Ideal and Reality: Cross-Curriculum Work in School Mathematics in South Africa

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Abstract: Within various school mathematics dispensations in South Africa the intention for cross-curriculum work is expressed in the official documents describing the intended school mathematics curriculum. This paper traces this expressed intention from 1962 to the present. The view is adopted that textbook authors are the major interpreters of the intended curriculum and therefore the manifestations of the cross-curricular ideal in school textbooks for the various periods are described and commented on. Using the manifestation of the cross-curricular ideal in the South African situation as backdrop, the paper concludes by suggesting ways to deal with three issues that seemingly mitigate against the realisation of this ideal. It is argued that the applications of and modelling in mathematics should be treated as a distinct separate section in the school mathematics curriculum; that mathematics activities should be designed so that learners with various levels of mathematical sophistication and expertise can deal with both the embedded context and the mathematics and that problems which use context only as a disguise for "pure" mathematics should not be summarily dismissed and written off as useless for the realisation of cross-curricular goals.

Kurzreferat: *Ideal und Realität: Fachübergreifendes Arbeiten in der Schulmathematik in Südafrika.* In Südafrika kommt das Ziel fächerübergreifenden Arbeitens im Rahmen verschiedener Regelungen für die Schulmathematik in offiziellen Dokumenten zum Ausdruck, die den intendierten Mathematiklehrplan für die Schule beschreiben. Dieser Beitrag zeigt die diesbezügliche Entwicklung von 1962 bis heute auf. Es wird die Ansicht vertreten, daß Schulbuchautoren die Hauptinterpreten des intendierten Mathematiklehrplans sind. Deshalb werden Hinweise auf fächerübergreifendes Arbeiten in Schulbüchern der verschiedenen Perioden beschrieben und kommentiert. Vor dem Hintergrund solcher Anzeichen für das Ideal fächerübergreifenden Arbeitens in Südafrika werden Vorschläge gemacht, wie drei Einwänden, die anscheinend gegen die Realisierung dieses Ideals sprechen, begegnet werden kann. Es wird dafür plädiert, daß Anwendungen der Mathematik und mathematische Modellbildung als separater Teil im Mathematiklehrplan behandelt werden sollten, daß mathematische Aktivitäten so gestaltet werden sollten, daß Lernende verschiedener Stufen mathematischer Fähigkeiten und mathematischen Könnens sowohl mit dem Kontext wie auch mit der Mathematik umgehen können, und daß Aufgaben, in denen der Kontext nur als Verkleidung der "reinen" Mathematik dient, nicht ganz aufgegeben und als vollkommen nutzlos für die Realisierung fächerübergreifenden Arbeitens abgeschrieben werden sollten.

ZDM-Classification: A30, D30, M10

1. Introduction

In recent years discussions about the necessity of cross-curricular work in school mathematics have surfaced in various guises (See, for example, Selkirk, 1982; Roper, 1994). Terminology such as "mathematics across the curriculum", multi-disciplinarity, interdisciplinarity and to some extent multiculturism characterises these discussions and positions. Although each of these terms has its own ideological intent they connotate within mathematical education a desire to move beyond the notion of a narrow focus on mathematically-driven school subjects such as physics and accountancy. One now finds inserted into school mathematics not only issues from these mathematically-driven subjects to form contexts for the application of school mathematics. So, for example, issues from areas as diverse as legal matters now form, at least at the level of proposals, the expanded universe for the application of mathematics.

Cross-curricular activities in school mathematics comprises mainly of the application of mathematics to context outside of mathematics. In general, these contexts are so stripped of their reality that it is unnecessary for the learner to make any sense of the context – the mathematics can be done without consideration of the embedded issues involved in the context. This is a complex issue due to a whole regime of indicators sensitizing learners to mathematics rather than to anything else. The subject they do is called mathematics, the timeslot within which they do it is designated as a mathematics period, the teacher is the mathematics teacher, the resources available (learning texts, expository texts, other technologically-allowed aids) are clearly labelled and identified as mathematics resources. It is against this background that cross-curriculum work in school mathematics in South Africa will be contemplated and commented upon.

2. The quest for cross-curriculum work in school mathematics

In this section we look at changes in the school mathematics curriculum in South Africa over the past thirty years (1962–1996) and trace the manifestations of cross-curriculum activities as they surface within school textbooks and official documents. For this period the South African school mathematics can be divided into four distinct periods, namely: (i) the pre-set-theoretic period (1962–1969); (ii) the set-theoretic period (1968–1983); (iii) the post-set-theoretic and non-governmental organisation (NGO) mathematics movement period (1984–1996) and (iv) the emerging post-apartheid school mathematics period (1996+). For the periods, the indicated years are approximate. The period 1962 to 1994 was that of apartheid education. During this period curricular changes were introduced differentially for differently-classified racial groups. So, for example, the "new" mathematics curriculum was first introduced for "whites" in 1968 and only later for other sectors of the South African population.

2.1 The pre set-theoretic period

During this period school mathematics comprised primarily of symbol manipulation and juggling. Although there was an aim in the mathematics syllabus documents which referred to the ability "to use mathematics in other subjects", this largely manifested itself as the inclusion of formulae for phenomena outside of mathematics but amenable for mathematical manipulation. A typical example of this would be

$$\text{In} \quad T = 2\pi\sqrt{\frac{e}{g}} \quad \text{make } g \text{ the subject}$$

(Matz/Sagel, 1961, p. 26)

This is the typical formula for the period of a simple pendulum and those students doing physics might have come across it. The likelihood they did is remote since this appears as an exercise very early in the mathematics text and the topic, "changing the subject of the formula", is normally dealt with during the beginning of the specific school year – much earlier than students will come across it in their physics course. As is evident in the above no mention is made about the context of the formula nor to the subject where it is used. To a large extend "the use of mathematics in other subjects" during this period was confined to activities similar to the one given above. It can thus be characterised as a period when mathematics borrowed artefacts (formulae in the above example) from other subjects and treated these artefacts void of their context.

2.2 Set-theoretic period

This period can be split into two parts – the pure set-theoretic (1968–1973) and set-theoretic and vector ones (1974–1983). During this era South African school mathematics curricula followed the international trend of instituting the "new mathematics". Statements in syllabus documents became much more explicit about the position of school mathematics and other subjects. Typical descriptions in the general aims for school mathematics were as follows:

1) To ... prepare and equip [the pupil] for further study in mathematics and *other subjects.*
2) To develop the pupil's ability to use mathematical knowledge and methods of solving problems which he may encounter in *other subjects* ... (my emphasis) (Provincial Administration of the Cape of Good Hope: Department of Education; 1968)

Statements such as the above can obviously be interpreted in different ways. Within the documents no indication is given on how these are to be interpreted and it is left to teachers to concretise such statements hinting at the cross-curricular. Generally, the interpretations given by textbook authors and national examiners to these statements were adopted.

If these statements are read as given then one would expect that learning materials and activities would reflect some form of cross-curriculum flavour in the sense that there will be direct pointing to other subjects or that the mathematics will take the other subject as starting points for acquainting learners with the context of the derived-from subject. Instances of specific explanations of outside-of-mathematics context started to appear in textbooks. The following exemplifies this emerging trend:

"You have learned that all measurements are liable to error. In very precise work the engineer and the scientist must try to make the error as small as possible. When they know the source of error they always try to remedy the error in their calculations. For, example, engineers realize that when a steel measuring tape is held off the ground it sags. This sag causes their reading to be larger than it should be. They have learned the error through sag depends on the *weight* of the suspended tape, the *length* between the supports and the *tension* on the tape. They express the relationship very precisely by the mathematical formula

$$E = \frac{w^2 l}{24p^2}$$

where E represents the number of length units of error, w represents the weight of the tape in pounds, l is the number of length units between the supports and p is the tension in pounds weight." (Emphasis in original)
(McMullen/Williams, 1969, p. 26)

The explanation above features in the section called "formulae" and is followed by a substitution exercise. Expanded explanations of the context, and presumably the other subject, such as this was the exception rather than the rule.

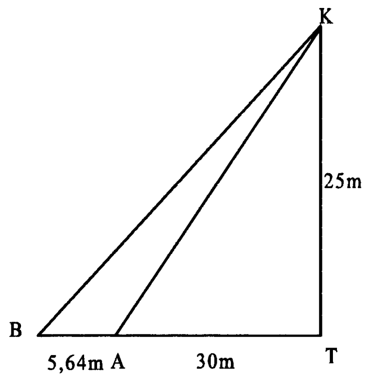
The second period of the set-theoretic era did not differ much from the first one. Interestingly, other subjects were now in some instances more clearly specified as is evident from the statement of a general aim

"to give pupils a clear insight into, and a thorough knowledge and understanding of those mathematical principles which will prepare and equip them for daily life and further study in mathematics, the pure sciences and certain applied sciences."
(Provincial Administration of the Cape of Good Hope, 1973)

The reference to other subjects were not discarded and generally the phrase "to ... prepare and equip [the pupil] for further study in mathematics and *other subjects*" was retained with the preceding statement added on. Embedded mathematical problems with little explanation of the context continued. An example of the last-mentioned statement is the following:

"A radar system is effective over the region R where $R = \{(x;\, y) \;:\; x^2 + y^2 \leq 25\}$. An air corridor Q crosses this region where $Q = \{(x;\, y) \;:\; 6 \leq x + 2y \leq 8\}$. Map this information on a graph and shade in the region $Q \cap R$. An aeroplane is at P where the distance from the origin to P is 4 and makes an angle of 30° with the axis of x. Is it true that $P \in Q \cap R$? Another aeroplane is at S in the air corridor, but out of the range of the radar. Write down in set notation the relationship between Q, R, S." (Malan/Nero/Wait, 1974, p. 73)

The irrelevance attached to the context comes through quite clearly in the following exercise. (My emphasis).



(Malan/Nero/Wait (1974), p. 250)
Fig. 1

In the figure above, A and B are a set of rugby posts, a try is scored at T and the kicker kicks from K. The kick will be over if it goes far enough, and within the angle AKB. Within what angle must he kick to be successful? (*If you don't know rugby, simply calculate AKB in the figure.)*

The slight reference to the area of study where the mathematics being dealt with can be applied is continued as the following explanation to a section illustrates.

"*Note:* It may interest you to learn that a projectile like the stone you throw, the ball you kick or the bullet you shoot, each follows a parabolic path.

When a parabola is revolved about its axis of symmetry the resulting surface is a paraboloid. A paraboloid has very many applications. The reflector of a motorcar lamp has the shape of a paraboloid to ensure that the light rays form a beam straight ahead." (Malan/Nero/Wait, 1974, p. 83)

During this period an investigation was launched into education in South Africa. One of the task groups in this investigation concerned itself with the natural sciences, mathematics and technical subjects. The task group produced two reports of which one dealt with the natural sciences and mathematics (RGN, 1981). The task group concluded that the coordination between the mathematics and physical sciences was insufficient. They recommended that the design of physical science, biology and mathematics curricula should not be isolated activities and that the common elements in each of these syllabi should be clearly indicated (RGN, 1981, p. 47). This is the first definite indication of cross-curriculum syllabus design, albeit between mathematics and the natural sciences.

2.3 The post set-theoretic period and the school mathematics NGO movement

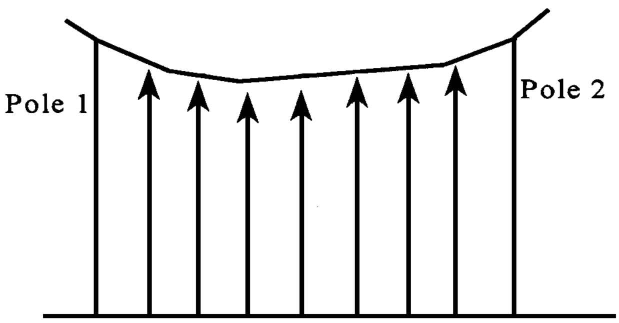
This period is certainly the most productive in terms of challenging the hold the various education departments had on the design, interpretation and implementation of the school mathematics curriculum. During this period non-governmental organisations dedicated to the improvement of school mathematics emerge, units dedicated to developmental work and research into school mathematics were established at universities and projects concerned with developmental work for school mathematics were initiated mostly through university mathematics departments and faculties of education. It is also during this period that the People's Mathematics movement was born and that the voices of the professional mathematics education organisations became more vociferous in curriculum matters.

The official syllabi still pointed to cross-curriculum work by referring to the notion of "use mathematical knowledge and methods in *other subjects*" (my emphasis) (Department of Internal Affairs, 1984). Textbooks did not change much and the incorporation of "other subjects" retained the character as in the previous periods.

The non-governmental sectors were more daring. Although their work also illustrated a lack of making aware or the giving of expanded explanations of the contexts being used there emerge an openness that the contexts did emerge from outside-of-mathematics. Terminologically, words such as models and mathematical modelling became part of the discourse of school mathematics. The Mathematical Association of South Africa (MASA), one of the professional organisations for mathematics educators and teachers, published their first monograph on mathematical modelling for schools (Blignaut, Ladewig and Oberholzer; no date). This monograph drew heavily on the work of Burkhardt, Treilibs, Stacey and Swan (1980), but for the South African situation the importance of the classic cycle of mathematical modelling was exposed to the mathematics teacher community for the first time. Statements such as "make sure you understand the real-life situation" and "When the mathematical model has been analysed (exactly or approximately), the results, expressed in mathematical terms, are to be translated back to the language of practice" (Blignaut, Ladewig and Oberholzer, no date, p. 5) try to exemplify the cycle and that all parts of the cycle must receive attention.

In addition to the emergence of the discourse on the mathematical modelling processes, learning activities incorporating practical work started to see the light. In one such activity (Blignaut, Ladewig and Oberholzer, no date, p. 44) dealing with the sagging cable, teachers are advised to conduct a discussion "about ... telegraph wires hanging in approximate parabola shape." Learners are requested to use ropes and poles to set up a sagging cable structure. Teachers have to "point out that how the apparatus now set up is a physical model of the situation" (p. 44) and the learners are instructed to

Measure the height (to the nearest 0,5cm) of the string above the table top at 10cm intervals along the table starting at pole 1 till you reach pole 2. Put the results into the table of values below.



Distance	0	10	20	30	40	50	60	70	80
Height									

(Blignaut, Ladewig and Oberholzer, no date, p. 44)
Fig. 2

With the data obtained through measurement learners are first requested to draw graphs of the distance against the height and finally to find a rule of the form $y = ax^2 + c$.

This period also saw the introduction of the implementation of and reporting on experimental courses driven by mathematical modelling and practical work. De Villiers (1986, p. 1) reports on an "experimental course in Boolean Algebra using firstly modelling". The course started with "practical problems, involving switches and switching circuits" and De Villiers (1986, p. 20) asserts that "Several pupils admitted that for the first time mathematics really started making sense to them, and that they 'could now see that mathematics didn't drop out of the sky'."

A third issue that characterises this period is the broadening of the range of situations used as context. Not only were situations from the physical and applied sciences and to a lesser extent sports, used. Socio-political issues and cultural issues started to be used as context for school mathematics. The insertion of socio-political and cultural issues into school mathematics were driven by the alternative mathematics education movement which later became incorporated in the People's Mathematics movement. Chris Breen (1986, p. 4) captures the alternative mathematics movement as one which will work towards the combatting of "elitism, racism and sexism as a by-product while focusing on the 'deep-structure' of mathematics." A somewhat typical example of such an activity, described as moving "the content into the world of the students" (Breen, 1986, p. 4) is the following:

The pupils are provided with a pamphlet dealing with unemployment. The pupils are then required to deal with the following issues:

1 What percentage of umemployed workers were unregistered in 1982?
2 What percentage of registered unemployment was contributed by the motor industry, South African Transport Services and the textile industry during 1982?
3 Calculate the percentages contributed by the motor industry, South African Transport Services and the textile industry with regard to all the unemployed workers throughout 1982?
4 Represent the answers to question 1 and 2 in the form of two separate sector (circle) graphs.
5 Approximately what percentage did registered unemployment represent of the unemployed workers in South Africa in 1982?
6 Do you think there will always be poor people in South Africa? Discuss the question amongst yourselves in class.
7 Do you share or agree with the aspirations and ideals expressed in the lyrics of the song "Imagine" by John Lennon? Discuss.

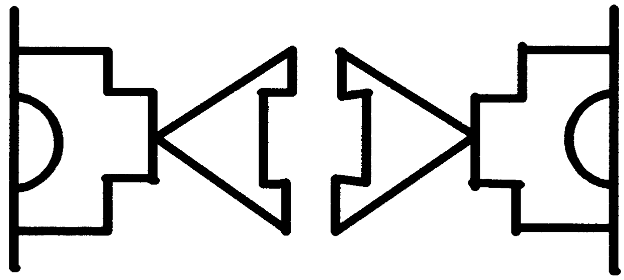
The cultural found its inspiration from the ethnomathematics movement and attempted to insert into school mathematics production activities from the South African context. Attempts were made to use traditional craft activities and artefacts in mathematical activities. These activities varied with some allowing the learners to "imagine" the processes the practitioners went through during the production of an artefact as is evident from the activity below. (Fig. 3).

A second kind of activity is where the mathematics is made very explicit from the start. Kitto (1990) describes some such activities and using the same context as above students are posed questions such as the following:

1 State which of the figures (a collection of diagrams of Ndebele, Sotho, Zulu and Swazi designs are supplied) contains rotational symmetry.
2 Fill in on the pictures, any axes of reflection.

(Kitto, 1990, p. 195)

The diagram below is a sketch of a design Ndeble women construct to decorate the outside of their homes. Carefully study the design and describe how you think the women went about to construct these designs.



Note to teachers: Pay close attention to the description pupils give, analyse such descriptions from a mathematical perspective and base further mathematical work on these descriptions.

(Julie, 1990)

Fig. 3

Comparing the South African work in this domain with that of Gerdes (1985) it differs in that (a) the producers of the material do not themselves learn the techniques or interview the designers to get a sense of their way of thinking and doing – they draw primarily on produced artefacts which are readily available, and (b) the consentization content is low or even absent.

2.4 The emerging post-apartheid era (1996+)

One of the issues the first democratic government in South Africa had to tackle was to transform the racially-based school education system. Purportedly the new system should reflect the values being striven for by the new society and should also prepare the students to graduate from schools better prepared to participate in the economic development of the country. Through a series of consultations and negotiations with a variety of stakeholders ranging from school student organisations to the labour movement, it was concluded that the best way to realise the goals of the "new" society was to organise the curriculum around outcomes-based education (OBE). Within this educational paradigm the quest for cross-curricular work is much more explicit. A strategy to operationalise this explicitness was to discard the notion of school subjects with its strong connection to academic disciplines, replace it with learning areas and then to cross-curricularise around desired outcomes. In reality what happened was that cognate subjects were grouped together. This anomaly was realised and a construction was designed to counter this perception. The devised construction was phase organisers which are essentially broad themes. So for example, there are six phase organisers identified for the foundation phase (first three years) of schooling. The six phase organisers are: personal development, society, environment, communication, entrepreneurship and health and safety (National Department of Education, 1997, p. 4). The intention is that all eight learning areas organise their learning programmes around these phase organisers.

A feature that stands out in this new educational programme is the explicit mentioning of the cross-curricular ideal. This is specifically mentioned in relation to the seven critical outcomes which are defined as "cross-curricular, broad, generic outcomes that inform all teaching and learning" with the purpose to "lead to the development of conceptual skills and understanding which transcend the specific, gradually developing the learner's capacity to transfer learning from one context to another" (Ministerial Committee, 1996, p. 26).

The school subject that was formerly named mathematics was changed to the learning area: *mathematical literacy, mathematics and mathematical sciences.* The old subject mathematics was not as drastically changed (or better still "grouped") as is the case with other subjects. The change in name was hotly debated. The argument that the retention of the name mathematics would entrench the bias toward pure mathematics contributed significantly to the learning area being named mathematical literacy, mathematics and mathematical sciences.

For the complete school programme there are seven critical outcomes centred around problem-solving; teamwork; effective communication; critical evaluation of information and the importance of science and technology. Learning areas have their own specific outcomes and the critical outcomes should be manifested in the specific outcomes of the learning areas. For mathematical literacy, mathematics and the mathematical sciences there are ten specific outcomes. The specific outcomes are accompanied by assessment criteria and it is within these criteria that the cross-curricular ideal becomes visible. The specific outcomes and some of the accompanying assessment criteria clearly brings to the fore this ideal.

Specific outcome 4: Critically analyse how mathematical relationships are used in social, political and economic relations.

Critical understanding of mathematics use in the media: recognise types of graphs used in newspapers and journals; critically analyse information from the media; analyse the use and effect of advertisements in society

Demonstration of knowledge of the use of mathematics in determining location: work with mapping scales; read maps, from street finders to atlas maps

Not only is the cross-curricular ideal accentuated in the specific learning area. In all learning areas there is encouragement to make connections between the outcomes of the different learning areas. For example, it is shown that for the phase organiser environment the following outcomes from the learning areas mathematical literacy, mathematics and mathematical sciences (mlmms) and economic and management sciences (ems) can be integrated.

Specific outcome (mlmms)

Critically analyse how mathematical relationships are used in social, political and economic relations

Specific outcome (ems)

Demonstrate the principles of supply and demand and the practices of production

Very little material is currently available although material developers are adapting some of their previously designed materials to fit the outcomes-based education paradigm. One such booklet claims that it "uses the theme of water to explore some key elementary mathematical concepts" and "looks at mathematics across the curriculum and integrates many of the necessary skills that are important when considering a holistic approach to basic education" (Niehaus, Chaane, Adams, Smith and Randall, 1996: inner-cover page). Some of the issues dealt with in the booklet are: making water safe to drink, the rain cycle, uses of water and saving water. This is indicative of the holism and integration the authors refer to.

3. Can the cross-curricular ideal be realised?

A first issue that comes to the fore from the above narrative on the quest for cross-curriculum work in school mathematics is the difficulty of giving sufficient attention to the outside-of-mathematics component. This is obviously predicated on the notion that in dealing with other subjects in the mathematics curriculum that learners should at least be conversant with the context in order to meaningfully deal with the mathematical. When dealing with the applications of and modelling in mathematics the issue of the knowledgeability of the context becomes more crucial. This is so since some familiarity with the context is needed at especially the stage of translation from reality (in this case other subject domain) to the mathematical formulation and the re-translation and interpretation of the mathematical model in terms of reality. Notwithstanding the difficulty of context-knowledgeability there are some worth in activities which pay insufficient attention to the outside-of-mathematics component. If carefully crafted there is at least the possibility that learners unfamiliar with the domain of the context could be sensitised to the context as is the case with the example of the parabola above. With respect to cross-curricular work such sensitization could then only be viewed as information-conveyance and leaving it to the learners to decide whether or not they find the information of value for their own personal use. A position such as this is accepting the inevitability of the primacy that must be accorded to pure school mathematics but that the information given about the context being used should be authentic and factual.

A second issue that comes through is that in many instances the mathematics needed to cross-curricularise is complex and sometimes not even part of the school mathematics curriculum. In an effort to bypass this the mathematical content is so simplified that learners need no more than simple arithmetic to deal with mathematical part of the provided activities. As Breen (1986, p. 3) comments about the activities using the socio-political as context "... the questions asked [are] limited to basic arithmetic calculations, simple graphs, elementary statistics and ratio and proportion. This would be an extremely unhealthy long-term mathematical diet".

The issue being alluded to by Breen is one of trying to stay as near as possible to the imperatives of the official mathematics curriculum. In activities of this nature, the simple arithmetic calculation type, the context is reasonably well known to the learners and it is not difficult for learners to engage in discussions about the outside-of-mathematics. The difficulty with the "unhealthy long-term mathematical diet" is one that can be overcome. It is not a mathematical problem nor a context one but rather a design problem. A possible solution is to present the problems in such an open-ended way so that learners at various levels of mathematical development can engage with the problems at their level of mathematical expertise. So, for example, the activity with unemployment as its theme can be redesigned in an open-ended way so that learners at various levels of mathematical expertise can engage with it at their level.

Moving beyond the above examples one of the central tensions in cross-curriculum work is the issue of what must be privileged. Lave (1988), who propagates the view that school mathematics is a distinct practice, is of the opinion that when working in one domain, such as school mathematics and using the context of some other practice moves activity into another domain which is neither the one nor the other. She asserts: "Math class is real, everyday practice, and so is lawn mowing ... but organizing a lawn mowing business in math class is neither lawn mowing practice nor real school practice." (Emphasis in original) (Lave, 1988, p. 20)

She, however, is adamant that mathematical activity must be privileged and offers a decision criterion for the inclusion of the outside-of-mathematics. Her criterion is that the outside-of-mathematics must offer "occasions for [learners] to engage their intensions in mathematical dilemmas" (Lave, 1988, p. 20).

I concur with Lave but with respect to cross-curriculum work in school mathematics it leads to the question forming the title of this section. Privileging the mathematics means that the answer to the question is negative. This negative is a qualified one. The negative response is not one which now calls for the abandoning of the applications of and modelling in mathematics which is the place where cross-curriculum work in mathematics is located. Rather, the response is a call in line with that of Lave but for the engagement of the intention of learners in the applications of and the modelling in mathematics so as to experience a way-in to how applied mathematicians and mathematics modellers do their work. A useful way to realise this is to separate the applications of and modelling in mathematics as a distinct section of the school mathematics curriculum in the same sense that algebra, geometry and trigonometry – to name a few – are distinctly marked and dealt with as separate sections in most school mathematics curricula.

4. References

Blignaut, J.; Ladewig, W.; Oberholzer, G. (No date: Mathematical Modelling. – Port Elizabeth: The Mathematical Association of South Africa (MASA) (PO Box 12833, Centrahill 6006, South Africa)

Breen, C. (1986): Alternative Mathematics Worksheets. – Unpublished paper. University of Cape Town

Burkhardt, H.; Treilibs, V.; Stacey, K.; Swan, M. (1980): Beginning to Tackle Real Problems. – University of Nottingham: Shell Centre for Mathematical Education

Department of Internal Affairs (1984): Education Bulletin 13/84. – Cape Town (Private Bag X9008, Cape Town 8000, South Africa)

De Villiers, M. (1986): Teaching Boolean Algebra Along Van Hiele Lines and Using Meta-mathematical Perspectives. – Stellenbosch: Research Unit on Mathematics Education, University of Stellenbosch

Gerdes, P. (1985): Conditions and Strategies for Emancipatory Mathematics Education in Undeveloped Countries. – In: For the Learning of Mathematics 5(1), p. 15–34

Julie, C. (1990): Class Notes and Activities on Ethnomathematics. – Unpublished classroom notes for preservice teachers. University of the Western Cape

Kitto, A. (1990): Ethnomathematics and Transformation Geometry. – In: The Proceedings of the 10th National Congress of the Mathematical Association of South Africa (MASA). Port Elizabeth: MASA

Lave, J. (1988): Word Problems: A Microcosm of Theories of Learning. – Unpublished paper. University of California, Berkeley

Malan, A. P.; Nero, R. L.; Wait, I. P. (1974): Modern Mathematics for Standards 9 and 10. – Johannesburg: McGraw-Hill Company

Matz, A. R.; Sagel, J. (1961): New Senior and Matriculation Mathematics. – Cape Town: Maskew Miller Ltd.

McMullen, A.; Williams, J. L. (1969): On Course Mathematics for South African Schools: Book 2 (Standard Seven). Adapted for South African schools by Bowker, J.; French, M. M. and Grant, A. J. – Johannesburg: MacMillan South Africa

Ministerial Committee for Development Work on the NQF (1996): Discussion Document: Lifelong Learning Through A National Qualifications Framework. – Pretoria: National Department of Education (Private Bag X895, Pretoria 0001, South Africa)

National Department of Education (1997a): Curriculum 2005, issue 11. – Pretoria

National Department of Education (1997b): Mathematical Literacy, Mathematics and Mathematical Science. – Pretoria

Niehaus, J;. Chaane, T.; Adams, C.; Smith, P.; Randall, I. (1996): The Water Book. – Johannesburg: Count

Provincial Administration of the Cape of Good Hope; Department of Education (1968): Junior Secondary Course: Syllabus for Mathematics. – Cape Town (Private Bag X9114, Cape Town 8000, South Africa)

Provincial Administration of the Cape of Good Hope: Department of Education (1973): Senior Secondary Course Syllabus for Mathematics (Higher Grade). – Cape Town

RGN Raad vir Geesteswetenskaplike Navorsing (1981): Onderrig in die Natuurwetenskappe en Wiskunde. – Pretoria: RGN (Private Bag X41, Pretoria 0001, South Africa)

Roper, T. (1994): Integrating Mathematics into the Wider Curriculum. – In: Orton, A.; Wain, G. (Eds.), Issues in Teaching Mathematics. London: Cassell

Selkirk, K. (1982): Links Between Mathematics and Other Subjects. – In: Cornelius, M. (Ed.), Teaching Mathematics. London: Croom Helm

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