Determination of Marginalized Youth to Overcome and Achieve in Mathematics: A Case Study From India

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Abstract

According to the United Nations Human Development Report (2016), poor, marginalized, and vulnerable groups still face substantial barriers to access post-secondary education and employment. These marginalized and vulnerable groups include women, girls, indigenous peoples, ethnic minorities, people with disabilities, migrants and refugees, the LGBTI community, and those discriminated because of their socio-economic status (UN Human Development Report (2016).

Increasingly, proficiency in mathematics is required for careers and for solving daily problems in life (Starkey & Kline, 2008; Ramaa, 2015). Basic numerical, mathematical, and scientific skills are an important mechanism to further education and to enable individuals to improve their job market potential. The risk of underachievement in mathematics around the world is greatest for students from low-income backgrounds, as well as linguistic and ethnic minorities (Ramaa, 2015; National Research Council, 1989). In India, these factors are compounded by lack of early exposure to math, poor teacher quality, and large class sizes (ASER, 2014). Although some research has explored difficulties in arithmetic for economically disadvantaged elementary students in India (see Ramaa, 2015), the challenges that marginalized adolescents encounter in completing secondary mathematics courses has been largely unexamined.

In this qualitative exploratory study, conducted from October 2015 to February 2016, we sought to understand the characteristics of adolescents from socio-economically marginalized communities in Mumbai and Bangalore, India, and their determination and perseverance to overcome challenges in mathematics and complete their secondary education. In particular, the study followed students who had dropped out of mainstream school and enrolled in India's National Institute of Open Schooling Program to complete their high school education and attempt the 10th standard board exams.

Results from data collected in the academic year showed that there were multiple factors, including lack of learning foundational skills at the primary school level and the type of intervention provided to complete high school, which influenced the students' achievement in mathematics. Findings from the study inform policy and programmatic decisions for students enrolled in India's National Institute of Open Schooling Program.

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Introduction

The students who attend the Samudra program in Mumbai wake up to the sounds in their slum. Their fathers are sliding open the doors to their shoe shops adjacent to their homes, their mothers are busy in the kitchen preparing food for the day, and outside rickshaw drivers and other merchants make their way to work. The four young boys and two young girls who participated in our study have different tasks as they start their day. The boys generally run morning errands for their parents, while the girls help out with household work or help their fathers open up the business. The students live in the same neighborhood and are family friends outside of school.

The students who attend the Parisandra program, in contrast, all attend a boarding school in the outskirts of Bangalore. The three boys and three girls in our study come from single parent homes or are orphans. They start their day at 6 am with a morning run, followed by morning tasks including making breakfast, cleaning their school grounds, or maintaining their school garden. For these children their school is their home and part of their education is to take care of the school they live in. Parisandra's students have an opportunity to go home to their family or guardians over the weekend.

The students of the Samudra and Parisandra programs participated in open-schooling programs established by the Indian government to promote high school graduation of students who have dropped out of mainstream education. The students of both schools not only came from marginalized backgrounds, but also have had inconsistent schooling. Having faced many challenges in their lives, from parental death to failing multiple grades or dropping out of school, the students in our study have persevered with resilient behavior and have come to these programs to complete high school.

Although some research has explored difficulties in arithmetic for economically disadvantaged elementary students in India (see Ramaa, 2015), the challenges that marginalized adolescents encounter in completing secondary mathematics courses has been largely unexamined. In fact, adolescents that have dropped out of school have recently been referred to as "opportunity youth," since they have extraordinary untapped potential. They can be extremely hopeful, despite their challenges (Kamenetz, 2015).

In our study, we investigated adolescents from marginalized communities in Mumbai and Bangalore, India, and their perseverance determination to overcome challenges in mathematics and to complete their secondary education. This exploratory, qualitative study, conducted from October 2015 to February 2016, set out to understand how two programs implementing the National Institute of Open Schooling Program approach teaching mathematics to adolescents from marginalized communities in Mumbai and Bangalore, India. The study focused on students who had dropped out of mainstream school and enrolled in India's National Institute of Open Schooling Program in order to complete their high school

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education and attempt the 10th standard (grade) board exams.

Our study focused on the following research questions:

- What are the common characteristics of students enrolled in NIOS programs, including youth environmental backgrounds?
- What challenges have the students encountered in learning mathematics in the past?
- How are the National Institute of Open Schooling Programs adjusting mathematical instruction to meet the needs of their students?

This paper is a descriptive study that explored the results and implications of two programs for students enrolled in India's National Institute of Open Schooling Program. The purpose of this paper is to provide constructive feedback to the programs who are implementing National Institute of Open Schooling Programs for marginalized students. Although the programs vary in their approaches and address different student needs, this research provides a good basis for further identifying any critical gaps in mathematics education for students who are enrolled in the National Institute of Open Schooling programs.

Literature Review

Math Achievement in India

Recent international assessments paint a bleak picture of mathematics achievement in India, especially for minority students. In 2009, two Indian states, Tamil Nadu and Himachal Pradesh, participated in the Program for International Student Assessment (PISA) which is administered to high school students. In mathematics, India ranked 73 out of 74, trailing far behind the other countries which participated such as South Korea, Singapore, and the United States (Anirudh Sethi Report, 2011; Indian Express, 2012). India chose not to participate in the 2012 and 2015 PISA cycles and will next participate in 2021 (Chopra, 2017).

The situation is equally bad at the early grades. The Annual Status Education Report (ASER) in India showed that approximately 73% of grade 3 students in rural India could not recognize numbers past 9, and could not complete any type of mathematical operations required at their level (ASER, 2011). If these students are fortunate enough to stay and advance in school, they acquire basic math skills in 6th standard instead of class 2 or 3 (Global Partnership for Education, 2012). This leaves them years behind their peers in mathematics and science, which can limit their post-secondary education and career options, and take a toll on their self-esteem and motivation.

In India, research has primarily focused on challenges facing upper middle class secondary school students in learning mathematics due to learning disabilities (Karande, Sholapurwala, & Kulkarni, 2011; Karande, Mahajan, & Kulkarni, 2009). Challenges that marginalized adolescents encounter in completing secondary mathematics courses has been largely unexamined. Since there is minimal research on the teaching and learning of mathematics for marginalized youth in India, there is a critical gap in the availability of education indicators for academic development and progression.

Teacher Content Knowledge and Pedagogical Knowledge

The level of teachers' mathematics content knowledge also impacts students' academic achievement (Hawk, Coble, & Swanson, 1985). However, the training teachers receive in India does not include adequate focus on student understanding in mathematics. Teachers often teach by rote memorization, or they recite mathematics operations and/or equations in unison with their class, which does not address comprehension of the subject. Research suggests that teachers do this to keep pace with over-ambitious curricula which are inappropriate for students lacking

preschool or kindergarten education. This method exacerbates the learning gap, leaving many students behind, such as in early grade mathematics (Pritchett & Beatty, 2012). In addition, poor teacher quality is combined with extremely large class-size and scarcity of in-class learning materials.

Marginalized Communities

There are many factors that can work to undermine students' ability to perform well in mathematics, and many of these are exacerbated when students come from marginalized backgrounds. For example, early exposure, particularly at home, to numbers and simple mathematics informally can set the foundation for success. In Organization for Economic Cooperation and Development (OECD) countries, it is common for students to have access to at least one year of early childhood education (OECD, 2017). Whereas in countries like India, compulsory education generally begins in 1st standard and students come to school with little or no preparation (Srikantaiah & Ralaingita, 2014). When students do not have early exposure, it can impact their progress in school and social mobility (Brantlinger, 1993; DiMaggio & Mohr, 1985; Lareau, 1989; McDonough, 1997; Srikantaiah 2008; Useem, 1992).

Chronic and Toxic Stress

Other factors that can impact students' ability to learn mathematics include poverty, malnutrition, physical and emotional violence in families, drug and alcohol addiction, and migration, which can all lead to chronic or toxic stress. According to the Center on the Developing Child (2017) at Harvard University, a child experiences toxic stress when they have prolonged activation of stress in non-positive environments without adult support. A less severe level of chronic stress can occur when a student endures these environments buffered by supportive relationships (Center on the Developing Child, 2017). Students may be exposed to experiences that are so stressful that they are in a state of constant anxiety and unable to cope (Zacarian, Alvarez-Ortiz, & Haynes, 2017). When a student's stress response system stays on high alert, the architecture of the child's developing brain and organ systems are affected and can cause a host of health, learning, and behavioral problems into adulthood (Center on the Developing Child, 2017).

In order to enhance the academic and socio-emotional development of students living with trauma, violence, and chronic or toxic stress, students can benefit from external support and a strengths-based approach[1]. Students need consistent, routine, predictable, nurturing, and stimulating interactions to ease their anxiety and stress in order to focus on learning math (Zacarian, Alvarez-Ortiz, & Haynes, 2017).

Self-Determination

While the United Nations defines "self-determination" as the right of a person to determine his own destiny (in regards to economic, cultural, and social development), self-determination for adolescents has been defined as a combination of skills, or components, which enable a student to act "purposefully and planfully" (Wehmeyer, 2004, p. 352; Wehmeyer, 1994; Trainor, 2008). These skills include: making choices, decision making, problem solving, goal setting and attainment, self-observation, self-evaluation, self-reinforcement, self-instruction, self-advocacy and leadership, internal locus of control, positive attributions of efficacy and outcome expectancy, self-awareness, and self-knowledge (Wehmeyer et al., 1997; Konrad et al., 2007; Thoma & Wehmeyer, 2005).

There is a strong connection between students' self-determination skills, academic performance, and post-high school outcomes (Martin, Portley, & Graham, 2010). Students need self-determination skills in order to be aware of their strengths and weaknesses, to be aware of resources available to them, and to take advantage of and use the resources (Cawthon & Cole, 2010; Chiba & Low, 2007; Martin, Portley,

& Graham, 2010; Webb et al., 2008). Students need self-determination skills to recognize the potential barriers that exist and to develop strategies to overcome the obstacles (Getzel, 2008). Students need self-determination skills to advocate for their academic needs, including skills to ask for clarification and help (Kosine, 2007). For students facing poor self-esteem due to years of failure and frustration in mathematics and, possibly, lack of adult support, self-determination skills need to be explicitly taught and practiced within a program or curriculum.

National Institute of Open Schooling

In response to the critical gaps in education in India, the Government of India set up the National Open School in November 1989. In July 2002, the MHRD amended the nomenclature of the organization from the National Open School (NOS) to the National Institute of Open Schooling (NIOS) with the mission of providing "relevant, continuing and holistic education up to pre-degree level through Open and Distance Learning System; contributing to the universalization of School Education; and catering to the educational needs of the prioritized target groups for equity and social justice" (National Institute of Open Schooling, 2012, para. 3). With about 2.71 million students enrolled, NIOS is credited to be the largest open school in the world with significant popularity in the commonwealth countries and in certain other developing and developed countries (National Open Schooling Program, 2012).

NIOS is an autonomous and parallel exam Board. However, unlike mainstream Boards, students are given the option of selecting the subjects they would like to study and are allowed to take the exams at their own pace. Many students do not choose the mathematics or science exams and opt for subjects related to commerce or arts.

The NIOS program started off as a self-initiated or self-study program where interested students could go to the nearest Accredited NIOS Institute and register for a fee. To enroll in NIOS, students need to go to school until 8th grade and be at least 14 years old. Students are provided with subject materials which they can study at their own pace at home or at a designated NIOS study center. They do not have to be a part of a program or institution to complete high school. Initiatives like the Samudra and Parisandra programs, which are aligned with NIOS accredited centers, were developed to help students who were completing 10th grade through NIOS by providing a more structured and supported approach. Both of these programs use the NIOS curriculum.

NIOS has partnered with 853 Agencies providing facilities at their study centers. The NIOS provides resource support such as the adaptation of NIOS model curricula and study materials to the voluntary agencies. Students can go through NIOS to complete their secondary (10th) or senior secondary (12th) grade levels. NIOS gives students an option of which subjects to take for their secondary and senior secondary levels – students can take a minimum of 5 out of 28 subjects and at least one language. Students are not required to take exams for all subjects through NIOS. They can also take the exam in any of the scheduled languages of India. Students now have the option of taking a Vocational Education program of NIOS at the Senior Secondary stage which includes subjects like computer and information technology.

There is no standardization in how institutes or organizations implement the NIOS program. At Samudra, the program focus was on preparing students to enter post-secondary education or pre-university programs without any knowledge gaps. At Parisandra, the focus was more on developing socio-emotional skills for the students and building their self-determination skills so that they can be independent and self-sustaining after finishing high school (Observation, October 3, 2015). Another major difference is that students at Samudra are expected to take all subject exams, so that they could enter post-secondary education (anonymous program coordinator,

personal communication, September 25, 2015). Parisandra's students were not expected to take all subject exams, but rather were allowed to opt out of mathematics or science because those subjects are harder. Parisandra's students were encouraged by their teachers to take exams which they knew they could pass without difficulty. The exam subjects included subjects such as data entry, English, Social Studies. During her interview, Kalpana talked about her aspirations to go into the medical field but said, "You need maths for that, Aunty" (personal communication, October 3, 2015). Kalpana said that mathematics subject exam was too difficult, and she needed to pass the 10th standard. Therefore, like the other students at Parisandra, she did not take the mathematics subject exam. The variability of how the National Institute of Open Schooling program is implemented creates diversity among the students who graduate from it and their continued education or career paths.

Unfortunately, there are many misconceptions about students attending NIOS. In preliminary conversations with potential research partners, educators and program coordinators to whom we spoke, there were different views about the National Institute of Open Schooling Program. A director of an orphanage in Bangalore mentioned that she didn't like the Open Schooling Program for the children in her orphanage because it lacked rigor and post-10th opportunities for students (anonymous program coordinator, personal communication, September 25, 2015). However, the National Institute of Open Schooling Program provides opportunities to students who would otherwise struggle in a mainstream 10th standard classroom. Many of the youth mentioned that the smaller class sizes, pace of the curriculum, and option to not take all subject exams made it more manageable for them to pass the 10th grade (personal communication, October 3, 2015). In actuality, NIOS is a self-paced way to attain a secondary school certificate. Any junior college or post-secondary institution must accept students that have passed their 10th standard exams through NIOS.

In the 2014 – 2015 academic year, a total of 155,469 male students and a total of 65,622 female students were enrolled in the secondary program. In that year, a total of 100,022 male students and a total of 32,713 female students took the mathematics exams. The fee for being enrolled in a secondary course was 1485 rupees for males and 1210 rupees for females. The fee schedule is subsidized for students from lower castes and those with disabilities (National Institute of Open Schooling, 2012).

Methodology

Setting and Participants

This exploratory qualitative study examined the learning difficulties marginalized youth face in mathematics in two urban mega-cities in India, Mumbai and Bangalore. Mumbai is the most populated city in India and is located in the state of Maharashtra. The approximate population of the Mumbai Metropolitan Region (comprising Mumbai, Navi Mumbai, Thane, Vasai-Virar, Bhiwandi and Panvel) is nearly 21 million, according to the 2011 census (Press Information Bureau, Government of India, 2011). It is also one of the most diverse cities in India, attracting Indians from other urban and rural areas for employment. The state language of Maharashtra is Marathi, but due to the diversity of the population, many other languages are spoken. In our exploratory study, Samudra staff explained to us that the majority of youth in their programs are originally not from Mumbai but have migrated to the city for work. Students struggle financially, lack family support, and have inconsistent schooling (Samudra content developer and master trainer, personal communication, September 10, 2015). And, often they are working while going to school to help their family make ends meet.

Bangalore, in the state of Karnataka, is the information technology (IT) center of India. The state language of Karnataka is Kannada. Because of the IT boom over the last two decades, the city population doubled from 4.3 million in 2001 to 8.7 million in 2011 according to the census. The IT companies attract people from all over India

to work in Bangalore, including youth. Most of the youth migrate to Bangalore for work, often times leaving behind their family, and interrupting schooling. Youth in Bangalore often work while going to school. However, the students in our sample did not work because they attended boarding school. When the students were not in classes, they participated in activities for the school -- helping keep the school clean, maintaining the school garden, or mentoring younger students.

In both Mumbai and Bangalore, we explored two research sites: Samudra Open School for Education in Mumbai and Parisandra in Bangalore. Both sites are registered with the National Institute for Open Schooling (NIOS), Delhi under the Open Basic Education (OBE) program.

At Samudra, there were approximately 60 students enrolled in the Hindi-language section, while approximately 10 students were enrolled in the Marathi-language section. Many of the students and their families migrated from Rajasthan and speak Marwadi at home, in addition to speaking Hindi. Most of the families work with leather and make sandals for a living, living under the poverty line. The students live in Mumbai slums, and Samudra recruited the students from the slum neighborhoods. To be eligible for the Samudra program, students must have passed 4th standard and be older than 14 years old (no age limit). Most students entered the program because they migrated to Mumbai before they finished their education in Rajasthan; or because, if they passed the 9th standard, their parents needed them to drop out of school to work and support the family. Some enrolled because they failed Math and English in 9th standard, while others failed Science. Students from Samudra were recruited by the program coordinator. The program coordinator visited the slums where the students lived and explained how the program at Samudra would give them a second chance at school. The program coordinator told the students that Samudra was a friendly environment with small class sizes, and they would not be judged for dropping out of school or failing. The program coordinator emphasized that it would be a safe environment for the students (personal communication, August 2, 2015).

When students enter the program at Samudra, they are pre-tested in English, language (Hindi or Marathi), and mathematics. They take a two-month foundational course covering all the basic mathematics they may have missed in their intermittent schooling. The foundational course covers concepts ranging from fractions, to algebra, and geometry. Once they review the basics, the students move onto tenth standard material. Students may choose to take general math or regular math (which has more algebra and geometry). The majority of students at Samudra take general math. Later, when students pass the 10th standard exam through the NIOS program, they can choose one of the three streams in junior college (11th and 12th standard): arts, science, or commerce. If a student takes regular math, s/he can choose to major in science in junior college. If s/he takes general math, options are limited, and s/he cannot major in science. Most of the Samudra students major in commerce, and the rest major in arts. No students are currently majoring in Science (Samudra content developer and master trainer, personal communication, August 2, 2015).

At Parisandra, students come from single family homes or they are orphans. They often have had interrupted schooling or have repeated multiple standards. Many of the students are trauma survivors, or have witnessed difficult family situations, and are at-risk for toxic stress. One student said in her interview that she saw her alcoholic father hang himself. Students are admitted to Parisandra at the request of a family member or guardian, and the maximum age of a student at Parisandra is 17. They are not given an entrance exam but have to come from a low socio-economic background, from a single parent home, or bean orphan. They must also agree to live on the Parisandra campus. The class sizes are very small at Parisandra. Only 12-15 students are enrolled in each standard and

class size is no more than five students. In addition, the classes are held in an alternative style: Classes are held outside in shaded areas, students are encouraged to sit on the floor, and the lesson delivery is very interactive, giving students more of an exploratory learning experience. Parisandra students found out about their program by word of mouth through family, friends, or their community (Parisandra program coordinator, personal communication, October 3, 2015).

The curriculum at Parisandra is not as rigid at Samudra. Students attend classes in English, mathematics, social sciences, and computers. In mathematics, students are introduced to concepts from the 10th grade curriculum without the pressure of learning the material for an exam or for their 10th board exams. Parisandra's main focus is on socio-emotional skills (Observation, November 17, 2015). Students also participate in art and craft activities, learn how to garden and cook, and engage in sports activities such as football and karate. One of the students interviewed from Parisandra wanted to be a classical Bharatanatyam dancer, and in an interview, he called himself an "eagle" which means transgender (Surya, personal communication, November 17, 2015). To support this student, Parisandra brought a dance teacher to the campus. They also allowed this student to speak with a medical professional about sex change operations to enable the student, in case he went this route, to make the right medical choices. Parisandra also allowed students to take the 10th standard board exams at their own leisure and in the subjects they preferred. The goal for Parisandra's graduates is to transition to either work or further schooling. Most of Parisandra's students enter employment after graduating, some of them continuing to volunteer at the school. Some students continue to secondary education in vocational education or commerce. None of the students interviewed in our study mentioned studying sciences, mathematics, or engineering for their future education.

Sampling

We employed a snowball, or chain, sampling strategy to recruit participants. This approach identified cases from people that knew people in a certain environment (Creswell, 2007). Samudra was chosen as a research site because the lead author had collaborated with the organization on another project and because they also had an open school program. Parisandra was recommended as a research site by the lead author's Fulbright host institution. It resembled Samudra's National Open Schooling Program demographically; however, the geographic and program approaches were different. This made researching the two programs interesting and diverse.

In order to determine which open school students would be interviewed at each site, we asked the program staff at each location to recommend 6 students that met the following criteria:

- Adolescents (between the ages of 14 and 18) that have either:
  - Dropped out (gap of more than one year), but have returned through a specialized or alternative program, or
  - Stayed in school, but have had persistently poor school performance (failing or scored 35% in math)
- Students that have past stressors that may have impacted their learning (Center on the Developing Child, 2017).
- Students that would feel comfortable expressing themselves in English, Hindi, or Kannada during the interviews.

With the assistance of program staff, 4 males and 2 females from Samudra and 3 males and 3 females from Parisandra were asked to participate. See Table 1 for a brief description of the participants.

Table 1
Description of participants

Mumbai: Samudra			
Pseudonym	Sex	Age	Place of birth (state)
Abhishek	Male	16	Uttar Pradesh
Randhir	Male	15	Uttar Pradesh
Siddharth	Male	17	Rajasthan
Karan	Male	14	Haryana
Karisma	Female	15	Rajasthan
Alia	Female	15	Rajasthan
Bangalore: Parisandra			
Pseudonym	Sex	Age	Place of birth (state)
Surya	Male	16	Tamil Nadu
Puneet	Male	16	Andhra Pradesh
Ramesh	Male	16	Andhra Pradesh
Kalpana	Female	16	Andhra Pradesh
Vijya	Female	16	Andhra Pradesh
Ramaya	Female	16	Andhra Pradesh

The lead author was in India collecting data while on a Fulbright fellowship and was able to conduct the interviews required for this exploratory study since she is fluent in Hindi and Kannada. Institutional Review Board (IRB) approval was granted by Gordon College for this study.

Procedures

Data was collected over a period of 5 months from October 2015 to February 2016. We

gathered qualitative data in the form of collective case studies, or personalized stories on similar individuals, on these 12 students to understand the difficulties they have in learning mathematics (Brantlinger et al., 2005). In order to better understand the students' experiences, the majority of the interview questions were open-ended, focused on the students' experience with secondary math and their goals for the future. Interviews with Samudra's students were all conducted in Hindi, and interviews with the students from Parisandra were all conducted in English with some Kannada.

We were also interested in the students' math skills and proficiency at various points in the academic year. In the first three meetings we learned about the students' family and educational backgrounds; the focus of the fourth meeting was on students' ability to solve problems that were included in a 10th standard mathematics textbook in order to learn more about students' mathematical thinking. The lead author administered two word problems to each student and asked them to perform a "think aloud" in which they verbalized their thinking and strategies (Ketterlin-Geller, Chard & Fien, 2008; Gersten et al., 2009). Students were given unlimited time to complete all math tasks. Each problem was on a separate sheet so that the students had plenty of room to show their work. Students were shown the problems one at a time and took about 5 minutes to solve each problem. After they attempted to solve the problem, or solved it, the lead author asked them how they arrived at their answer.

After obtaining written consent and verbal assent from each of the participants, the on-site researcher conducted interviews. An outline of the data collection is listed in Table 2 below. All testing and interview protocols can be found in the appendix at the end of this article. At Samudra, the program coordinator was present at the interviews to help with any translation difficulties from Hindi to English.

The lead author also administered a pre/post-test to the students to understand the baseline knowledge that students had at the beginning of the interviews, and to determine the amount of mathematical reasoning and knowledge gained over the five-month period. The same test was administered for both the pre and post-test. The pre-test and post-test questions were informed by assessments administered by Samudra because their program's pre-test was measured by basic computational and application tasks in a concise manner. The two word problems used in the interviews were adapted from general math textbooks (Maharashtra State Board of Secondary and Higher Secondary Education, 2015; 2015b).

The pre-test covered mathematics concepts of:

- Number recognition -- students were asked to recognize numbers and write them in numerical format.
- Place value -- students were asked to recognize the place value of a digit in a number with ten thousands.
- Word problems -- students were asked to solve word problems such as "If Ram has 38 pigeons and 19 of them flew away, how many does he have now?"
- Fractions -- students were asked to solve addition and subtraction problems with fractions.
- Conversions -- students were asked to convert between measurements such as volumes, weights, and other units.

Table 2
Data Collection

Date	Data collected
October 2015	Introductions and pre-test (see appendix)
November 2015	Interview: Students' past personal and educational backgrounds
December 2015	Interview: Understanding school curriculum – student perceptions of school and community
January 21, 2016	Solved two word problems while performing a think aloud (see appendix)
February 2016	Wrap up and post-test (see appendix)

In order to analyze the data, we adapted the theoretical framework typically associated with vertical case studies: Bray & Thomas' (1995) framework for multi-level analysis (as cited in Phillips & Schweisfurth, 2008, p. 22-23). The 12 case studies were analyzed in the context of the program sites and examined through structures created through social norms, educational practices, and national policies. These structures shape local processes at the sites, as well as possible impact on individual student's lives (Vavrus & Bartlett, 2006).After reading through all of the interview transcriptions, we coded responses that emerged from the data, keeping our research questions in mind (Creswell, 2007; Merriam, 2009). From these categories, or themes, we looked for patterns and meaning across the cases and data (Creswell, 2007).

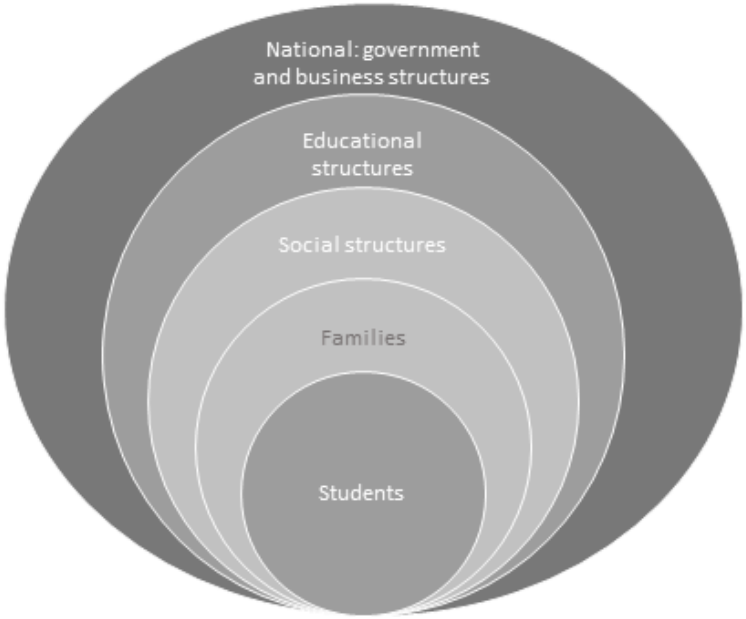

Figure 1 Framework for multi-level analysis (adapted from Bray & Thomas, 1995; Phillips & Schweisfurth, 2008)

Results/Discussion

We sought to understand the challenges the youth faced in learning mathematics in two programs. As discussed earlier, our research was exploratory and, therefore, our results are represented in a descriptive manner illustrating the common life experiences the youth faced across the two programs. The differences were mainly due to programmatic approaches to teaching mathematics, but were also due to their family life, suggesting that students are influenced by the social and educational structures that are present in their lives. We also explored the challenges students faced in studying or solving mathematics problems.

The results indicated that there were four areas which impacted how students in our sample performed in mathematics:

- Toxic stress from living in poverty and family situations;
- Previous educational experiences, particularly in mathematics;
- Programmatic approaches to help the students pass the 10th standard board exams; and
- Solution pathways.

Toxic Stress

Due to eligibility requirements of the programs, students of Samudra and Parisandra all came from poor and marginalized backgrounds. Their families migrated to urban areas for better financial opportunities. Samudra's youth moved from their home towns to Mumbai, some with their families, whereas Parisandra's students were in and around Bangalore because either their parents migrated before they were born, or their grandparents migrated to the city.

Students from Samudra migrated mainly from rural areas of Rajasthan for work in Mumbai. Four of the students migrated with their nuclear families, and two were split up. Randhir, for example, said he came to Mumbai with his uncle and father. His mother and sister joined a year or so later (personal communication, September 25, 2015). In Parisandra's program, students came from Tamil Nadu and Andhra Pradesh. Although most of Parisandra's students were born and brought up in and around the city of Bangalore, their parents or grandparents moved to this area for work in construction, factories, or household cleaning.

Unlike Samudra's students, five of whom came from families with both parents, Parisandra's students came from single parent homes or were orphans. Therefore, they were eligible to live at Parisandra's boarding school. In our sample, all of Parisandra's students came from single parent homes.

Students of Parisandra spoke about trauma in their families more than the students from Samudra did. Kalpana recounted how her father hanged himself because he was alcoholic (personal communication, October 3, 2015). Puneet said his mother worked a lot and was usually not at home. When she was at home, she scolded him a lot, causing him to join neighborhood gangs which eventually got him trouble with the law (shoplifting) (personal communication, October 3, 2015). Surya confided to the lead author that he was gay, and talked about the challenges he faced in *coming out* to his single parent father and extended family. Surya felt that his mom would have understood him better (personal communication, November 17, 2015). Other students interviewed from Parisandra mentioned it was difficult growing up in a single parent home or without parents and how this led them to attend Parisandra. They mentioned it as an event in their lives with no external display of strong emotion, such as crying, observed. Nor did they want to talk about it in detail except that they missed this family member in their lives.

None of the students at Samudra mentioned trauma in their interviews, but instead mentioned the financial struggles they

were experiencing. All of them supported their families in their family business or with other after school work. One of them, Siddharth, came from a single parent home. His father was absent in his life, so to support his mother and younger brother he worked after school (personal communication, November 17, 2015). All of the students from Samudra also mentioned the lack of role models in their lives and how coming to Samudra made up for it because their teachers were great role models.

The chronic stress experienced by the students in both programs led them to the National Institute of Open Schooling Programs at Samudra and Parisandra. Abhishek remembered being at home after failing the 9th standard and thought that he did not have any other options left. However, Samudra's program coordinator came to his neighborhood and asked him to join Samudra and whether he would like this second chance at school. Abhishek said it was the best decision he made (personal communication, October 3, 2015).

Previous Educational Experiences

All of the students interviewed struggled with mainstream schooling. For Samudra's students, all of them mentioned that migrating to a new city, sometimes in the middle of a school year, was particularly hard. The low cost private schools they attended had extremely large class sizes and teachers would often rush through material in order to cover everything in the curriculum. Ramesh said that mathematics was "too difficult" (Ramesh, personal communication, November 17, 2015) in the low-cost private high school he attended before Samudra. "There were over 100 students in my class," he recalled and that made it challenging for him as he felt his needs were not being met in that educational environment (Ramesh, personal communication, October 3, 2015). He dropped out and fell two years behind his peers as a result.

Alia also recounted a similar story, describing how she felt demotivated in the low-cost private school she attended. She felt "stupid" because she could not keep up or learn properly. She felt the opposite in Samudra's program and said the teachers were very helpful (Alia, personal communication, October 3, 2015).

Parisandra's students also had difficulty attending the low-cost private schools in Bangalore, sometimes encouraged by peer groups who influenced the students to not attend school and to engage in other unproductive activities. All of Parisandra's students had dropped out because they failed a standard or two and were discouraged. Four of the students said they did not like their teachers. Kalpana said, "It was hard to follow or learn maths from [her teacher]" (personal communication, October 3, 2015). Puneet recalled that his bad school experiences were harder because of his peer group. He said his friends discouraged him from going to school and because of that he got in trouble with the law a few times (shoplifting charges) (personal communication, October 3, 2017). All of the students agreed that Parisandra's teachers were much "nicer" than other teachers they had had.

Due to the challenges the students from both Samudra and Parisandra faced in their mathematics education – from having to migrate to new areas, to large classrooms, to being unable to follow an ambitious mathematics curriculum – their foundational skills in mathematics were weak and that impacted their self-determination skills. In the example below, a student from Parisandra solved the pre-test problem by adding or subtracting the numerators and denominators, showing no conceptual understanding of computation with fractions. In Figure 1 below, the student (Puneet) added straight across to come to the sum of 8/15 in problem iii. In problem iv, the student subtracted the numerators but added the denominators. Unfortunately, none of the students from Parisandra could solve this problem on the pre-test.

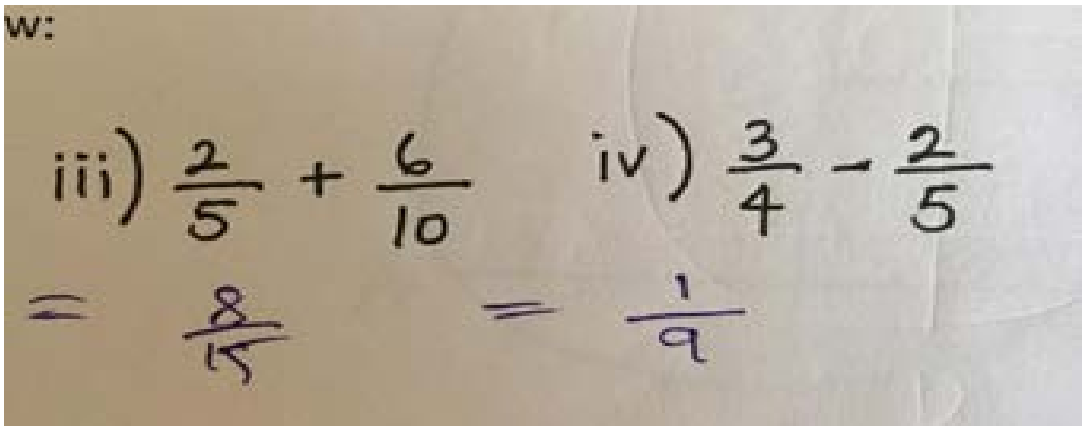

Figure 2. Parisandra student work(Puneet, student work, October 3, 2015)

Additional data obtained from the pre-test showed that students at Parisandra and Samudra were strong in number recognition and place value. It was difficult to assess their knowledge of word problems, fractions, conversions, and geometry because these items were left blank by the majority of students on test. The concepts students struggled with were those taught in upper primary or early secondary, when they dropped out. Samudra's students, all of whom passed the 10th standard board exams, did better on their post-tests. We noticed improvements in solving word problems, conceptual understanding of fractions, and geometry. Only one student still struggled with these concepts -- Sunil. He did manage to pass his 10th standard board exam; however, he opted to go into a vocational track after graduating high school – a training program to fix hardware on computers.

In general, Parisandra's students found the post-test we administered difficult. Only two students who completed the post-test, Kalpana and Ramesh, were accurate with a majority of their responses. The other students still struggled with the same concepts that were in the pre-test. Unfortunately, data on whether the students from Parisandra passed their 10th standard board exams, or what they are doing now was not made available to the lead author.

Programmatic Differences

Despite guidelines set up by the National Institute of Open Schooling Program, it is important to note the flexibility for implementing the program. The policy outlines that students should be introduced to the content areas in order to pass the 10th standard board exams; however, students had a choice of what subjects they would like to study. In addition, students were not required to take all exams at once, but rather they could space them out. At Parisandra, for example, students planned to take one exam paper per month.

Both Samudra and Parisandra had small class sizes from which the students benefited. Samudra's class size was around 10 – 12 students per class, and Parisandra had only 6 – 7 students per class. In their interviews students from Samudra said they preferred the smaller classes. Youth from both programs also said that their teachers cared more than the teachers they previously had; this could also be the result of small class size, or better teacher-student interactions.

Samudra, however, modeled their program very closely to typical 10th standard classes. The program's director said she wanted the students to easily transition back into post-secondary education or alternative programs.

Therefore, students in Samudra's program took all the 10th standard board exams, which included mathematics and science. To address gaps their students faced in mathematics, for example, Samudra's pre-tests indicated that the students were weak in fractions and division. Samudra spent the first three to four months of the school year re-teaching foundational concepts, such as building a strong number sense and mastering fractions and division.

Parisandra, on the other hand, focused their curriculum on socio-emotional skills. Parisandra wanted their students to not only focus on the academic; but, through a self-learning and open classroom approach, they wanted their students to develop emotionally, socially and physically. They wanted their students to have self-determination. Parisandra's teachers would only allow students who were academically capable to take the 10th standard board exams through the NIOS program. Students took the subjects they preferred and at their own pace. Therefore, teaching students vocational skills like spoken English was important at Parisandra.

Parisandra did teach mathematics; however, it was not rigorous and did not follow a specific curriculum. Teachers followed online guides to teach mathematics and made sure they covered the major topics of the curriculum. One teacher said, "Our goal is for them to pass their 10th standard board exams. Some subjects are easier to pass than others" (teacher from Parisandra, personal communication 2015). Subjects which were easier to pass included computers (knowledge of Microsoft word, excel, and data entry software). For example, all of the students interviewed opted out of taking mathematics and chose data entry. Data entry, they were advised by their teachers, was easier to pass than mathematics. They also decided to space out their exams and not take them all at once. Therefore, students from Parisandra not only had a choice of which exams they wanted to take, but also when they would take them.

Although socio-emotional skills are important, particularly for students who have faced so many challenges early on in their lives, there is also a danger of focusing too much on these skills because doing so could interfere with their self-determination or their perseverance to pursue post-secondary education. Students at Samudra had more of a balance in that they were supported by program staff to come back to school, who understood the challenges they were facing, but at the same time encouraged the students to continue to post-secondary education.

The teachers at Parisandra, wanted the students to be able to live as productive citizens after they graduated and get jobs. They encouraged their students to pursue their aspirations (Parisandra program coordinator, personal communication, October 3, 2105). For example, Surya wanted to become a Bharatanatyam dancer. Parisandra organized dance lessons for him and adjusted his curriculum accordingly.

Solution Pathways

We also explored how the students approached problem solving. This was done in part to further understand the gaps they had in mathematics, but also to see their thought processes. After the first two meetings where we learned about the students' family and educational backgrounds, we asked them to solve problems included in a 10th standard mathematics textbook. We gave the students four problems – two at one meeting and two at another meeting. They were then asked to explain how they arrived at their answer.

Striking differences existed between the way Samudra's and Parisandra's students approached the problems. As soon they saw the problem, all of Samudra's students wrote down what was given, what needed to be solved, and

any questions/ approaches they planned to use at the top of their papers. They used the rest of the paper to solve the problem. Although only two students from Samudra answered the problems correctly, all of them wrote down their logic on how they tried to solve the problem. When the students were asked about the process of solving the problem, they were all able to explain what was given to them, what needed to be found, and their logic for solving the problem.

Parisandra's students had a different approach to solving the problems. Two of Parisandra's students solved all the problems correctly; however, they didn't write down anything on their papers. When asked how they solved the problems, Ramesh told the lead author, "Aunty, don't ask me...this is the answer." (Ramesh, personal communication, January 21, 2015). Kalpana also said, "I don't know Aunty." (Kalpana, personal communication, January 21, 2015). When asked to write down their problem-solving process, they struggled with this too. Both Ramesh and Kalpana scribbled down a few numbers given in the problem and then put down their pencils slightly frustrated. "Is this necessary?" is what Ramesh kept asking in Kannada. After 5 minutes of waiting for them to explain their answers verbally or in writing, we moved onto the next problem.

Below is an example of a student's work from Samudra where the student wrote out what was given in the problem, what needed to be solved, and how he solved the problem (in Hindi). He wrote out what was provided in the problem -- that the cost of 10 books is 150 rupees. He then wrote that he needs to figure out how many books he can get for 600 rupees. He showed his work on the right-hand side. He then came back to the center and solved the problem, writing: therefore, 600 rupees would give you 40 books.

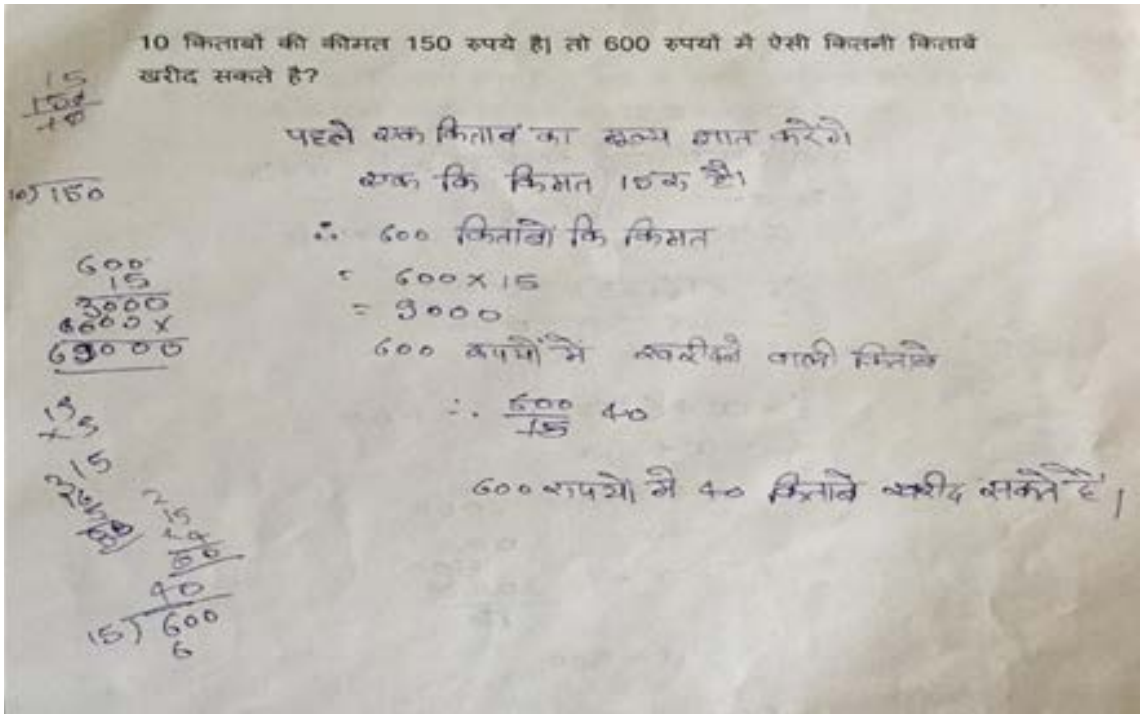

Figure 3. Student work from Samudra (Abhishek, student work, January 21, 2016)

All the students from Samudra attempted the problems given to them; however, other than Ramesh and Kalpana, students from Parisandra could not solve the problems, but also did not attempt them. Surya said, "I don't like math." (Surya, personal communication, January 21, 2015) and changed the topic to what he last learned in dance. In fact, all of Parisandra's students complained a little when the lead author told them she was giving them math problems. In the first three interviews with the students, the lead author spent the entire time talking to the students about their lives and educational experiences. They seemed to enjoy telling their stories. So, when the lead author came to their school the third and fourth time with math problems, they were not happy. Puneet said, "I like talking to you Aunty...can we just talk?" (Puneet, personal communication, January 21, 2016). These types of responses can be reflective of the different family backgrounds students from Samudra and Parisandra come from.

As mentioned earlier, students from Parisandra came from broken homes or were orphans; therefore, they acted more attached to the lead author than the students from Samudra. The students at Samudra also enjoyed the lead author's company by inviting her to their homes for tea and to watch movies with them. Their community support system was stronger – they had both parents at home, and also extended family or friends nearby. When the lead author declined tea or a movie, they were not upset.

In conversations with the students from both Samudra and Parisandra on their understanding of the problems presented to them, and also on their performance on the pre and post-test given to them, we noticed that they were able to recognize numbers fluently. Although we were unable to make this connection with our data, previous research showed that students' experience in their family businesses or outside work added to their informal math skills (Sitabkhan, 2012).

Another interesting finding is that based on the interviews, Parisandra students did not see how math could be relevant in their everyday lives, particularly in terms of career options. Samudra's students were better informed. This impacted the student aspirations in the field. None of Parisandra's students wanted to go into STEM disciplines, saying it would be too difficult, whereas Samudra's students were aware of where they would use math in their careers. Most of Samudra's students decided to go into commerce and understood how math was valuable in this field. Abhishek, one of Samudra's highest performing students who performed average for his standard / grade level in mathematics, knew the different STEM fields quite well. He said that after much consideration, he was going to study to become a pilot where he would use math and science.

Conclusion

In this exploratory and descriptive study, students shared many personal experiences and factors that impacted their ability to complete their mathematics education, such as poverty, physical and emotional violence in families, alcohol addiction, and migration which can all lead to chronic or toxic stress. As a result, these students chose to complete their education by an alternative route, attending programs adhering to the National Institute of Open Schooling curriculum. Both the Samudra and Parisandra programs guided students through the NIOS curriculum, rather than a self-study approach; however, their approaches differed due to their different target populations. Ultimately, in our sample, students at the Samudra program fared better on their 10th standard exams. However, the two programs varied in their approach, with Parisandra focusing more on the socio-emotional well-being of their students.

Although students in our sample had different paths to their NIOS program, including various social and educational structures that

played a role in their math performance and choice of vocation, students in our study had *prasakti* (pronounced "prah-sahk-tee," which in Sanskrit means "perseverance"). All students in the study should be recognized for their perseverance to come back to school to pass their 10th standard and complete high school.

Implications

As organizations consider setting up an alternative pathway for high school graduation or completing 10th standard exams, the following implications from this research will help inform programmatic decisions.

1. **Know your population**. Students may be at-risk for or experiencing toxic stress and need more external support and a strengths-based approach. Students, overall, benefit from consistent, routine, predictable, nurturing, and stimulating interactions. Consider if your students are at-risk for toxic or chronic stress from living in poverty and family situations.
2. **Assess student prior knowledge**. Students may enter alternative programs with various degrees of previous educational experience in mathematics. Administering an assessment at the beginning of the school year will help teachers know the baseline levels of their students and adjust their instruction based on students' needs.
3. **Explore student solution pathways**. During the baseline assessment, attention should be paid to the solution pathways that students use to arrive at their answer. Students with conceptual understanding should be able to explain and justify their approaches.
4. **One size does not fit all**. There is no one-size-fits-all program. Programmatic approaches to help the students pass the 10th standard board vary. Knowledge of the student population and their background experience should inform course offerings.
5. **Encourage application of mathematics**. Providing opportunities to apply the mathematical concepts learned and connecting them to daily life would make math interesting and motivate students. For students who may struggle with self-esteem in mathematics and motivation, making mathematics meaningful and applicable to their lives will increase engagement with the subject.
6. **There are consequences**. Be aware of the consequences of the program structure on student choices/tracks in STEM.
   a. Four out of six students from Samudra entered commerce degrees and one decided to work.
   b. With commerce degrees, past graduates of Samudra's program have had difficulty finding jobs because of the saturated market in the field.

By incorporating these best practices into alternative graduation programs, educational centers can support marginalized youth achieve in mathematics and move closer to their high school graduation goals and have better opportunities for secondary education, vocational education, or employment.

Limitations of The Study and Future Research

This study was conducted with a relatively small sample size (N = 12) and the population was made up of students from only two NIOS programs. The sample was taken from low-socioeconomic class sections of Mumbai and Bangalore, and represents only a piece of the diversity in the country. More research can be done to determine how other NIOS programs are meeting the needs of their students. Also, this was an exploratory study and the pre-test and post-test results were not normed.

Notes

A strengths-based approach is one in which "teachers identify and acknowledge the assets and capacities of students, understand and value their cultural ways of being, and support and create opportunities for learning through thinking and social interactions" (Zacarian, Alvarez-Ortiz, & Haynes, 2017, para. 38).

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Appendix

Pre-test/Post-test

1. Write the following words in numbers:
   a. Four thousand five hundred
   b. Nine lakh two thousand three hundred and ten

2. Write the place value of the underlined number:
   a. 4, 3̲89
   b. 2̲5, 761

3. Ram has 38 pigeons, 19 of them flew away, how many pigeons does Ram have now?

4. If 1 house gets 2 liters of milk, how many houses will get 70 liters of milk?

5. If 1 pen costs Rs. 7, how much do 35 pens cost?

6. Solve the fractions below:
   a. 2/7 + 7/7 =
   b. 8/9 – 4/9 =
   c. 2/5 + 6/10 =
   d. 3/4 – 2/5 =

7. Fill in the blanks:
   a. 1 cm = _____ mm
   b. What is the equation to find a triangle?
   c. a^m x a^n =
   d. 500 grams = _____ kilos
   e. (9)2 = _____
   f. 1 hour = _____ minutes

List of interview questions

Background

a. Name
b. Date of birth
c. Education Experience
d. Where they are from
e. Family background

Schooling Experience

a. Can you tell me about your schooling?
b. Where did you go to primary school?

c. Did your parents or elders read to you at home?
d. What type of games did you play at home growing up?
e. Do you work? What do you do?
f. What type of games do you play now?
g. What's your favorite subject in school? Why?
    a. If math and science – why?
    b. If not, why not math and science?
h. What do you learn in math class? (can also inquire about teachers here)
i. What do you learn in science class? (can also inquire about teachers here)
j. How would you use math or science in the real world?

Outside of School

a. Tell me about your daily schedule.
b. What time do you go to bed at night, and what time do you wake up in the morning?
c. Tell me what you do for exercise.
d. What makes you happy?
e. What makes you smile?
f. What makes you laugh?
g. What makes you sad?
h. If you have a problem in life, tell me how you go about solving it
    a. Who do you approach for help?
    b. How do you manage stress?
    c. What do you do to feel calm during a stressful situation?
i. What do your teachers do when you are stuck on a problem? How do your teachers help you with challenging problems?

Math Problems

The cost of 10 books is Rs. 150. How many such books can be purchased for Rs. 600?

Hema purchased a wrist watch and a wall clock for herself. The cost of the wrist watch is thrice the cost of the wall clock. Total cost of the wrist watch and a wall clock is Rs. 2,000. Find the cost of a wrist watch and a wall clock.