

Connections between Mathematics and Arts & Culture: An exploratory Study with Teachers in a South African school

Joseph Dhlamini

Mathematics Education, PhD student, Tshwane University of Technology, South Africa
jjthemba@yahoo.com

Abstract This paper presents results of a two year study, at Master's level, which was undertaken to investigate how two Grade 9 Arts and Culture teachers incorporated mathematics in their Arts and Culture lessons in their classrooms in South Africa. Data from concept mapping activities and subsequent interviews with both teachers were collected and analysed using typological methods of analysis. Data collected from the study revealed that teachers still continue to grapple with the notion of integration. Lack of proper training and insufficient teacher knowledge seem to be the challenging factors for teachers to navigate successfully through the notion of integrated teaching and learning. Drawing from the theory of situated learning, this paper argues that although integration between mathematics and Arts and Culture is desirable in teaching and learning, it is problematic in practice. The analysis from this study raises important pedagogical issues about the link between 'integrated teaching' and 'teacher training-and-content knowledge'.

Introduction and contextual background

Curriculum reforms are taking place in many countries across the world. In a South African context, the reforms have meant that schooling shift from following a structured schedule of study characterized by a strong separation between bodies of knowledge (Snyder, 2000), to an interdisciplinary approach of instruction. The introduction of Outcome Based Education (OBE, Department of Education, 2003a) has placed demands on teachers to adopt new styles of teaching, with integrated approaches being central. The notion of integration has permeated and become synonymous with the new curriculum such that teachers are encouraged to organise their teaching in ways that promote integration of one learning area with another. There is a belief that integration can foster stronger working relationships not only amongst educators, but also amongst learning areas that are being taught. So integration seems to be key in understanding learning systems being framed in the new ways of working in the South African curriculum. When teachers collaborate across disciplines, as Jennifer Stepanek (2002) argues, they gain new insights and new ways of approaching familiar and often complex subject matter. However, implementing the new curriculum has been marked with complexities and criticisms, with others raising concerns that teachers are not adequately trained to handle new curriculum demands. It is realised that this could be due to the fact historically, they are educators who are certified in specific disciplines. Therefore, it is both ambitious and unrealistic to expect them to possess knowledge that can enable them to navigate integratively effectively across subjects (Czerniak, Webber, Sundmann and Ahern, 1999).

These concerns, in addition to claims that integration might mean different things to different teachers (Davison, Miller and Methey, 1995), make integration a seemingly complex teaching innovation to comprehend and also implement in practice. Regarding integration, Adler, Graven and Pournara (2000) have noted that 'the teacher is expected to possess a broad general knowledge of his or her subject matter and possibly also to be an expert in other subject areas. This is clearly seldom possible and might leave the teacher feeling powerless to cope with the new demands' (p. 6). The challenge still remains for teachers to incorporate and articulate new pedagogies that emphasize integration within and across disciplines. From this background, it becomes clear that there is a challenge for Arts and Culture teachers to incorporate new pedagogical approaches that emphasize the need to integrate mathematics and Arts and Culture.

This paper reports on a study that involved two Grade 9 Arts and Culture teachers in South Africa. The aim of the study was to establish how these teachers deal with situations in which they are called upon to reflect on their mathematical knowledge while teaching their Arts and Culture curriculum (DoE, 2003b). This paper reports on aspects of the following research question of the study:

Within the context of the new South African curriculum, what connections do Grade 9 Arts & Culture teachers make between mathematical concepts and concepts in an Arts & Culture topic?

It was important for this study to focus on links between mathematics and Arts and Culture because most of the research reviewed (for example, Davison, et al., 1995; Huntley, 1999; Lyublinskaya, 2006) have placed more emphasis on exploring integration between mathematics and science, than on mathematics with other learning areas.

Literature review and theoretical framework

Interest in this study was initiated by the realization that integration is placed as a fundamental aspect of the new progressive South African curriculum (Adler, et al., 2000). In South Africa, when the traditional curriculum was replaced by Curriculum 2005, the OBE-oriented approach, it became clear that teachers had

to familiarize themselves with new pedagogical approaches to teaching and learning. A wide range of new concepts was introduced to the system of education, with integration being the most popularised. Few years after its inception, Curriculum 2005 was reviewed and most of its 'design features' (Adler, et al., 2000) were removed. However, integration continued to remain the key feature of the subsequent revised version. Teachers, as they enact the new curriculum, are expected to implement integrated teaching in their lessons. However, as already alluded, there is a concern that teachers are not well oriented to deal with the demands of integrating across disciplines (Czerniak, et al., 1999; Adler, et al., 2000; Huntley, 1999). This raises serious pedagogical concerns, particularly in view of the fact that substantive teacher content knowledge is a prerequisite in order to facilitate connections between disciplines (Huntley, 1999). This study was therefore designed to provide space to investigate how teachers worked with these new pedagogical demands for integrating across subjects. The focus here was on how Grade 9 Arts and Culture teachers are able to make connections between concepts that are embedded in the two subjects, mathematics and Arts and Culture.

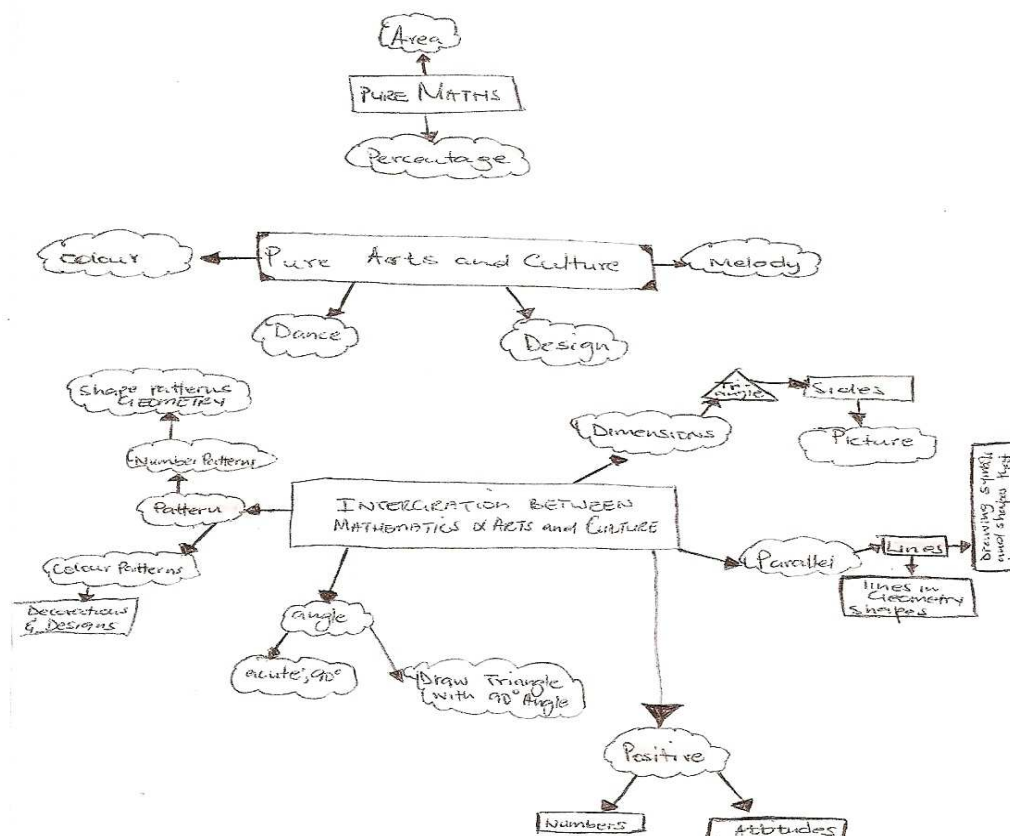
It was believed that the findings of this study would be critical in helping curriculum designers to heighten the awareness of the need to train teachers and also encourage them to integrate across subjects. Some of the literature on integration has claimed that there is a 'historical lineage of connections between mathematics and Arts and Culture' (Beckmann, Michelsen and Sriraman, 2005). The two learning fields are historically inter-connected, with Arts and Culture providing possibilities to visualize mathematical thinking and expressing mathematical thoughts that are possibly complex to comprehend theoretically. Mathematics, on the other hand, can contribute to the solution of significant unresolved cultural problems, for instance, global birth control and epidemic control (Sriraman, 2005). It is therefore significant that these issues are brought to the awareness of the Arts and Culture teachers with the view that their awareness might stimulate them to make important and relevant connections. Teachers need to realize that there are various opportunities that provide possibilities for connecting mathematics and Arts and Culture, and that they can explore these opportunities in order to enhance their professional experiences of integrated teaching and learning. Arts and Culture is a critical learning area within the South African school setting. Learning Arts and Culture can assist in liberating students' potentials to do well in subjects such as mathematics. According to the Department of Education (2001), 'liberating the imagination, [is] a first step in the creative process, and the expression of culture, is a skill, a goal in itself which ranks in importance with mastery of numbers and natural laws in the school setting' (p. 9).

The theory of situated learning (Lave and Wenger, 1991) was used to frame this study. This theory is founded on the premise that knowledge is situated, and is a product of the activity, context and culture in which it is developed and used (Brown, Collins and Duguid, 1989). This theory presupposes that one learns differently in different situations, so learning is situated within a context. The key issue here is that the 'development of knowledge, and how it is later applied, is situated within a context', that is, the development and formation of identity are both tied to the setting in which they are acquired (Adler, et al., 2000). Subsequent to this view, Adler, et al. argue that the transference of knowledge from one setting (context) to another is always problematic because 'knowledge and skills cannot be neatly lifted out of one setting and imported ready-to-use into a new setting' (p. 11). The researcher has used this theoretical framework to highlight the fact that implementing the notion of integration, in teaching and learning settings, is potentially problematic as this process involves the sharing and transfer of knowledge from one context to the other. This view is strengthened by the realization that mathematics and Arts and Culture present two different learning contexts that are constituted with different learning activities and culture. Furthermore, how one conceives and embeds concepts from one discipline to another depends on one's understanding of the possibilities of connections that are available. Such a conception is likely to be subjective and highly dependent on the nature of the contexts involved.

Study design and data collection

A qualitative descriptive research methodology was used, and because qualitative research is inherently multi-method in focus (Naidoo and Parker, 2005), the researcher was able to collect data through a concept mapping activity and subsequent interviews which were administered on the participating teachers. A concept mapping activity was fore-grounded because concept maps are quicker, more direct and considerably less verbal (White and Dunstone, 1992). The concept mapping task which was administered on teachers involved the following concepts, which were drawn from a Grade 9 Arts and Culture textbook, Millennium Arts and Culture Grade 9 Learner's Book: angle; area; colour; dance; design; dimension; melody; parallel; pattern; percentage and positive. Teachers were asked to identify concepts which they perceived as 'pure mathematics', 'pure Arts and Culture' and those they considered to be integrating

between mathematics and Arts and Culture (parallel concepts). After this activity both teachers were interviewed based on the results of their concept mapping activities.



The Arts & Culture teacher’s Concept map

Results and observations

The observations in this paper are based on an analysis of the concept map constructed by one Arts & Culture teacher. The teacher was teaching Arts and Culture on a fulltime basis and had teaching experience of approximately 15 years. The teacher indicated that he was quite familiar with both versions of the curricula, the traditional and the new revised curriculum. He acknowledged having attended OBE training workshops arranged by the Department of Education and, at other times, by non-governmental organizations. The figure below shows the concept map drawn by the Arts and Culture teacher.

As can be seen from figure above, there are three components in the map: it shows concepts that seem to belong to the top part “Pure Maths”; secondly, those that are “pure Arts and Culture” concepts, and those that “Integrate between mathematics and Arts & Culture”. The teacher felt that the concepts *colour*, *melody*, *dance* and *design* were pure Arts and Culture concepts, and so could not be linked to mathematics. This is interesting, particularly in light of Graumann’s (2005) comments below in relation to the connection between mathematics and music:

Rhythm and notation is a relatively simple mathematical field, which provides a good opportunity for application-oriented practice of fractions. The determination of pitches and scales respectively tunes is a big chapter in which the development in the theory music from Pythagoras to twelve-tone music can be opened up by mathematics. In this context, the ancient theory of music can serve as a field of application for fractions as well.

The absence of connections between these concepts and mathematics was further confirmed in the interview with the Arts and Culture teacher when he repeatedly stressed that the concepts *colour* and *music* could not be linked to mathematics. However he was passionate about integration and acknowledged that “teachers should be trained on integration” because some of her colleagues were “still struggling with integration”. He noted that teachers sometimes relied on other teachers as well as learners for assistance with integration. According to him, “the learners will definitely help you, you can give them a problem, they will give you answers that you did not expect, they will integrate”. He identified ‘area’ and ‘percentage’ as the only concepts that can be linked to mathematics. During the interview, he insisted that ‘percentage’ is a mathematics concept. He stated: “In Arts I don’t talk about percentage”.

The teacher noted that integration is encouraged in curriculum documents through the statement of Learning Outcomes (LO). He acknowledged that some of the LOs encouraged the integration of mathematics with Arts and Culture. He particularly quoted Assessment Standard 9 in the Grade 9 Arts and Culture Curriculum in which the concepts 'positive' and 'negative' are mentioned, namely that there are "positive and negative effects of television, radio, documentaries or films on our lives" (DoE, 2003). He acknowledged that such topics are likely to stimulate mathematical discussions, thus opening up opportunities for connections between the two subjects. He noted that learners can "learn two things at the same time" when such topics emerge during lessons.

Overall, this activity revealed interesting observations. Teachers acknowledged that integration had replaced the traditional style of teaching. This was made evident by the fact that both teachers had clustered concepts on the integration category of their map, thus revealing that they regarded most concepts as integrating. However, their actual teaching practices were not in line with this acknowledgement, as was revealed later in the interviews with the teachers. There were areas where it became evident that teachers do not foster a spirit of non-coercive collaborative work. For instance, teachers' views differed on certain concepts such as 'percentage', 'area' and 'pattern'. In some cases teachers were not sure in which category they needed to place a concept, i.e. whether the concept belonged to mathematics or to Arts & Culture. Interviews with the teachers also revealed that teachers acknowledged links between mathematics and Arts and Culture, they provided numerous examples to support this claim. However, both teachers acknowledged that they had little knowledge of mathematics, and consequently struggled to incorporate mathematics in their instruction. As a result of this lack of mathematical knowledge they either conduct their teaching in traditional ways or rely on students to assist them with integration. There was a strong emphasis on the fact that teachers relied on their students for integration to be feasible. In fact one of the teachers insisted: "these kids help us many times, they know more maths than us. We prefer them than teachers". From this view it was evident that teachers regarded themselves as incapable of implementing the notion of integration properly, they regarded students as being more knowledgeable on integration than them. They strongly insisted that they preferred working with students than working with other teacher colleagues.

Conclusion

This qualitative case study has provided us with knowledge regarding challenges that teachers face as they attempt to integrate across learning fields. Teacher-knowledge is a critical area that requires immediate attention. The findings from this study concur with Huntley's (1999) observations whereby it is noted that:

Teachers are positive about integration, however, they do not possess the necessary knowledge and expertise to properly enact this teaching innovative in their classrooms. These gaps in their knowledge limit the extent in which teachers explore inter-disciplinary connections. Teacher knowledge is a prerequisite to making connections between subject fields.

The fact that most of the teachers were trained and socialized to be subject specialists (Czerniak, et al., 1999), and in the process not possessing general knowledge to other subjects, also emerged in this study.

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