

Current Research on MS&T Curriculum Integration in Western Australia: Examining the Knowns and the Unknowns

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This paper summarises the final report on a study first described to MERGA conference delegates in 1998. Following an extensive review of research on integration spanning the past 30 years, a number of middle school settings of integrated teaching and learning from across a range of demographic and socio-economic areas were studied over three years in order to provide data upon which a number of assertions related to curriculum integration were formulated. Using a number of approaches to data collection, the facts about curriculum integration were documented and six assertions were compiled concerning what we believe we know about the process. Another five assertions about what we believe we still need to understand about this process were also compiled. Arguments for and against integration are discussed from the viewpoints of the students, teachers and administrators.

Curriculum integration has created an upsurge of interest among teachers and administrators in Australia and overseas in recent years, with discussions focused particularly at the middle school level (National Council of Teachers of Mathematics, 1995; Nixon, 1991; Rutherford & Ahlgren, 1990; National Research Council, 1989). Proponents of integration argue that subjects like mathematics, science, and technology should be integrated with each other, or with other learning areas, so that students can recognise the contextual relevance of the subject matter and identify the links that exist between these discipline areas (Kleiman, 1991). Further, integration often has been proposed as a potential cure for many of the ills associated with teaching young middle school adolescent students – ills such as their perceived alienation from traditional curriculum subjects and structures (Bean, 1991; Cormack, 1996; Cumming, 1996). And yet, research examining integration in practice is rare (Berlin, 1989; Hargreaves, Earl, & Ryan, 1996). The two central questions, whether students learn the basic mathematics, science and technology concepts when teaching and learning occurs in an integrated environment, and whether, indeed, integration addresses the fundamental problems associated with teaching adolescents, remain unanswered. Teachers and researchers simply do not know the answers to questions about the advantages and disadvantages of integrated teaching practices in mathematics, science and technology, nor do they know much about the consequences of this approach to teaching in terms of student learning.

This paper attempts to fill part of this void by reporting a synthesis of findings from a three-year study of integrated practice in several schools in Western Australia. Because of the research design which involved the investigation of many approaches to integration (in different schools and localities, through a series of case studies) a broad base of information has resulted. The paper presents a meta-analysis of these findings in order to draw together the outcomes of the study, discuss the implications of the findings and point to areas of continuing concern.

Theoretical Framework

The argument for integrated teaching presented in the literature is strong. A provocative analogy is presented by Kleiman (1991), who suggests that if we taught music the way we traditionally teach mathematics or science, students would practice scales for years without playing a song or that students of art would draw lines and shapes without ever getting to create a picture. If we view integrated teaching and learning from an humanistic perspective, Kleiman (1991) argues, integration “provides a vehicle for thinking, a medium for creating and a language for communicating” (p. 48). According to advocates of integration, mathematics, science and technology should be used in rich environments integrated with other learning areas so that students can learn to appreciate the contextual utility and elegance of the subject matter.

From a related perspective, Hargreaves et al. (1996) point out that integration promotes greater relevance, especially between high status, academic subjects (like mathematics and science) and lower status, practical ones (like technology, manual arts or home economics). However, integration threatens the advantage of people who traditionally have benefited from an academic curriculum, including teachers. This is because integration usually involves the recognition of forms of achievement and intelligence that are beyond the established methods of evaluation. Complaints that an integrated curriculum lowers standards, destroys ‘real subjects’ and results in a ‘wishy-washy’ curriculum are criticised by Hargreaves et al. (1996) as the result of political and philosophical manoeuvres to maintain structures of power and control. The structures of power and control that Hargreaves et al. refer to are maintained within high schools by practices such as formal subject-based examinations and subject departmental divisions. Critics question whether the students learn the central concepts and skills that define the separate disciplines of mathematics and science. Thus there are theoretical and ideological arguments for and against integration, and all of them were encountered in the three year study of integration reported here. The results shed some light on the arguments, in particular, from the point of view of the participants in the various integrated programs.

Methods

The research reported in this paper resulted from a collaborative study involving the authors and the Education Department of Western Australia. The authors visited 16 schools, including 12 high schools and 4 primary (elementary) schools in the metropolitan and country districts within the State of Western Australia. The schools were selected on the recommendation of several key State curriculum personnel who advised that curriculum integration had been attempted in these schools in Grades 6-9.

Government, Catholic and Independent high schools were included in the sample, and the visits involved classroom observations, interviews with teachers, students and other school personnel, and document analysis. Some of the visits focused on teaching, others on learning, some on mathematics, science and technology teaching in integrated contexts. Written reports at the intermediate and final stages of the research were fed back to the participants for comment and correction. The three-year research project has been reported in several presentations and journal articles (Venville et al., 1998, 1999a, 1999b, in press) and in a monograph casebook (Venville et al., 1999c), a copy of which has been placed in every government high school in Western Australia courtesy of the State’s Education Department. In this paper, we use a cross-case analysis to report a synthesis of our findings over this three-year period, focusing on what we believe we now know about integration, and what we still need to know.

Findings

What we believe we know about Curriculum Integration

1 Integration is a curriculum ideology

Our first proposition is that integration is an idea or stance about curriculum that is associated with a particular value position about schooling for adolescents and about the importance of subject matter. While this value position has broad acceptance in the educational community, it is not without its critics. Many educators believe that in seeking common ground, integration results in a 'watering-down' of the syllabi and creates problems in other aspects of the integrated areas (such as assessment). Also, there is some evidence from our work to suggest the existence of the uncritical adoption of the integration idea by mathematics, science and technology teachers without a sound understanding of its ideological basis. An example of this was the case of the mathematics teacher in a government high school who, because of his conviction of the value of curriculum integration, believed that it was incumbent on him to carry out all aspects of the process personally – that is, demonstrate to his class the role particular mathematical concepts played in physics, music, chemistry, English and the social sciences. A worthy sentiment, but the extent to which he engrossed himself in this task created other stressful problems for the individual.

2 Integration comes in many forms

Integration is often described as if it were a single form of instruction. However, we found a variety of different forms of integration being utilised by the 16 schools in the study. Each form is described briefly below:

- Thematic approach:

This approach was observed in two schools. These were used to integrate the curriculum, and teachers responsible for each of the learning areas developed a program of work complementary to the theme. Examples included: the Sydney Olympics, decision making in business, family relationships and ancestry, communication nets, popular culture, Earth and people, and scarce resources. Teachers commented on the different levels to which they were able to integrate their learning topic area within the theme, with most teachers expressing the view that they were able to make a number of significant links.

- Cross-curricula approach:

Cross-curricular issues such as numeracy, computing skills and literacy served as a basis for integration in several schools. For example, a technology teacher pointed out that literacy was clearly integrated into the technology course through the interpretation of a design brief and written assignments, and that mathematical skills were utilised, especially in the measurement area. Computing was also integrated, with students using word processing for their research assignments, and in using programs such as CAD for the design of products.

- Technology-based approach:

Students in one school were given a project to work on for 10 to 12 weeks. It included a mathematical, a technological and a scientific research component. The project brief was to design and produce an electric powered vehicle that could climb a steeper gradient than anyone else's on a standard test track. The mathematics research component investigated the effects of changing variables on Logo model hill climbers and recording, analysing and presenting the groups' results from the time trials.

- Topic approach:

In one school, a mathematics teacher and a social science teacher initiated a project amalgamating mathematics, statistics and social science on the topic of World Environment. The project ran for three weeks and required students to research a developed and a developing country, and then perform various mathematical and statistical analyses on the data they collected. – such as extrapolating population trends, calculating means, medians, modes and standard deviations, and presenting the results in graphical form.

- Competition approach:

Competitions such as the Solar Car Challenge and Science Talent Search provided good opportunities for integration between mathematics, science and technology in several of the observed schools. In the Solar Car Challenge, the mathematics component of the integrated activity involved the students in calculating the most efficient angle for the solar panel, and conducting and documenting the statistical analysis of the car racing trials.

- Integrated assignment approach:

Three schools used integrated assignments between learning areas which took between one lesson and two weeks to complete. In one school, the mathematics teacher organised integrated mathematics and science assignments every five weeks. One of these investigations was on pendulums and involved the class in developing a hypothesis and experimental procedure, statistically evaluating the data and presenting the results in graphical form

- Common teaching approach:

One form of integration involved using the same framework for designing and writing up investigations in mathematics and science. Teachers stated that using the same approach assisted students to perceive similarities in the processes involved in the Working Mathematically and Working Scientifically strands of the Student Outcome Statements. The common approach provided a catalyst to integrate both content and skills across the learning areas.

- Synchronised content and processes approach:

Teachers in three schools explained how the content in their different learning areas was synchronised as much as possible to allow similar content and processes to be taught at similar times. This involved the teachers in each school writing down all they hoped to achieve during the year, making a map of the possible links, and then re-arranging the program to facilitate the plan wherever possible. One example of these links involved chi-square analysis in mathematics and statistics and Punnett square problem solving in genetics. The teachers were able to synchronise the teaching of these concepts and explicitly link the ideas together.

- Local community projects approach:

Two schools had been involved in local community projects which integrated skills and content from a number of learning areas. One project involved students, in liaison with a local shopping complex, providing plans for an improved arrangement of parking and pathways prior to major earthworks taking place. Another school described how students had worked with the local council to prepare an inventory of services provided to the community.

- Natural/Informal approach:

Teachers in four primary school explained how much integration happened naturally because they taught the majority of learning areas to the same students, and 'links just cropped up'. In one school, technology was promoted as a vital learning tool to extend other subjects. For example, mathematics investigations were used in technology projects, and the students explored situations such as the cultural value and profit margin of the artefacts produced. One group of students made a bird-feeder by designing a template and then constructed the final product.

It can be seen from the above approaches that integration is like an umbrella under which many views on various aspects of integration are represented.

3 Integration challenges the grammar of schooling

Our third finding is that integration challenges what Tyack and Tobin call "the grammar of schooling" (as cited in Hargreaves et al., 1996, p. 86) – that is, the 'apparatus' of schooling, including teacher training, curriculum materials, subject departments, professional associations, assessment structures, school timetables and students' university futures – and vice versa. While the teachers in our project were being urged by school authorities to integrate the curriculum, the grammar within the school often seemed to be working against the rhetoric on integration.

4 Instances of successful integration are idiosyncratic

We found that instances of successful integration – where teachers seemed to making genuine attempts to integrate and the classroom atmosphere seemed conducive to learning – were patchy. Rarely was integration a school-wide phenomenon, rather it generally relied instead on a few dedicated teachers or teaching teams. We noticed that over time, some teachers tended to drift away from integrated practice back towards discipline-based teaching. Integration also ebbed and flowed as teaching teams configured and reconfigured within a school.

5 Integrated teaching works best in inclusive contexts

According to Bean (1991), integration is about wholeness and unity rather than separation and fragmentation. We documented several examples of this kind of integration where students were able to make interdisciplinary links (between mathematics, science, technology, English, other languages, physical education, the social sciences, music and art) and transfer knowledge and skills from one context to another. These linkages were enhanced in inclusive contexts, where students and teachers were also found to be working in team environments and where students were able to call upon community and family support.

6 Integrated learning involves gains and losses

The gains we noticed in students' capacity to transfer knowledge were often offset by deficiencies in specific subject matter knowledge. We recorded several instances of students' retaining naive mathematical and scientific understandings in a situation where there was an absence of remedial teaching to address such deficiencies. There were also gains and losses for the teachers, in terms of the time and effort involved to create and implement an integrated program, and there was very little formal evidence available to measure the success or otherwise of their endeavours.

What we still need to know

1 What is the problem that integration is addressing?

This has been a continuing question for the research team. As mentioned previously, we noticed many instances of uncritical adoption of integrated teaching methods and observed the large amount of time invested by teachers to develop integrated support materials. However, we wonder if sufficient consideration has been given to the nature of the problem itself. What exactly are the problems surrounding the schooling of adolescents, and are there other ways (perhaps even more effective ways) of addressing them?

2 How is integration addressing this problem?

If we do recognise the problem as one of alienation, for example, how is integration supposed to be a solution? In our own work, we have observed several instances of integrated learning environments that appear to be addressing such problems. We have also observed other less successful learning environments. Is the key to the problem good teaching (of mathematics, science and technology) rather than integrated teaching per se?

3 What are students actually learning in integrated contexts?

While we can report on some instances of successful integrated teaching and learning in mathematics, science and technology classes, we are still short on solid evidence of what it is that students are actually learning. Part of this problem lies in the nature of the learning and the absence of measures for such learning, and part lies in the dearth of close-up research into what students know and can do as a result of integrated settings. We suggest that the move towards outcomes based teaching and learning will throw some light on these issues.

4 How can integration be scaled up and sustained over time?

We observed that integrated teaching appears idiosyncratic and erodes over time. If it transpires that integration does provide an answer to the problem of adolescent schooling (as many commentators would have us believe), we are still faced with the problem of scaling up and maintaining the momentum. How, in the face of the constraints identified earlier, can integration be envisioned as a broad-based solution to the systemic issue of adolescent schooling?

5 How is assessment best handled in integrated contexts?

If one imagines a school 'assessment continuum' with, say, mathematics at one end and science at the other, then we have a representation of non-integrated subject assessment wherein assessment procedures are separate and distinct. Integrated assessment would fall somewhere within that continuum, and assessment procedures in this case are somewhat blurred. The question of how best to assess an integrated syllabus or curriculum appears to be largely unresolved, although the assessment of cross curricular integrated projects seemed to pose no problem, with credit assigned according to the quality of the science, mathematics and technology input. Is the project the only form of assessment vehicle one can use in integrated contexts though?

Reporting on assessment in integrated teaching contexts is clearly problematic in many schools at present also. We saw almost as many different report forms in use in schools as there were schools in the sample. These ranged in appearance from simple, one-sided forms to four-page booklets providing for most detailed qualitative feedback from all teachers involved in integrated activities. Teachers expressed concern at either the over simplistic nature of the forms, or (more often) their complexity, which had resulted in confused and sometimes angry responses from parents.

Conclusion

Curriculum integration in schools is being implemented in various countries throughout the world. The responsibility for implementing integrated curricula rests with the classroom teacher who has very little time to spend on this time-consuming task. Developing activities and assessment tasks that meet integrated curricular goals is difficult, and the fact that the term is not understood by some school administrators, teachers and parents makes the job of implementing it all the more harder. Lonning and DeFranco (1997) believe that several key issues must be examined if we are to answer the question "what does the integration of science and mathematics really involve?" Their first point is that integration can be justified only when students' understanding of the mathematics and science content is enhanced. Second, integration makes sense only when it grows from the mathematics and science curricula rather than from other sources that may provide only shallow activities lacking meaning for both students and teachers. Third, it seems clear that one method of teaching in a manner conducive to integration is to focus more on how concepts can best be taught, rather than on how they can be integrated. This is because not all mathematics, science and technology concepts can or should be taught in an integrated fashion.

The authors of this paper believe that we have identified further issues that need to be resolved before we can be satisfied that we are successfully integrating the curriculum. Integration is a potentially powerful means for assisting teachers and students to understand the world from a broader perspective. Its potential for enhancing teaching and learning in mathematics, science and technology warrants our attention.

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