of grade 7 have been enrolled into this programme.

2.2. Monitoring and assessment of learning at Muktangan

2.2.A. Formative and Summative

Assessment at Muktangan at all grades is in the form of formative and summative tests at the end of each semester and academic year. The exact pattern of assessment (segregation of marks) for standard 5 to 8 for the science subject is depicted in table 1. The summative scores reflect the performance of the students tested through a written paper as mandated by the education board. One could interpret these to be (but only) a test of the student's ability to transfer the cumulative knowledge on the concepts introduced for that grade, on the test-day. Formatives on the other hand are a form of continuous assessment and assess the student's ability to apply their learning, express their creativity and provide collaborative and peer-learning opportunities. Table 2

depicts performance grades of students across seven Muktangan schools over two academic years. Notably, ever since the integrated pedagogy approach has been adopted, a four percent and six percent rise in those attaining between 51-70% or an average grade for grade six and seven has been observed. Likewise, a four percent drop was observed, in those attaining a lower grade (C2, below 50%) during in the academic year 2016-17 over the previous year.

2.2.B. Student tracking

Students in grade 6 and 7 move from being intuitive thinkers to critical thinkers understanding making concrete, abstract operations. They begin to develop the ability to evaluate information being imparted in a classroom. Students are able to grasp abstract concepts, make observations from varied perspectives, use reference books to identify and classify and are able to use scientific vocabulary outside their school text book and showcase leadership qualities. Students in these grades transit from learning science as a subject to '*sciencing*', '*rationalising*' and '*inquiry*'. The science department at Muktangan uses this as a reference to develop its in-house student tracking tool.

2.2.C A Tool

The tool (appendix A) comprises of elements that represent 15 core skill-domains across four levels (Level 1 4) that reflect developmental milestones in *sciencing*. The tool has provisions to assess students as they progress from grade five to eight.

2.2.D Methodology

For the academic year 2016-17, a total of 21 science teachers across seven Muktangan mentored Mumbai Public Schools (MPS) observed their students for the entire academic year and marked each child observed over each of the 15 domains. The appropriate level that best represented the developmental milestone attained up to that time-point was ticked. If the student had not demonstrated either of the four levels for a particular domain, a cross was marked. The tool was used to monitor all students, that included those with learning disabilities, physical and genetic disorders as well as those with behavioral issues. In this paper, we have focused on results of students of grade six and seven only.

2.2.E. Results and discussion

52% of girls and 48% of boys aged 12 to 13 years in grade six and 49% girls and 51% boys from grade seven were observed over one academic year (2016-17). Overall, 567 students were observed by 24 teachers across both grades. Each teacher observed not more than 15 students in each class. Each teacher observed not more than 15 students per grade, and on an average each teacher observed 24 students across both grades together.

Data is summarised in table 3. Results indicate that between 1 to 5% of students in both grades had not yet reached the minimum expected (level 1) developmental milestone in each of the core skill-domains. For convenience of discussion and coherence, closely associated domains have been grouped under common categories such as '*measuring*', '*observing and questioning*', '*sciencing and investigating*', and '*practicum*'. It is observed that less than half (~32%) students in both grades could use calibrated measuring tools during classroom activities. The rest were still using basic approximate measures like half, full, twice, etc. As students progressed toward the end of grade 7, a higher number were curious and motivated to make scientific observations, asking secondary questions based on observations and answers, could describe observations in simple scientific language, as compared to grade 6 students. It was evident from the results of the tracking data that a larger section of students in the higher grade demonstrated proficiency that was closer to their expected developmental outcomes. A higher number could plan an investigation into a problem with minimum support from their teacher, considerably higher number (~40% in grade 7 against less than 25% in grade 6) could gather scientific data from appropriate sources, over 30% students of grade 7 against ~20% in grade 6 could conduct simple experiments independently but a dismal lesser that 10% could draw inferences on their own in both grades. As expected, a higher number (>40%) of students in grade 7 could were familial with scientific vocabulary in passages provided in class, and could confidently read scientific text and write passages based on their learning. A higher number of students in grade 7 (~30%) as against less than 20% in grade 6 could represent data in tables using appropriate standard units of measurement. About half the students in each grade could follow instructions independently, however less than half of these (16% in grade 6 and 17% in grade 7) were proficient in helping their peers follow instructions while conducting learning activities in the classroom. Data highlights that higher number of students in

grade 7 as against grade 6 could independently correlate concepts to the activity being conducted and this information could be crucial for the science teachers to either make amends to their lesson plan or provide timely reinforcements to support student's learning. Close to 50% of students in each grade could confidently handle material introduced by their teachers during class hours, however less than half the students in each grade demonstrated willingness or competency to work in small and large groups with complete participation (collaborative learning), while less than 10% students in each grade showed willingness to take up leadership roles in the classroom.

3. Insights into the future.

The Muktangan model has a proven track record in scholastic performances of it students at the state board examinations. Each year all students pass with at least 80% students scoring 60% marks or more. Muktangan schools have a student drop-out rate of under 4% which is way below the national level of 38% for government-mentored schools across any medium (Elementary Education in India Analytical Tables 2014-15, Mehta). Muktangan advocates that teacher education and school cannot function in isolation of each other but rather integration of 'learnings' need to flow from the schools to teacher education and vice-versa.

Since the beginning of academic year 2016-17 the science department at Muktangan has evolved to incorporate the good practices from different teaching styles to adapt to the learning needs of the unique young minds that the organisation caters to. Classroom routines have gradually transited from focusing on activities to 'providing experiences'. The curricula and lesson plan are designed to include the learning environment that includes the teacher as the 'facilitator of learning' rather than the more knowledgeable other, the classroom and everything within as 'tools to learning' that together with the social constructs provide a 'learning environment' rather than a school classroom. Collaborative learning and learning to lead, has superseded task-completion. The process of attaining quality education has shifted from seeking to know to 'constructing *learning* opportunities and knowledge'. There has been a deliberate effort to shift from Bloom's approach of memorisation that formed the basis of the pyramid to thinking, questioning and 'doing' that is key to Muktangan's approach of learner-centered education.

Although the science department at Muktangan followed a comprehensive assessment process that comprised of continuous assessment through weekly tests, reviews, practical work, activities and projects and an end of semester summative test the data from the tracking tool highlighted that these have fallen short of reflecting the prescribed or expected levels of the age specific developmental domains of the students. Like Robert Owen stated, *"tests are a convenient tool to categorize individuals"*. The department's approach acknowledges that a learning classroom would comprise of students with diverse interests and strengths and at different milestones of their development in agreement with Howard Gardener's theory of multiple intelligences (Mike Fleetham, 2006). Data revealed that the tracking tool adequately met the requirement and can provide the teacher and the administration more accurate insights of the level attained or accomplished for each milestone for every individual and also as a group. Current data indicated that over half the students were yet to reach concrete operation milestone (Level 3 and beyond) for most domains tracked. Analysing data over the coming years could help recognise a trend or pattern among students for each grade and help teachers make amends in the pedagogical approaches incorporated and provide teachers and administrators feedback toward adaptable and adoptable pedagogical practices. The tracking system coupled with the formative and summative assessment process when amalgamated with the pedagogical approaches truly provides the department a close loop mechanism to ensure quality in science education, making the process learner-focused rather and knowledge or curriculum-focused.

4. Reference

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Grade 5 and 6					
Formative (50 marks)					Summative (50)
Practical (10)	Activity (10)	Project (10)	Open Book (10)	Class & Home work (10)	Written paper (50)
Grade 7 and 8					
Formative (40 marks)					Summative (60)
Practical (5)	Activity (10)	Project (5)	Open Book (10)	Class & Homework (10)	Written paper (50)

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Table 1: Summary of marks break-up into formative and summative assessments. *Figures in brackets indicate maximum marks*.

Grade	**Academic year**	**A1 (91-100)**	**A2 (81-90)**	**B1 (71-80)**	**B2 (61-70)**	**C1 (51-60)**	**C2 (41-50)**
5	2015-16	4	13	18	27	32	7
5	2016-17	2	17	23	32	20	6
6	2015-16	9	12	20	28	23	8
6	2016-17	2	11	23	26	29	10
7	2015-16	5	10	16	22	25	22
7	2016-17	4	8	17	23	30	18
8	2015-16	7	12	16	27	24	15
8	2016-17	3	10	19	26	32	9

Table 2: Students attaining different grades (A1 to C2) in summative and formative assessments across all Muktangan schools over two academic years. *Figures in brackets indicate percentage range.*

	Grade 6					Grade 7			
Female	52					49			
Male	48					51			
NO	**L1**	**L2**	**L3**	**L4**	**NO**	**L1**	**L2**	**L3**	**L4**
Measuring									
2.79	22.30	38.68	31.71	4.18	2.52	21.58	43.88	26.62	5.40
Observing and questioning									
Making observations									
2.44	33.10	39.02	15.68	9.76	1.80	30.58	31.65	26.62	9.35
Questioning									
2.44	34.49	33.45	25.78	3.83	5.04	20.14	37.41	24.10	13.31
Recording and interpreting observations									
1.74	22.65	36.24	22.30	17.07	3.60	25.90	34.53	29.14	7.19
Sciencing and investigating									
Planning investigations									
2.09	53.31	24.04	19.16	1.39	2.52	33.81	28.06	29.14	6.12
Gathering data									
4.18	40.42	32.40	18.47	4.53	2.16	27.34	33.09	28.06	8.99
Experimenting									
2.68	37.58	39.60	13.42	6.71	2.13	23.40	42.55	20.57	11.35
Representing data									
1.74	34.49	45.64	11.15	6.97	2.16	26.26	42.45	21.22	7.55
Scientific vocabulary									
2.17	29.71	37.68	23.91	6.52	3.60	24.82	32.37	33.09	5.76
Understanding instructions									

1.05	20.56	40.42	21.95	16.03	2.52	17.99	31.29	31.29	16.55
Reading scientific text									
1.39	28.92	32.40	30.66	6.62	2.88	22.66	30.22	33.09	11.15
Writing scientific text									
2.09	32.40	29.27	32.75	3.48	2.16	23.38	30.58	36.69	7.19
Practicum									
Handling material									
1.05	21.25	41.81	23.00	12.89	2.16	20.86	32.73	31.29	13.31
Collaboration									
2.09	21.95	41.81	24.04	10.10	3.24	21.22	38.13	29.14	8.27
Correlating activity to concept									
1.39	31.01	45.30	15.68	6.62	3.24	29.14	37.77	23.74	6.12

Table 3: Summary of tracking data of students from grade 6 and 7. All values are in percentage.

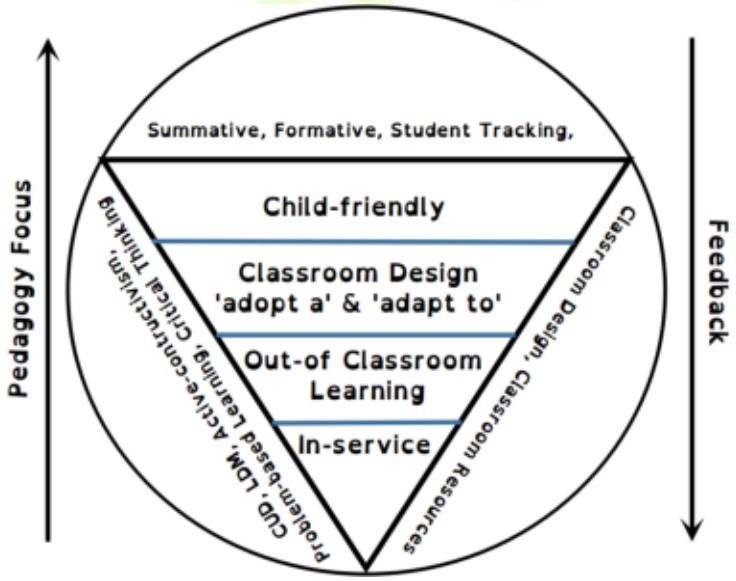

Figure 1. Illustration to summarise integration of pedagogies with a learner-centered approach and close-loop feedback system to ensure quality in science education.