ACTION RESEARCH ON MIXED AGE GROUP (MAG) CLASSES FOR MATHEMATICS IN MIDDLE SCHOOL

Hema Gowda, Kanchana Suryakumar, Shubha Venkataraman

Abstract: *Three Mathematics teachers discussed the need to address the common perception of Mathematics as an intimidating subject, even as they worked with children of different skill levels and worked towards preparing them for the Board Exam in Grade X. While such challenges exist for all subjects, Mathematics seems to have gained a special status as students move from concrete to abstract concepts. The linear manner in which the Mathematics syllabus is typically laid out probably adds to the fear of not being able to "catch up", once a student falls behind.*

Out of these discussions was born the idea of an Action Research (AR) project where grouping children vertically (mixed age instead of same age) in the Middle School could enable necessary scaffolding and help with a smoother transition into High School. A three-year study was planned so as to allow the first group of Grade VI students to complete three consecutive years of the Mixed Age Group (MAG) experience before they moved to High School (Grade IX). At the time of writing this paper, this study was in the third academic year. The research carried out in the first two and a half years is described here, along with possible implications for the next year.

Abbreviations: AR – Action Research, MAG – Mixed Age Group

Note: A shorter version of this paper was first presented at an International conference in January 2018, EPISTEME7 (http://episteme7.hbcse.tifr.res.in/).

INTRODUCTION

Our school is a not-for-profit organisation in an urban setting and comprises about hundred and fifty students, with about fifteen students per class. The school has been supporting children from all socio-economic backgrounds, including first-generation learners. An inclusive community, 10% of each group comprises students who have special needs.

The teachers at the school come from equally varied backgrounds, brought together by their shared belief in a holistic and child-centric learning environment. The school provides a fostering and supporting environment for students as well as teachers to explore new ways of engaging with the teaching-learning process.

This Action Research project is one such exploration, an attempt to provide children (who struggle with abstract concepts) with additional opportunities to revisit those topics.

Given the special place that Mathematics seems to hold in the minds of children, parents and society at large, this research was undertaken to effect greater enjoyment in teaching and learning the subject, with opportunities for children to learn at their own pace. The three teachers (referred to as "we" through the document) who are currently part of the MAG implementation are the authors of this document. We have been teachers of Mathematics for

one, four and seven years respectively, and have been teaching grades six to twelve. All three of us have an Engineering background, with several years of experience in the corporate sector, before we changed career paths and moved to teaching. All of us share an interest in teaching Mathematics. A Facilitator met us approximately once a month, guided us through the entire AR and documentation process and also shared relevant research papers with us every now and then. Given our packed schedules, we did not have occasion to interact with Mathematicians or academics in order to inform our research further. This paper is laid out in the typical flow of Action Research (Costello, 2011), viz. PLAN, ACT, OBSERVE and REFLECT.

PLANNING

Objectives for the MAG Classrooms

In the 2014-15 academic year, we observed that a significant number of students from Grades V to IX required additional help in Mathematics, either in class or outside regular classes. This necessitated the intervention of additional 'support teachers' to provide remedial help. For example, while some children worked on finding square roots of Decimal Numbers, others in the same class grappled with Whole Number arithmetic. If Number Types and their arithmetic are viewed in a linear fashion (Whole Numbers → Integers → Rational Numbers), this disparity in the same class translates into roughly three levels of mathematical skills.

This resulted in considerable splitting of the teacher's time and attention, leading to a reduction in the time spent on instruction for each level. Often, this demanded increased after-class support. Hong et al (2012) highlight the positive effects of increasing time spent on instruction – however, we observed the converse effect as our instruction time in class reduced. Out of this situation was born the idea of carrying out Action Research with a vertically grouped (Martin & Pavan, 1976) or 'mixed age' class with the following objectives:

1. To provide every child in Middle School (Grades VI, VII and VIII) the opportunity to work at his/her pace and revisit topics in Mathematics until the child is confident and ready to move to the next skill level.
2. To reduce, if not eliminate, the need for remedial classes and work with children, inside the classroom, at the level that they are comfortable with.
3. To help reduce the load of a differentiated lesson plan and consequent splitting of a teacher's time, so that she/he may focus on - at most - two levels of skills at a time.
4. To reduce the fear of Mathematics and help a child engage actively and positively with the subject.

Planning for the Mixed Age Group (MAG) Classes

Planning for the MAG classes involved the following:

1. Appropriate material: Our school permits teachers the flexibility to choose appropriate textbooks and reference material for a class. We decided to use the National Council of Educational Research and Training (NCERT) Mathematics textbooks for Grades VI, VII and VIII as our reference books. Here, the linear layout of topics spanning Arithmetic, Algebra, Geometry and Statistics - such that each year begins where the previous year concluded - made our planning simpler.
2. Alignment of topics across groups: At the end of each year, the three MAG teachers examined the Math topics that they wanted to cover in the following year, and aligned

their classes such that similar topics would be handled simultaneously, with gradually increasing levels of challenge. This was done because aligning the topics would make it easier for a child to move across groups at the beginning of each new lesson.

Month	Class 6	Class 7	Class 8
June	Basic Geometrical Ideas	Lines and Angles, Triangle and its Properties	Understanding Triangles, Quadrilaterals
June, July	Algebra	Algebraic Expressions	Algebraic Expressions and Identities, Factorisation
July	Knowing our numbers	Estimation and working with larger numbers	Estimation and working with larger numbers
July	Data Handling	Data Handling	Data Handling, Introduction to Graphs
August	Understanding Elementary Shapes	The Triangle and its Properties, Congruence of Triangles	Understanding Quadrilaterals
August	Simple Equations	Simple Equations	Linear Equations in one Variable
September	Whole Numbers	Integers	Integers
September	Integers	Integers	Squares and Square Roots, Cubes and Cube Roots
Sept, Oct	Symmetry	Symmetry	Visualing Solid Shapes

Figure 1 is a sample snapshot of such an alignment of topics.

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July	Knowing our numbers	Estimation and working with larger numbers	Estimation and working with larger numbers
July	Data Handling	Data Handling	Data Handling, Introduction to Graphs
August	Understanding Elementary Shapes	The Triangle and its Properties, Congruence of Triangles	Understanding Quadrilaterals
August	Simple Equations	Simple Equations	Linear Equations in one Variable
September	Whole Numbers	Integers	Integers
September	Integers	Integers	Squares and Square Roots, Cubes and Cube Roots
Sept, Oct	Symmetry	Symmetry	Visualing Solid Shapes

Figure 1: Sample Alignment of topics

3. Moving across topics: We moved between Geometry, Algebra, Arithmetic and Statistics to give children variety. We also hoped to understand if obvious areas of interest or strength arose (e.g. some children like Geometry more than Algebra; some have stronger Arithmetic skills, etc.)
4. Planning lessons: Once the Annual Plans were in place, we wrote out our Lesson Plans for each topic, ideally a week or two ahead of the classes. Since MAG helped reduce the number of levels within a class - typically limiting it to two levels - common lesson plans could be made for the entire class. Appropriate worksheets were designed to provide necessary scaffolding for children who required more practice and/or time with a topic.
5. Timetabling: The final step in planning was to ensure that timetabling was done such that all three classes (VI, VII and VIII) had their Mathematics periods at the same time. This made it possible for a child to move across groups during Math class alone.

Student Involvement in MAG Action Research (AR)

Students are a critical part of the AR and their buy-in into the idea plays a key role in its success or failure. The initial discussion around and resultant decision to implement MAG involved only the teachers and Principal. These discussions happened after the end of the 2014-15 academic year. The students were introduced to the idea during their first Mathematics class, once the new school year started in June 2015. [Refer Observing section of this paper for details of these interactions.]

Ever since, we have been following this process of introducing the idea of MAG and inviting questions and suggestions from all, as a new batch of Grade VI students joins the group every year and the previous year's Grade VIII leaves the MAG.

Parental Involvement in MAG Action Research (AR)

It is important for parents to get involved in the MAG discussion early on, both to understand what is happening in their child's Mathematics class as well as to support the child, as needed, all through the year. We therefore involved parents at every step of the MAG process: having discussions at the beginning of the year, following up during Parent Teacher Meetings (twice a year) as well as inviting formal feedback at the end of each year of MAG.

ACTION

Implementation of MAG

We conducted preliminary tests for each child in the three same-age groups. These tests helped both the teacher and student understand the level that he was comfortable with and hence aided with deciding a child's group. We experimented with the type and frequency of the preliminary tests, switching from topic-wise (each topic mapping to a chapter in the NCERT textbook) to stream-wise (Algebra, Arithmetic, Geometry) tests; multiple tests to a single one at the beginning of the year; individual papers at different levels to a combined paper with questions at different challenge-levels. Irrespective of the type, nature and frequency of these tests, evaluation did involve a subjective component – as it almost always does. While broad rules were followed to use objective data as far as possible, exceptions were made so that no child felt coerced into joining a specific group.

Based on these tests, the teacher suggested an appropriate group for each child and followed this up with a teacher-student discussion on how this decision was reached. The teacher gave each student an overall summary of the areas that the child would benefit from revisiting, or working on at an advanced level – as the case may be. Table 1 outlines one possible scenario.

Grade VI Group	**Grade VII** Group	**Grade VIII** Group
Topic: Fractions	**Topic:** Fractions	**Topic:** Fractions
Concepts covered: Introduction to fractions; addition and subtraction of Like Fractions	**Concepts covered:** Addition and subtraction of Unlike Fractions; introduction to multiplication of fractions	**Concepts covered:** Multiplication and division of fractions; properties of Rational Numbers
Pre-requisites: Basic understanding of division	**Pre-requisites:** Representation and interpretation of fractions; identification of fractions	**Pre-requisites:** Perform Arithmetic operations like addition, subtraction and multiplication on fractions; decode and solve word problems

Student A: Already familiar with concepts at this level	**Student B**: Comfortable with concepts at VI level, needs to practice addition and subtraction of fractions	**Student C**: Not comfortable with pre-requisites. Will benefit from revisiting concepts at grade VII level
Move to Group VII	**Stay** in Group VII	**Move** to Group VII

Table 1 Student movement across groups (named according to grade, but constituting children of mixed ages)

The Teacher's Role in MAG AR

Initially, MAG AR appeared to warrant a mere rearrangement of classes, but it later became evident that it necessitated much more: from a significant change in pedagogy, to considerable interfacing with the following stakeholders:

- The School Management – convincing them of the initial idea and keeping them updated on progress and challenges

The students – constantly dialoguing with them, watching out for undue emotional stress and cases of bullying

The parents – explaining the thought behind the idea, keeping them updated of their child's progress in class and seeking their help to support their child through classroom changes

Other teachers – answering questions related to "what we were up to", if we saw any benefits and if we saw reason for other subjects to move to the MAG model as well

Action Research Facilitator – diligently recording all observations and sounding off ideas and concerns

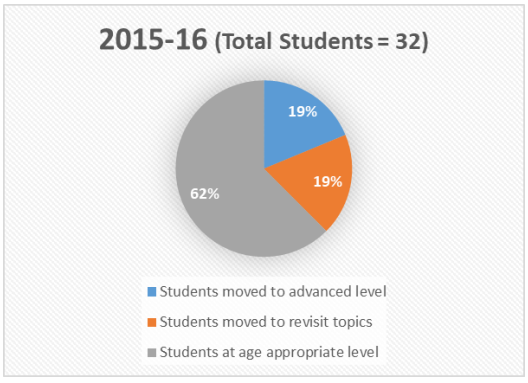
Fellow Action Researchers – periodic meetings to exchange notes, plan and re-plan continuously

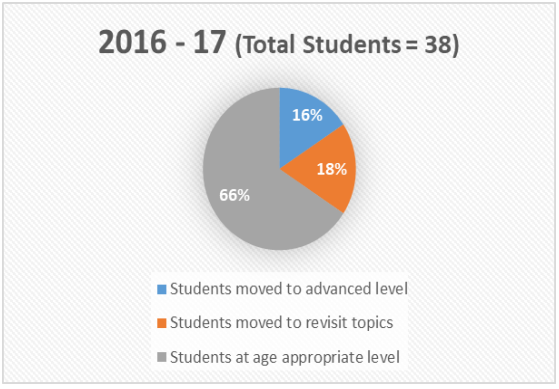
OBSERVING

In this section, we have included data from all the groups that have been part of the MAG AR over the last three academic years. The group that is of particular interest in our study is the group that started off in 2015-16 in Grade VI. This group is now in the third and final year of our study and is in the unique position of having benefited (or not, as the case might be) from exposure to MAG for the full duration of Middle School.

Student Movement Across Groups

During our initial discussions with students in the first year, some children were anxious that they would be "sent back" to a lower class. Teachers explained that no child will be "sent back" or "demoted".





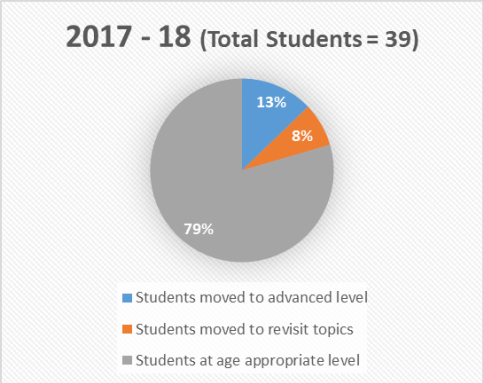


Figure 2 Student movement across groups

During their Mathematics class alone, each child would work at the level that each one was comfortable with. This could involve revisiting a topic covered earlier, visiting a new topic with the current class or moving to an advanced level in the topic. Though the children did not explicitly express such concerns in the following years, they continue to be anxious about having to work with a younger class. Figure *2* shows the movement of students across the three groups during the three academic years. Three factors affected the numbers as seen in the graph:

1. Some children refused to move up or down because they were not comfortable moving to and working with children from another class. Their decision was respected. This affected the number of students who could have moved and hence benefitted from this key feature of our MAG implementation. This number was low, however – just one child each year.
2. Since our MAG implementation included grades VI, VII and VIII. Children in Grade VIII could not benefit from moving up and working at an advanced level. This number was significant in the second and third years of MAG, with two and four children not being able to move up, respectively.
3. Similarly, children in Grade VI who would have benefitted from revisiting topics at a lower level, could not move down as our MAG classes started at Grade VI. However, since most topics in Geometry, Algebra and Statistics were at a beginner's level in Grade VI, we discounted this factor and decided to reassess this group of children when they moved to Grade VII

Since the second factor is significant and a restriction imposed by our specific implementation of MAG, Table 2 lists the recalculated values for group movement, including children who were at an advanced level in Grade VIII and could have potentially moved up. In this recalculation, we have included children who *could* have moved up in the "Students moved to advanced level" category.

	2015-16	2016-17	2017-18
Students moved to advanced level	19 %	21 %	23 %
Students moved to revisit topics	19 %	18 %	8 %
Students at age appropriate level	63 %	61 %	69 %

Table 2 Recalculated student movement across groups

Each batch of students is different from the previous one – some have a greater number of students requiring additional help, while some have more students who can work at an advanced level. However, one significant observation is that across the three years of MAG, 30-40% of the students were found to be potential candidates for working at a level different from their age-appropriate class.

An important point to note is that 60-70% of the children remained in their age-appropriate class. How did MAG benefit these children? The teachers believe that we were able to spend more time with these children in the MAG classes as our attention was not split across multiple levels, as would have been the case in SAG classes. Hence children who remained in their age-appropriate class also benefited from MAG.

During this process of class movement, cases of teasing were brought to our attention. These typically involved one student pointing out to another that he/she needs to work at an easier level or that the problems they work on are "so simple".

Students who worked at an advanced level had also been heard boasting about their 'challenging' Math classes. In each of these cases, teachers typically had a circle time with their individual classes or held joint sessions with all three classes, pointing out that the idea behind MAG was to help each child get comfortable with (and gain confidence in) Mathematics. Here, we confirmed Theilheimer's (1993) findings about how students themselves come up with solutions during such circle time discussions. We reached out to students, asking for their help to make MAG successful by helping their classmates out, as against lowering their self-confidence.

Student Progress

Students' progress over the three years was also recorded in terms of the following parameters:

- Test/Exam performance: improvement in test scores, reduction in repeated errors and reduction in assistance required during tests
- Subjective parameters: improved and active participation in class, willingness to take up new challenges (typically, seeking out more work)

Sample data for these parameters is shown in Table 3, covering a period of two years.

Student	**Exam Score**	**Repeated Errors**	**Assistance during tests/exams**	**Subjective parameters**
Student X (Stayed in age-appropriate group)	46% at the end of first year to 55% at the end of second year	Reduction in repeated errors in Fraction and Decimal Arithmetic (e.g. $\frac{3}{6} = 2$)	Graduated from requiring most questions explained during a test to fewer clarifications sought out during the test	Became more regular with assigned work; started enthusiastically raising his hand to answer questions out of turn
Student Y (Moved to revisit topics)	51% at the end of first year to 61% at the end of second year	Reduction in errors related to adding algebraic terms (e.g. $2x + 3x = 5x^2$)	Graduated from requiring most questions explained during a test to fewer clarifications sought out during the test	Proactively completed corrections; increased confidence while answering questions

Student Z (Moved to advanced level)	Consistently above 80%	Errors related to rushing through the paper reduced; child started revising his answers patiently	Child was given the opportunity to engage with the topic at a deeper and more challenging level. Required minimal or no assistance during test	Highly engaged in class; challenged the teacher on various topics, expressing a desire to dive deeper.

Table 3 Sample student progress over two years of MAG

Since the third year of MAG is still in progress, we have not yet captured year-end results. Our current observations in the third year, however, are in line with the trend indicated in the table.

Based on this progress, students were grouped into three categories: Beginning, Developing and Proficient – reflecting increasing levels in the above parameters.

Figure 3 shows student progress over the three years of MAG.

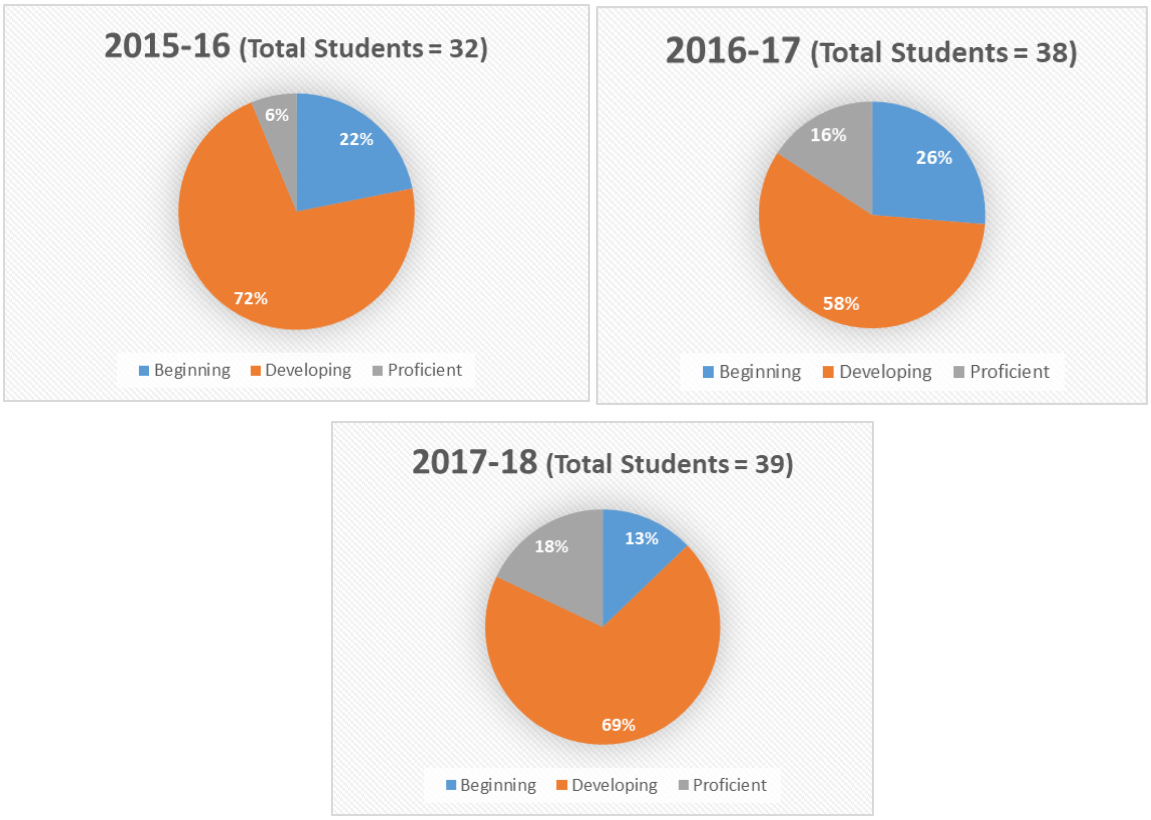


Figure 3 Student progress

There has been an increase in the number of children in the *Proficient* group and a decrease in the number of children in the *Beginning* group by the third year of MAG. This data also matches a similar trend in movement of children across groups (Table 2) – increase in the number of children moving to an advanced level and decrease in the number of children moving to revisit topics.

The group that started VI grade in 2015-16 has been of particular interest in our study as it is currently in the third and final year of MAG. This is the first group that has had the benefit of three years of MAG – that is, MAG over the complete Middle School years. Figure 4 shows the student progress for this group across the three years. This group has twelve students and has shown a promising trend that reaffirms the behaviour seen across different groups: reduction in the number of students in the *Beginning* category and increase in the number of students in the *Proficient* category.

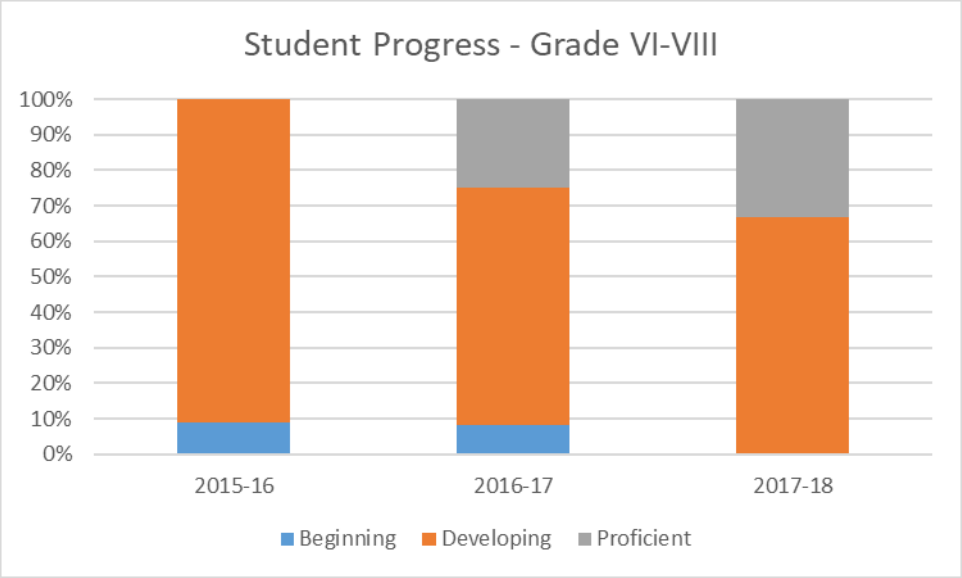


Figure 4 Student progress for the first group of Grade VI students

Students with Special Needs

Students with Special Educational Needs (dyslexia, dyscalculia, attention challenges, etc.) still require one-on-one attention in most cases. In the case of these children, the need for remedial help and additional support teachers continues to be experienced. Table 4 captures one such example.

Student	Exam Score	Repeated Errors	Assistance during tests	Subjective parameters
Student β	Less than 30%. No significant improvement in score over two academic years due to MAG	No reduction in repeated errors in basic Arithmetic. E.g. errors in multi-digit multiplication and division	Continued to require explanation and clarification for almost every question in every test/exam	More willing to answer questions in a 1-to-1 setting. Continued to be highly nervous about tests/exams

Table 4 Student progress for child with Special Educational Needs

Student Feedback

At the end of each year of MAG, we collected feedback from the students. Students were requested to provide subjective as well as objective information (see Figure 5 as well as *Conclusion* for

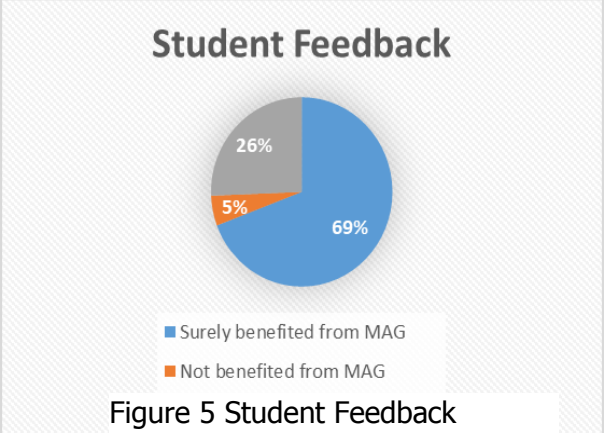


Figure 5 Student Feedback

examples of both) on whether (and why) they believed that they had benefited from MAG. Interestingly, their feedback has been more or less similar across the three categories (benefited, not benefited, unsure) over the three years. The total number of students across the three years has been 30-40 each year. A few students who remained in their age-appropriate class were unsure if they had benefited from MAG. Since they had not moved across groups, they were not able to determine if things would have been different had the classes been Single Age Group classes (SAG). The teachers, however, believe that we were able to spend more time with these children in the MAG classes as our attention was not split across multiple levels, as would have been the case in SAG classes.

REFLECTING

While information has been laid out linearly for the purpose of this document, the Action Research Plan-Act-Observe-Reflect cycle (Costello, 2011), in reality, occurred as multiple cycles, sometimes one within another, and at other times, as interlinked cycles. The following sections reflect on various aspects of our MAG AR, highlighting objectives that have been met as well as issues that still need to be tackled.

Reaction to MAG Grouping

In the process of grouping children based on their comfort levels with various Mathematics topics, our implementation has resulted in an explicit grouping of children into three levels - this has had two fallouts. One set of parents and students have welcomed the clarity that this process has provided, as it has helped them understand what needs to be done and how. Another set, however, is uncomfortable with such explicit grouping and have reacted with increased anxiety over each group change. Reasons for a student's discomfort include: working with a younger group, moving away from their group of friends/classmates and a mismatch in their self-evaluation and classroom performance.

While almost all children have requested that MAG continues every year in their feedback, the anxiety some children have expressed over group change and the resultant tensions in classroom interactions are important points to ponder over. This suggests that the core idea of allowing a child to work at her comfort level is appreciated but our specific implementation may require a revisit.

Challenges in Year on Year MAG Implementation

Our implementation has required three teachers working in parallel, with aligned classes for Mathematics, for grades VI, VII and VIII. Within the three years of MAG, we have experienced two teacher changes and a constant juggling of plans when any activity is planned outside the classroom (field trips, sports-related outings, theatre- practice, etc.). When any one of the three classes is involved, the other two are affected as children are distributed across classes.

Teachers move up with their classes, new teachers join, old teachers leave. Retaining this MAG model, which is specifically for Middle School Mathematics classes, adds an additional load on planning for all the Middle School teachers as well as the School Administration. While teachers have benefited from fewer levels within a classroom and increased interaction between teachers of the three grades, the increased planning and coordination overhead also suggests that the current implementation of MAG may need to be revisited.

Meeting Objectives of the MAG AR

We worked with students from Middle School with the hope of seeing a difference in comfort and confidence levels, with Mathematics, when the students moved to High School. Table 5 captures a summary of our objectives and the extent to which they have been met.

Objective	Met / Not Met	Evidence
Provide every child an opportunity to work at his/her pace until the child is confident and ready to move to the next skill level	Yes	Data from student movement across groups (Table 2), student feedback (Figure 5) and student progress (Figure 3) indicate a positive trend
Reduce the need for remedial classes and work with children inside the classroom at the level they are comfortable with	Yes, for students who need more time with a topic No, for students with special needs	Data from student movement (Table 2) indicates an increased flexibility to work in another class instead of making time outside class to catch up (remedial classes)
Reduce the load of a differentiated lesson plan and splitting of a teacher's time; allow a teacher to focus on at most two levels	Not met for all teachers	Factors that still warrant a differentiated lesson plan and teaching strategy: - too many children in a class (e.g. children move into VII from both VI and VIII) - children with special needs - children who are disinclined to work and are in a prolonged catch-up mode
Reduce the fear of Mathematics and help a child engage actively and positively with the subject	Yes	Data from student feedback (Figure 5) and student progress (Figure 3), in-class participation and student attitude indicate a positive trend

Table 5 Meeting Objectives of MAG

Ideas for Future Implementation

Below are some ideas that have emerged from our discussions about alternate implementations of MAG:

- Create a sufficiently robust "Resource Centre" that would enable children to work on materials at different levels within the same classroom. This would help reduce the stress over group changes. This model, however, requires a considerable investment of time to create such a resource centre. Secondly, a teacher would still need to spend a considerable amount of time meeting the demands of multiple groups, at different skill levels, within the same classroom. It would then become critical to work towards children becoming more independent, with the teacher providing minimal guidance.
- Have a co-teacher work with the Mathematics teacher in the classroom. This gives the teachers an opportunity to work with two or more groups at a time.
- Implement the idea of vertical grouping or MAG for different subjects across different classes. This helps set a common model of classroom implementation for the whole

school. This could help a student understand how each child works at different levels for different subjects. It could also reduce parental anxieties over perceived judgments about their children's abilities.

CONCLUSION

With the last year of MAG AR currently in session, this paper describes work in progress. The process, however, has resulted in tremendous learning for each teacher involved. The AR process necessitated continuous discussions and updates to all teachers involved in the project and this has helped provide considerable clarity on various challenges and strategies applied by teachers in all three groups. In addition to the benefits that we believe the students have gained from the MAG classes for Mathematics, the teachers too have benefited from the planning, strategising and implementation process. Over the three years of MAG implementation, parents have predominantly been appreciative and supportive of the idea.

Some parents appreciate the opportunity and additional help that their child receives by revisiting topics at a lower level and believe that this experience has increased their child's self-confidence. Other parents have expressed concern if their child worked at a lower level and have therefore tried to help their child strengthen their mathematical skills.

Still others have seen this implementation as an opportunity for their child to be challenged beyond their comfort zone and have actively tried to push them to a higher level. Some parents have come back and told us how visibly excited their child is with working at a higher level in Mathematics.

Student feedback such as "I felt MAG has increased my self-confidence" and "MAG is awesome and challenging", along with teachers believing that "I now have so much information and co-teacher support to handle different challenges in my class" reassure us that we are headed in the right direction. On the other hand, feedback such as "I'd still rather be in my own [age-based] class" or "this is merit-based grouping" tell us that we still have some way to go before we can definitely conclude that the process has been rewarding for all involved.

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