INTEGRATION OF MATHEMATICS AND SCIENCE: DOING IT CORRECTLY FOR ONCE

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Abstract. The cry for the integration of mathematics and science is a result of American students' results on international exams. Literature that advocates this integration of science and math n the United States dates actually back to before the 20th century. Berlin and White (1999) reported that the first article about integrating science and mathematics was published in 1905. If we want to improve the learning of students in mathematics and science, good mathematics teachers should have the freedom to develop strategies that will allow students to construct their understanding of mathematics in their mental frames of reference. Likewise, science teachers should be able to connect the appropriate mathematics links to their program. Effective use of mathematics in science will strengthen each discipline and allow the learners to link for themselves the „language" and description of the universe.

Keywords: Curriculum Reform, Integration of Mathematics and Science, Interdisciplinary Study, Mathematics Education, Science Education, Secondary School Education Reform

Integrating science and mathematics together sounds like a recent development going on since the 1960s. Literature that advocates this integration of science and math n the United States dates actually back to before the 20th century (Berlin & White, 1999; Isaacs et al., 1997). Berlin and White (Berlin & White, 1999) reported that the first article about integrating science and mathematics was published in 1905 after a fifteen-year survey of

related literature. The cry for the integration of mathematics and science is a result of American students' results on international exams. Our student's performance on these exams, when compared to their international cohort scores in mathematics and science draws attention to improving test scores. In the most recent Trends in International Mathematics and Science Study (TIMSS) study (2003), the United States has made impressive strides of achievement at the eighth-grade level but remain flat with other grades tested (Workosky, 2004). In light of these results suggestions are being voice how more improvements could be sought. The National Science Teachers Association (NSTA) advocated in Workosky's article that more math and science courses should be offered and even required from students. The other popular solution to improve the performance for both areas is to combine both disciplines into one field of study.

This proposal for integration of mathematics and science is popular as its advocates see both subjects as similar fields. The advocates of integration claim that mathematics is the language of science and this creates a natural „fit". Advocates for the integration of math and science are easy to come by and several professional organizations support this integration such as: National Council of Teachers of Mathematics (NCTM), National Research Council (NRC), and American Association for the Advancement of Science (AAAS) (Berlin & White, 1999). Even the National Science Education Standards of 1996 recognizes the integration of mathematics and science as an important part of the educational reform. Several states have moved to the call for integration of mathematics and science in their state educational standards as a result of the 1996 National Science Education Standards. However, integrating mathematics and science in the real classroom in Indiana and other states tied with state implemented education standards this task becomes more formidable.

The advocates of integrative studies refer to mathematics as the language of science and have developed taxonomies to support linkages between science and mathematics. These taxonomies include skills that direct student learning in problem solving, reasoning, information-manipulating, information-management, and symbolic-representation skills. The conceptual skills of the integrated course require the students to examine and understand the concepts, principles, and theories of science and mathematics for integration. In reality these topics generally revolve around few concepts. Topics shared by both science and mathematics curricula include the study of measurements, patterns and relationships, probability and statistics, spa-

tial relationships, and variables and function (Isaacs et al., 1997; Berlin & White, 1999; Rutherford & Alhgren, 1991).

Only when these mathematical skills are directly involved in the science curricula can there be integration. Andrew et al (1997) observed that when there is not a clear relationship between mathematics and the science lessons, the value of the integration is lost. Furthermore, opponents to integrative studies have observed „the infusion of mathematical methods into science and science methods into mathematics to the point that they are indistinguishable as to what is being taught" (Berlin & White 1995, p.241). These curricula resulted in little learning and positive experiences for students.

The integrative programs are hindered by schools curricula that are driven by textbooks. Most integrative activities in mathematics and science tend to be at the level of instructional activities. There does not seem to be a whole scale integrations that the advocates were hoping to see. Few teachers lack the time, resources or the innovation to develop their own programs. The successful programs on integration that have remained are those at a more „modest" scale. These programs (Steen, 1994), teach appropriate skills where appropriate needs are true to the subject. Courses that teach mathematics and science concepts together must have a clear connection for the learner. By showing a clear connection science can teach understanding and mathematics reveals order and patterns.

For a successful integration of mathematics and science curriculum, certain procedures regarding scope and sequence of the courses must be observed and followed through with. The mathematics that the students use in solving mathematically based questions in science, must be the exactly as learned in their mathematics instruction. This connection between theory and application helps reinforce the new material and creates relevancy for the learner. The math added in the science classroom should be transparent and applicable.

Mathematics used in the science classroom should reinforce the perspective of investigation, exploration and experimentation in science. The applied mathematics provides quantitative evidence to the science endeavor, taking it beyond just descriptions

For science, mathematics underscores the importance of careful observations, data collection, logical thinking and modeling as part of the scientific method.

If a school system is determined to teach mathematics as a part of science certain actions need to be heeded to successful integration.

• First, few teachers are prepared to give both subjects the emphasis required to do an appropriate job. The science teachers will most likely cover the immediate mathematics needed to solve their problems, and the mathematicians will be most interested in teaching the traditional theoretical applications at the expense of the science content.

• The second concern about total integration at the senior high school level is the degree of mathematics needed to successfully engage in courses such as biology, chemistry and physics. The nature of these courses requires a unique foundation of mathematics.

• Furthermore, high school curriculum is more complicated to integrate. If integration of mathematics with science is to be successful, it must occur at the middle school and elementary level of education where the integration generally will be more local.

Many schemes are being designed for integration of mathematics and science, but the center of the designs should be the learner. Learners should be asked to use appropriate skills that they are able to manage. Berlin and White (Berlin & White, 1995) have observed that the increased use of mathematical modeling in appropriate applications in science class helped students to recognize the connections between the two fields.

If we want to improve the learning of students in mathematics and science, good mathematics teachers should have the freedom to develop strategies that will allow students to construct their understanding of mathematics in their mental frames of reference. Likewise, science teachers should be able to connect the appropriate mathematics links to their program. Effective use of mathematics in science will strengthen each discipline and allow the learners to link for themselves the „language" and description of the universe.

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