DEVELOPING STUDENT MATHEMATICS SKILLS

HOW PRACTUTOR ALIGNS WITH THE BEST PRACTICE

PracTutor

Personalized, fun way to master Math and Language Art

With the growing role of science, mathematics and technology in modern life, the objectives of personal fulfillment, employment and full participation in society increasingly require that all adults- not just those aspiring to a scientific career- be mathematically, scientifically and technologically literate. (PISA, 2003)

The intention of this document is to encourage the approach to teaching and learning mathematics that gives strong emphasis to the processes associated with confronting problems in real-world contexts, making these problems amenable to mathematical treatment, using the relevant mathematical knowledge to solve problems, and evaluate the answer in the original problem context. If students can learn to do these things, they will be better equipped to make use of their mathematical knowledge and skills throughout life.

The second section of this white paper examines one of the educational products, PracTutor, in terms of major strategies used to improve mathematical achievement.

> *Mathematics is important not just in the education of scientists, engineers and economists but also in the education of every working citizen in the United States. It is hard to see how anybody can pull down anything better than a minimum wage job in the years ahead without quantitative skills.*
>
> ***MSEB,** Making Mathematics work for minorities, report of a convocation, 1989.*

A strong sense of one's own ability to learn mathematics is of key importance. (OECD-2010)

Student performance in mathematics depends significantly on teaching and learning factors. Thus, it is necessary for us to review our teaching and learning practices. The goal of mathematical literacy can be attained if teachers can shape the classroom environment in ways that enhance students' involvement with mathematical problems and with each other.

NCTM defines five mathematical literacy goals for all students (NCTM, 1989):

- Learn to value mathematics;
- Become confident in their capability to do mathematics;
- Become mathematical problem solvers;
- Learn mathematical style of conversation;
- Learn mathematical reasoning.

These can be achieved by providing students an instructional format in which students can construct their own understanding. This in turn depends on the activities a teacher can facilitate to the students, and the previous knowledge that students bring to the learning situation.

Factors that affect student's mathematical achievement

1) Socio-economic Status

Socio-economic background plays a major role in determining the achievement levels of students. Use of appropriate teaching and learning strategies can moderate its impact on achievement.

2) Student attitudes, motivations and self-concept

Self-confidence and motivation are consistently correlated with student achievement. Student motivation is a significant aspect of learning. It is important to help students reduce mathematical anxiety and increase students' sense of self-efficacy in mathematics and their self-concept.

3) Time allocations

Effective strategies can either decrease time needed or increase time spent on learning mathematical concepts. Thus it is important to keep students motivated to learn and provide tools which will best utilize the time students spend studying mathematics.

Carroll's Model of School learning defines academic achievement as a function of

1) Time needed to learn

Time that a student takes to learn a topic.

2) Opportunity to learn

The opportunities that a student gets to explore the curriculum.

3) Ability to understand Instruction

The effort that a student has to put into understanding the topic.

4) Quality of instructional Events

Quality of instruction being provided to the student.

5) Perseverance

The amount of time the student engages with the standard.

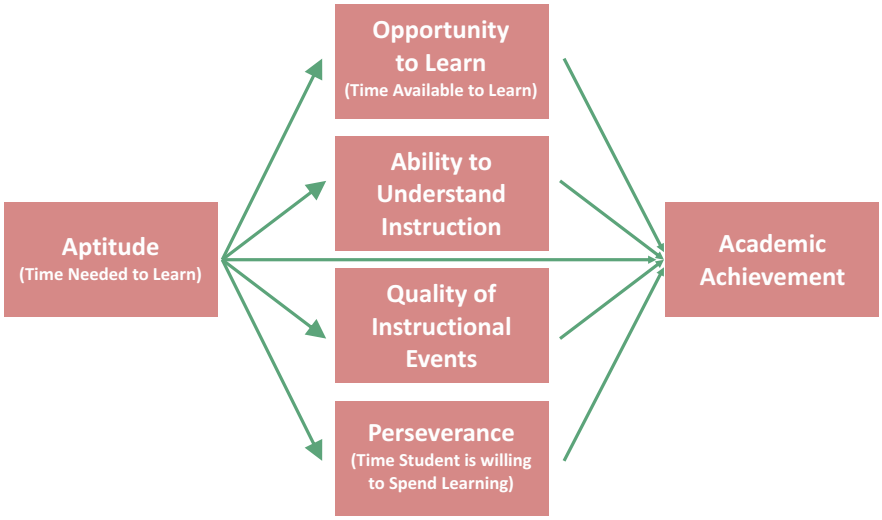

Figure 1. Carroll's (1963,1989) Model of School Learning.

Carroll's Model: School Learning = f(time spent/time needed)

HOW PRACTUTOR HELPS STUDENTS DEVELOP MATHEMATICAL SKILLS

USE OF INTERACTIVE COMPUTING TECHNOLOGIES (ICT) LIKE PRACTUTOR IMPROVES STUDENTS' MATHEMATICAL SKILLS

"Interactive computing technologies (ICT) enhance both the teaching and learning of mathematics. Great benefits can occur if the technology (1) is controllable either by students or teachers, (2) is easily accessible in a way that enables student explorations, and (3) promotes student generalizations" (Demana & Waits, 1990).

Interactive computing technologies provide students with a rich environment for active learning. Researchers have established a clear relationship between improvement in student understanding of mathematical concepts and use of computer environment for learning. As per Kaput (1989), computerized learning-programs provide students with a mechanism for students to discover their own errors. Palmiter (1986) found that with an ICT, students learn advanced mathematics in lesser time and have enhanced conceptual understanding. OECD report, "Are Students Ready for a Technology-Rich World; What PISA Studies Tell Us (2005)", too shows a clear progression in student performance in mathematics the longer students use a computer.

In the following section, we analyze one of the web-based learning programs, PracTutor in terms of strategies that promote mathematical achievement:

1) Encourage exploration and investigation

"Students actively construct their individual mathematical worlds by reorganizing their experiences in an attempt to resolve their problems" (Cobb, Yackel, and Wood, 1991).

Students need to engage in self-exploration of mathematical content, and they need to carry out self-investigation of concepts. This process develops flexibility in their reasoning skills and expands their learning base.

STUDENT LEARNING STRATEGIES THAT INFLUENCE MATHEMATICS LEARNING

1) Student's use of time

The groundbreaking Carroll's (1963) model of school learning defines learning as a function of efforts spent in relation to efforts needed or School Learning = f(time spent/time needed).

A limiting factor on learning is the reality that students may fail either to use all the instructional time available or may find ways to extend this time. Therefore, it is important to keep students motivated to learn and provide tools, which will best utilize the time students spend studying mathematics.

2) Meta cognitive strategies

Meta-cognitive strategies are generic approaches that the use in addressing a learning task. There is enough support in the literature for the hypothesis that student use of meta-cognitive strategies contributes to achievement. Wang, Haertel and Walberg (1994) consider it as having the greatest influence on achievement.

3) Co-operative and competitive learning situations

Substantial literature exists on co-operative learning in classrooms (see, for example, Slavin, 1994; Johnson and Johnson, 1989). Students who engage in competitive learning tend in many countries to be among the higher achievers.

Goals of Mathematical proficiency can be attained if teachers shape the classroom environment in ways that enhance students' involvement with mathematical problems, and with each other as they engage in mathematical activity.

(NCTM 1989)

PracTutor:

Student Home-page displays all the standards a student needs to master in a grade to meet the Common Core State Standards. PracTutor gives the choice of selecting the Standards they want to attempt; students can select any Standard they feel comfortable with. A number of videos are made available for each mathematical concept which gives students instructional freedom and improves their chance of mastering a Standard.

2) Allow students to build on their prior knowledge

"Not only are children capable of developing their own methods for completing school mathematics tasks but that each child has to construct his or her own mathematical knowledge. That is … mathematical knowledge cannot be given to children. Rather, they develop mathematical concepts as they engage in mathematical activity, including trying to make sense of methods and explanations they see and hear from others" (Yackel et al., 1990).

It is the knowledge that students bring to the class that shapes their understanding of a new concept. If we understand learning mathematics as a constructive process, the most effective way of teaching students is by planning activities based on what they already understand and are interested in learning.

PracTutor:

Pretests administered at the beginning of each domain are the best tool to quiz students for their prior knowledge. They are special domain-specific tests, which analyze student competency against the Standards of a domain. Once teachers are aware of students' current state of knowledge, they can design further instructions based on student competencies.

TEACHING STRATEGIES THAT INFLUENCE MATHEMATICAL LEARNING

1) Disciplinary climate

Disciplinal climate refers to a classroom atmosphere that is efficient, conductive to learning, free of disruptions and in it, on-task behavior is maximized.

Disciplinary climate has the strongest (and positive) correlation with performance. {Study of time-on-task by Denham and Lieberman, 1980; classroom-distractions by Behnke et. al., 1981; teacher-control by Crocker and Brooker, 1986 and Marzano's, 2003, review of "What Works in Schools."}

2) Teacher support and student-teacher relations

It is measured in terms of a teacher's interest in student-work, the help offered with student learning, and appreciation of student opinion.

For better mathematical achievement, the instructional format should be such that the students can construct their own understandings. This in-turn depends on the type of activities teachers can facilitate to the students as well as a teacher's understanding of students' previous knowledge brought to the learning situation by each student.

3) Use of Manipulatives

Lessons involving manipulative materials will produce greater mathematical achievement than the lessons in which manipulative materials are not used if the Manipulative-materials are used well. (Suydam and Higgins, 1977)

Manipulatives allow students to develop strong connections among different mathematical concepts. Moreover, they give students a chance to demonstrate their conceptual understanding of these ideas. In short, they serve as an alternate representation of mathematical concepts.

PracTutor:

PracTutor has created its own set of Manipulatives based on the Kinesthetic-tactile learning style. Teachers are expected to introduce these Manipulatives during the initial stage of learning (Wearne and Hiebert, 1988a). Manipulatives allow teachers to emphasize several different representations of a mathematical idea and help students make conceptual connections.

The goal is that the students must learn to translate their conceptual understanding into a diagram or model and vice versa.

Similarly, when given a verbal problem, students should be able to write an equation as well as represent it graphically or with the use of manipulatives.

4) Use high quality instruction and scientifically based research based curriculum

It is necessary to link mathematics and the real world through problem-solving activities.

Such a curricula offers numerous benefits:

1) It enhances students' response in real-world situations.

2) Integrate Mathematics with other content areas and provide culturally relevant materials.

3) It provides students with a chance to solve non-routine and open-ended problems.

By using the problem-solving approach in class, students come to value mathematics as a useful tool that can be applied to out-of-school activities. Wisely-framed questions offer students the opportunity to relate mathematics with their own interest and concerns.

PracTutor:

PracTutor is designed to derive maximum instructional benefit that is embedded in Common Core State Standards (CCSS). The real strength of the questions is derived from the experience of K12 teachers who have contributed to the PracTutor question bank.

Benefits of using Common Core State Standards

1) PracTutor has a bank of high-quality questions that help students develop real-life connections with questions.

2) Students gain mastery in word-problems.

3) Students are able to develop the meaning underlying basic skills and procedural algorithms (Brownell and Chazal, 1935).

4) Students develop flexibility in thinking strategies with non-routine and open-ended problems.

5) Students develop their cognitive ability (Fuson, 1992c).

6) Students develop their spatial ability (Moses, 1977; Wilson and Begle, 1972).

5) Teacher attitudes and student attitude

High levels of positive-feeling toward mathematics and intrinsic motivation are important prerequisites for student creativity, student use of diverse problem-solving strategies, and deep understanding of mathematics (McLeod and Adams, 1989; Schiefele and Csikszentmihalyi, 1995).

As per Fennema (1977), suggests that research supports that a positive correlation exists between student attitude and mathematical achievement. Similarly, DeCharms (1984) suggests that teaching children to both set personal learning goals and take responsibility for their own learning of mathematics leads to increased motivation and higher achievement in mathematics.

A meta-analysis of 26 research studies concludes that there is a consistent, negative correlation between mathematics anxiety and achievement in mathematics.

The most effective ways to reduce mathematics anxiety are a teacher's use of systematic desensitization and relaxation techniques (Hembree, 1990).

PracTutor:

The rich, interactive learning environment of PracTutor helps students perceive mathematics as a useful and interesting subject (Callahan, 1971; Selkirk, 1975). It also provides intrinsic motivation via PracCash, Praccity and mastery certificates. Feedback is another important faction in students learning of mathematics (Holmes, 1990).

6) Using performance-based assessment

Mathematical instruction and mathematical assessments must be "interdependent" to achieve the maximum benefits of performance-based assessments (Frederiksen and Collins, 1989; Linn et al., 1991; Wolf et al., 1991).

Nitko (1989), suggests that students should be given access to their assessment results and should be provided with assistance to use those results as learning tools to reflect on their strengths and weaknesses in mathematics. Davis(1978) concludes that performance-based assessments in a mathematics classroom is a teacher's "best chance" to determine a student's level of understanding or development of meaning in mathematics.

PracTutor:

PracTutor assessments test students as per the expectations of common-core state standards. In congruency with above-mentioned research work, PracTutor has ensured that students have complete access to their assessment results. Moreover, they can check the correct solutions of the assessment questions from their own dashboard.

The following PracTutor features are in congruency with the suggestions made by Aschbacher (1991):

1) Students have to answer questions that require them to do activities (Manipulatives), and solve problems that require higher-level thinking skills and problem-solving skills.

2) Assessment tasks are engaging, demanding and meaningful.

3) Questions are set in real-world contexts

4) They are aligned with the Common Core State Standards.

Conclusion

PISA has defined mathematical literacy as "…an individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgments and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen" (OECD, 2003e).

For a long time, content of school mathematics curricula was based on the need to provide a foundation for the professional training of a small number of specialized jobs. In the 21st century, the role of science, technology and mathematics has merged to create a new global environment; everyone must consider both the extent to which they possess mathematical knowledge and understanding, and the extent to which they can activate their mathematical competencies to solve problems they encounter in life.

PracTutor provides teachers with a tool that presents students with an opportunity to prepare them to meet 21st century standards. It is designed in such a way that its regular usage could be of genuine benefit in developing students' mathematical skills.