Michèle Stears

Relevant science curriculum: what do children regard as relevant?

First submission: 21 January 2010
Acceptance: 28 April 2010

This article attempts to find out what children regard as relevant science. As the research was located within the framework of social constructivism, emphasis was placed on the context where learners came from and within which they were learning science. Data were collected to determine how learners responded to a relevant science curriculum. Analysis of the data suggests that learners respond in different ways. Some saw relevance in improving their understanding of science concepts, while others experienced the curriculum as relevant because it satisfied their personal and emotional needs. The findings show that the essence of a relevant science curriculum lies in a particular design. A relevant curriculum acknowledges that science education is more than only science. This has implications for the development of a science curriculum.

Relevante wetenskapkurrikulum: wat beskou kinders as relevant?

Hierdie artikel probeer vasstel wat kinders as relevante wetenskap beskou. Die navorsing is binne die raamwerk van sosiale konstruktivisme geleë en plaas dus klem op die sosiale konteks van leerders, asook die konteks waarin hulle wetenskap leer. Data is versamel om vas te stel hoe leerders reageer op 'n relevante wetenskapkurrikulum. Analise van die data toon dat leerders op verskillende maniere reageer. Sommige het relevansie ervaar in die verbetering van hulle wetenskaplike kennis, terwyl ander die kurrikulum as relevant beskou het omdat dit hul persoonlike en emosionele behoeftes bevredig het. 'n Relevante kurrikulum neem dus in ag dat wetenskapopvoeding meer behels as die onderrig van wetenskap en dit het noodwendig implikasies vir die ontwikkeling van wetenskapkurrikula.

Dr M Stears, School of Science, Mathematics and Technology Education, Faculty of Education, University of KwaZulu-Natal, Private Bag X03, Ashwood 3605; E-mail: stearsm@ukzn.ac.za

Acta Academica
2010 42(2): 199-216
ISSN 0587-2405

<http://www.ufs.ac.za/journals_ActaAcademica>

SUN MeDIA
BLOEMFONTEIN

This article explores the meaning of relevant science. National and international reform in science education has emphasised the fact that science education should be relevant. As a goal for science education, relevance is usually interpreted in terms of contextualised science content (cf Campbell *et al* 2000). It is assumed that this will enhance science learning, leading to an increase in science enrolment and more students choosing science as a career. Members of the science education community and the general public expect a curriculum to deliver students who have scientific knowledge and skills and, if the curriculum is relevant, will allow them to apply these in their lives. It is interesting to note that most research on relevant science curricula focuses on what content may be relevant (cf Gaskell 1992) and is usually conducted with students in secondary schools. The research conducted in this study attempts to interpret different dimensions of relevance. It explores not only how learners make meaning of their everyday lives, but also what "science" they deem to be relevant and worth learning within a specific context.

1. Literature review

The global call for reform in science education has also affected South Africa. The advent of democracy in South Africa witnessed the implementation of many changes, including changes to the education system. The legacy of apartheid was most obvious in the education system implemented prior to 1994, and it was imperative that a democratically elected government would eradicate the inequalities of the past. The introduction of Curriculum 2005 (DoE 1995) as a single national curriculum heralded a different approach in education. This curriculum not only advocated the development of knowledge and skills, but also emphasised education for democracy and citizenship (including social justice). Curriculum 2005 is outcomes-based and learner-centred, and seeks to balance central control (and a single curriculum) with local design, by requiring educators to design curricula according to central guidelines and set outcomes (cf Stears 2009). However, to design relevant curricula requires some understanding of what learners (and others) perceive to be relevant.

Research has indicated that learners' interest in science has decreased (cf Teppo & Rannikmäe 2004). A number of policy documents from different countries suggest that science educators design curricula that are interesting and relevant to the everyday experiences of students (cf Taylor 2001). International discussions on reform in science education have recommended that science instruction be grounded in practical contexts and that school science teachers design curricula that are interesting and relevant to the everyday experiences of their learners. Various members of the science education community such as policy-makers and curriculum designers regularly call for a more relevant science curriculum. This raises the question of what is meant by relevance (cf Malcolm *et al* 2004). Various researchers have explored the meaning of relevance. Relevance is a complex notion with many dimensions. Campbell *et al* (2000) raised two fundamental questions, namely "relevant to whom?" and "relevant to what?"

Learners bring multiple interests, meanings and understandings to learning. This raises issues of relevance, as learners will respond differently to different dimensions of relevance. Interpretive frameworks and personal experiences have considerable impact on the way in which children make inferences and construct knowledge. This fact has to a large extent been ignored in previous research. If teachers understand their learners' socio-cultural background, they may be better equipped to understand not only how learners learn but also what the interests and intentions of their learners are (cf Osborne & Freyberg 1985). Hence the call for an approach to science education that is more culture-sensitive and probes what occurs in the minds and hearts of learners in the science classroom (Jegede & Aikenhead 1999: 3).This knowledge will allow teachers to plan learning experiences that might be relevant to learners with regard to their purposes and context. Context is a very important aspect of relevance as relevance depends on context. How does one determine what learners find relevant (cf Stears & Malcolm 2004)? When the context changes, what was previously regarded as relevant might become irrelevant. Context was a crucial aspect of relevance in this research as the topics used in the lessons were relevant to that specific environment.

Relevance, however, is a complex notion. Is it relevant to the learner, the teacher or the community? Is it relevant because it is interesting or useful? Is it relevant in the short term or in the long term? Most calls for reform in science education refer to those aspects of relevance that are geared towards relevance to improve science learning. Recent reforms in science curricula have shifted towards more relevant science knowledge in that the science included in many curricula can be used as a tool for personal and societal improvement (cf Wallace & Louden 1998). Numerous international surveys of science curricula suggest that there should be a core as well as regional variations in the curriculum (cf Peacock 1995). Such a curriculum would be more relevant to learners and should relate to their interests, their everyday lives, and their understanding (cf McRobbie & Tobin 1997).

It is generally assumed that students will learn if science is interesting, connected with everyday life, and useful for their lives and future development (cf Teppo & Rannikmäe 2004). The theme of the ICASE (2003) conference held in Penang, Malaysia, was relevance in science education, investigating increased relevance similar to the aspects of relevance mentioned above. But are there other views of what constitutes relevance? Most parents want their children to receive an education that will provide them with the skills to live as competent and engaged citizens (cf Linkson 1999). On the other hand, parents want their children to be familiar with their culture and to maintain the beliefs and practices of that culture. Curriculum 2005 strongly suggests that cognisance should be taken of indigenous beliefs and incorporated in the curriculum. This should contribute to making the curriculum more relevant for indigenous people. Other authors have called for similar curricula (cf Fleer 1997, Zarry 2002). Thomas (1997) advocates a science curriculum that is relevant in that it is able to bridge the gap between learners' common-sense knowledge and the formal knowledge of science. While all of these are important dimensions of relevance, learners may respond to other dimensions.

The ROSE (Relevance of Science Education) project is an international project researching science (cf Sjøberg *et al* 2004). Its aim is to promote relevance of content and context in science and technology curricula. This has become an important issue as one cannot sustain a universal science curriculum if it benefits only a handful of learners who wish to pursue a career in the sciences. More recent research of the ROSE project participants links the way learners understand the world and view themselves and their environment to the values of the society in which they live (Schreiner & Sjøberg 2007). These authors are of the opinion that what young people regard as interesting and relevant is influenced by the society in which they live. This view supports the move towards eliciting the views of learners as to what is interesting and valuable to learn (cf Osborne & Collins 2001), as different communities may hold different values and therefore different views of what is useful knowledge. Another suggestion is that outcomes for science education for primary education should be different from those for secondary education (cf Fensham 2004). There should be less focus on scientific knowledge as an outcome, in particular in primary science. Designing a science curriculum that is relevant requires knowledge of learners. For this reason, research suggests that teachers be involved in curriculum design (cf Goodenough 2001, McCutcheon 2001).

Relevant science should also be characterised by relevance with regard to purpose and methods. For example, relevance could refer to society, employment or everyday life, to a distant future or immediate needs, to fantasies and curiosities or practical requirements. Building all these dimensions of relevance into the curriculum requires a view of relevance in both a pedagogic and content sense. This means including a variety of strategies when designing learning programmes as well as allowing learners to influence what will be learnt. Relevance is not only about instrumental purposes (practical, usable). Exotic and curious topics, far removed from the context, might be relevant because they are interesting: "Ten year olds often find dinosaurs, sailing ships and life on Mars much more relevant than the stuff in their own backyards" (Malcolm 2005: 171). This presents a dilemma, namely whether what is referred to as relevance in fact means interesting. It is conceded that the dimensions of relevance which learners respond to are, in fact, those which interest them. Learners experience something as relevant because it interests them. Even when a topic is deemed irrelevant in a certain context but interesting, it is relevant to the learner in a personal and developmental way. In the broader research community there seems to be an understanding that there is a relationship between relevance and interest as many research papers discuss what learners find interesting (cf Kim & Fisher 1999, Teppo & Rannikmae 2004). In fact, extensive bodies of research equate relevance for students with interest. The main focus of this research is "relevant to whom", as it explores what the learner experiences as relevant science. This may promote an understanding of which dimensions of relevance the learners respond to. The dimensions of relevance explored in this study were those topics and experiences in which learners were interested. Sometimes they were interested because the issues related to their everyday lives and sometimes they were interested because they had knowledge to share. At other times they were interested because activities were fun or they were interested in "irrelevant" events and phenomena. There is less concern with the notion of relevance as defined by policy-makers in science education than with relevance that might be interesting.

As a learning theory, social constructivism provides a lens through which the research is conducted, in its recognition of the roles of children's knowledge, purposes, social groups and interactions in learning. Learning does not take place in cognitive isolation, but within the context of activities and social interaction, informed by the day-to-day contingencies of culture. Social constructivism may be helpful in interpreting relevance to learners as it acknowledges that the ways in which learners construct knowledge depend on how they view the knowledge to be constructed. This raises issues of relevance, as learners will respond differently to different dimensions of relevance. Bloom's (1995: 169) framework of "contexts of meaning" shows that learners bring multiple interests, meanings and understandings to learning. He argues that emotion-values-aesthetics, interpretive frameworks and personal experiences have considerable impact on the way in which children make inferences and construct knowledge. Previous research has ignored this issue. Notions of relevance must go beyond the rational-cognitive and include other criteria (Posner 1992).

Critical constructivism is an added perspective in this research, as it is also concerned with educational purposes and the nature of the classroom community. There is a strong focus on classroom practice and the need to interpret what happens in the classroom in a broader personal, social and political context. Rodriguez's (1998) socio-transformative model addresses transformation in the classroom where learners are empowered by having some input into what is to be learned. A critical constructivist approach raises questions about the type of knowledge learners interact with. Both social constructivism and critical constructivism are concerned with relevance.

The purpose of this research was to explore what is understood by relevance and what relevance means to different learners in a specific context, and to seek answers to the question of how learners might experience different dimensions of relevance in the science classroom when they engage in learning experiences related to their personal lives. A series of science lessons were designed using input from teachers and learners. These lessons were deemed relevant in various ways. The aim was to observe how learners would respond to these lessons and which aspects of relevance they regarded as important.

The following research question guided the study: What do grade-6 learners in a specific context regard as relevant in the science classroom?

2. Methodology

This qualitative study was conducted in an interpretive paradigm. Classroom observations and interviews were used to obtain data. The researcher participated by teaching a lesson series in science while the class teacher was present in the classroom. The participatory aspect of the research was emphasised as the researcher, class teacher and learners worked together to produce a series of science lessons. The teacher used her knowledge of the learners to contribute to the lessons. She also contributed her skills with regard to learner-centred lessons. Input from the learners was crucial as they indicated what their interests were.

Learners from three grade-6 classes were asked to list any number of topics in which they were interested. One hundred and twenty learners responded. Fire was chosen as the topic because all learners identified it as something in which they were interested. The majority of them come from informal settlements where fire is a real danger, and have experience of homes burning down. When they were asked to write or tell stories about fire, the personal and social aspects of fire were dominant. The researcher contributed by designing a series of lessons on fire which was taught to one of the grade-6 classes. Seven worksheets were used that included a number of activities designed to allow learners to bring their lives and experiences into the classroom. The teacher made the lessons relevant by contributing to the content in which learners are interested. She was able to give advice as to how the learners' everyday experiences could be incorporated into the lessons. This included relevance with regard to further schooling as she felt that the lessons needed to include aspects of science that came from the science curriculum. In this study the teacher's knowledge of her learners was crucial in designing more meaningful, relevant and personalised science lessons.

The worksheets covered a number of topics aimed at achieving a range of outcomes. Worksheet 1 dealt with the causes of fire. Activities in this worksheet included telling a story about the different causes of fire and drawing pictures of what they remember best from the story. These activities gave insight into the aspects of fire that were most important to different learners and what was most relevant to them with regard to fire. Worksheet 2 covered the concept of flammability, and the predict-explore-confirm approach was applied. This activity probed responses to relevance with regard to everyday knowledge. Worksheet 3 covered the concept of energy transformation. Learners engaged in activities such as finding out if fire has energy, which forms of energy are observed when a fire burns, how fire is used in our homes, and what are sources of energy. This activity tried to probe how learners related to formal science concepts and how they were able to link these constructs to their everyday understanding of fire. Worksheet 4 covered the causes of fires in homes, as well as the ways of extinguishing fires. This was linked to the scientific concepts with regard to fire, for instance what is required to make a fire burn. Various activities such as individual writing, group discussion, a practical investigation and consensus activities were engaged in to determine whether these learners had any scientific explanation for the phenomena they experience and whether they were interested in the scientific explanations for such phenomena. Worksheet 5 prompted discussions about what people use to extinguish fires. Learners produced a bar graph to present information. The purpose was to determine whether learners could present information in different ways. Worksheet 6 dealt with the effects of fire on people. The strategies employed involved a jigsaw activity, as well as a drawing activity to illustrate the pathway air takes into the body. This activity was linked to the role of smoke. As this activity depended on learners working together, the notion of learning from each other was the main purpose of the activity, as well as introducing learners to new concepts. In worksheet 7 learners engaged in two activities. In one activity they were required to write about the positive, negative and interesting things about fire. In the second activity the beginning of a story was read to them and they were required to finish the story by writing what they thought the outcome of the story would be. The purpose was to determine what knowledge learners value and what they perceive as relevant knowledge.

The series of lessons used in this study was designed as an example of relevant science, while serving as a tool to elicit deeper understandings of what learners in this specific context experienced as relevant to their lives. Although the main focus of this research was the relevance of using everyday knowledge in the classroom, bringing everyday knowledge into the classroom allowed for the inclusion of a number of dimensions of relevance. The series of lessons was regarded as relevant for the reasons listed above, but it was also an instrument to collect data about learners' interpretations of relevance. The purpose was to find out whether learners responded to other dimensions of relevance.

The approach followed in the lessons taught made use of content and pedagogical strategies to promote science learning. The content selected was based on the everyday lives of the learners and the pedagogical strategies applied were aimed at identifying the concepts that were to be taught; designing activities that developed these concepts through learners' existing knowledge; probing learners' way of thinking about certain concepts, and using activities to extend knowledge. The strategies also allowed for the achievement of outcomes that were not specifically science outcomes, but were achieved through the learning of science.

While the lessons were designed to develop a scientific view of the everyday phenomena that influence the lives of learners, the intention was for learners not only to develop and formalise their everyday knowledge to a scientific view of that knowledge, but also to take the knowledge they had developed in the classroom into their daily lives. In this way the curriculum would address the needs of learners more comprehensively.

The lessons were taught over a period of four days and data were collected by the following methods:

- Classroom observations

  The lessons were videotaped and the tapes observed. This allowed the researcher to observe the learners as they engaged in the various activities and what the levels of participation were.

- Learner interviews

  Groups of learners were interviewed at the end of each day on which the lessons were taught. The interviews helped to determine what the learners were interested in; how they used the knowledge learnt at school in their everyday lives; how they used their everyday knowledge in the classroom, and how they felt about bringing their personal lives into the classroom.

- Teacher interview

  The class teacher was present in the classroom while the lessons were taught and was interviewed subsequent to the teaching of the module. She was able to evaluate the content of the lessons and the learners' responses to it.

- Assessment tasks and tests

  All activities were accompanied by worksheets which learners were required to complete. The variety of activities made it possible to assess in which type of activity learners performed better. Tests were administered upon completion of the lessons. The purpose of the test was mainly to establish the degree of conceptual development that had occurred.

Data from the interviews, videotapes and assessment tasks were analysed to determine the ways in which the learners responded to these science lessons.

3. Findings and discussion

Observations of the class in action demonstrated that all learners participated actively in the activities on the worksheets. These included doing experiments, drawing, telling and writing stories, and describing events. The fact that the content of the lessons was taken from their everyday lives provided a context which learners perceived to be relevant as they were interested in learning more about fire.

Responses on worksheets and in tests, as well as observations of learners while they engaged in tasks showed that a number of learners had developed an understanding of certain concepts. For example, they could explain energy changes caused by fires and how people died in fires:

> I believe a fire has energy because a fire has heat. When we did this activity, I understood that energy changed from one form to another and that there are different forms of energy.

It was, however, noted that a significant number of learners did not demonstrate increased conceptual development. They were not able to process new knowledge in a way that allowed them to build on existing knowledge. This was evident from their responses in the worksheets and tests, as well as the interviews. Most responses to questions were based on everyday experiences:

> I saw the candle go out when the jar was placed over it, but I do not understand what this has to do with the fire. I know that the candle needs air, but a fire needs wood or paraffin.

A predict-observe-explain activity provided the opportunity for learners to develop problem-solving skills, while groupwork provided opportunities to develop teamwork and communicating skills. The fact that learners set the pace in many activities required an ability to manage their learning. These skills are not specific science skills, but were developed through learning science. They are broader life skills such as described in the critical and developmental outcomes of Curriculum 2005 (DoE 1995). A larger number of learners than those who showed improved conceptual development showed improvement in these skills. Relevance for these learners lay in their interest in the content, as well as their enjoyment of practical activities:

> Everyone in my group knew a lot about the different materials homes are made from and could easily say which materials would burn more easily.

When class discussion turned to personal knowledge and everyday experiences, all learners demonstrated an interest in contributing to these discussions. For instance, learners were asked to tell a story about fire or relate their experiences with fire. For a number of learners these discussions were a priority. The value of these lessons for all learners lay in satisfying personal and social needs. Certain learners were most responsive to strategies that encouraged socialisation, where security within the group was important, as well as those strategies that required creativity, such as drawing, or creative writing:

> I am not too interested in what makes a fire go out. To me it is more important to know how to put it out.

The findings show that a number of learners, when engaged in science content that is relevant to their everyday experiences and that interests them, demonstrated enhanced conceptual development as they were able to improve their existing knowledge. However, a significant number of learners were not able to do this. In spite of the application of a range of teaching strategies and the high level of participation of these learners, there was little evidence of any significant conceptual development. Information from interviews, as well as analyses of responses in worksheets and tests showed that these learners persisted in repeating the everyday knowledge they already had. They showed no inclination to expand their knowledge. It would therefore appear that, in spite of the inclusion of a range of aspects that are generally regarded as relevant, some learners did not respond by improving their conceptual knowledge of science. If improved learning in science is regarded as an outcome of relevant science, it clearly does not apply to all learners.

The findings show that the majority of the learners found relevance in issues that were interesting, that satisfied their curiosity and that helped them with their everyday survival, rather than relevance in mastering science concepts. Where the science content related to learners' everyday lives, confidence was built as they engaged with content that they related and were able to contribute to in the classroom. It would appear that such science lessons enhanced the development of learners' personal, emotional and social outcomes. A different level of engagement was evident during the activities where learners produced creative work. The stories learners were expected to complete, their written stories as well as their drawings showed a high level of participation and preoccupation with the social implications of fire in their lives, rather than a deeper understanding of the underlying scientific concepts.

Those learners who view school as a safe haven, a nurturing environment where confidence and important aspects of day-to-day survival are taught, need a curriculum that is localised. A localised curriculum will address these social and emotional outcomes of learners, in particular in this context where the experiences of the learners form the basis for the lessons taught. These learners benefit by being affirmed in an atmosphere where their knowledge is appreciated. This allows them to participate in an educational context where they are able to contribute to the general pool of knowledge. A relevant curriculum satisfies a broader range of needs and one must look beyond conceptual development. If the science content selected is taken from the learners' everyday experiences, or better still, if learners are allowed to provide some input into the selected science content, opportunities are provided to address learners' needs with regard to their day-to-day survival. The learning experiences of these learners may not have the purpose of developing a scientific view. The purpose might be emotional security in an atmosphere where confidence is built and learners are nurtured by caring teachers. If social and personal outcomes are the primary goals, these learners would not be concerned with processing new knowledge that is not immediately useful.

4. Conclusion

The dimensions of relevance explored in this study were those topics and experiences in which learners were interested. Sometimes they were interested because it related to their everyday lives and sometimes they were interested because they had knowledge to share. At other times they were interested because activities were fun. Sometimes they were interested in "irrelevant" events and phenomena. Examples of such phenomena are: What are volcanoes? How can fire from a volcano flow like water? Why does it snow at Christmas? (as seen on television). There is less concern with the notion of relevance as defined by policy-makers in science education than with relevance that might be interesting. The essence of a relevant science curriculum therefore appears to lie in a particular design. This design accommodates many dimensions of relevance, such as relevant content, context and purposes. Such a design helps learners to negotiate the difficult border between the formal school environment and the informal home environment. A relevant curriculum acknowledges that science education is more than only science, but also recognises the implications for science curriculum development in that it suggests that curricula should be localised.

From a social constructivist point of view learning is mediated by the social environment in which the learner operates. A curriculum that is socially relevant would be expected to enhance learning. While learning was indeed enhanced, it was not always science learning that was enhanced. Some learners constructed knowledge in an environment where they could use their existing everyday knowledge as a foundation to extend their scientific knowledge by constructing more abstract concepts (cf Stears *et al* 2003).

The findings show that science that is interesting and that relates to learners' everyday lives is useful because learners are able to use their new knowledge in their everyday lives. It does not necessarily lead to conceptual development. If conceptual development is the only outcome of science education, then relevance has a limited effect. However, if acknowledgement of social and personal needs in the science class is an outcome of science education, relevance has a much broader meaning. Meeting these needs appears to be more important to many learners than learning science concepts. Addressing learners' needs has implications for curriculum development if one wishes to make science education accessible to more than a handful of learners. Science educators and curriculum developers may consider the inclusion of outcomes other than science outcomes in science curricula designed for the primary school.

Bibliography

BLOOM J
1995. Assessing and extending the scope of children's context of meaning: context maps as a methodological perspective. *International Journal of Science Education* 17(2):167-87.

CAMPBELL B, F LUBBEN & Z DLAMINI
2000. Learning science through contexts: helping pupils make sense of everyday situations. *International Journal of Science Education* 22(3): 239-52.

CORRIGAN D, J DILLON & R GUNSTONE (eds)
2007. *The re-emergence of values in the science curriculum*. Rotterdam: Sense Publishers.

DEPARTMENT OF EDUCATION (DOE)
1995. *White paper on Education and Training, Notice 196*. Pretoria: Government Printer.

FENSHAM P J
2004. Beyond knowledge: other outcome qualities for science education. IOSTE 2004: 23-28.

FLEER M
1997. Science, technology and culture: supporting multiple world views in curriculum design. *Australian Science Teachers Journal* 43(3): 13-8.

FRASER B & K G TOBIN (eds)
1998. *International handbook of science education.* London: Kluwer Academic Publishers.

GASKELL P J
1992. Authentic science and school science. *International Journal of Science Education* 14(3): 265-72.

GOODENOUGH K
2001. Multiple intelligence theory: a framework for personalising science curricula. *School Science and Mathematics* 10(4): 180-95.

IOSTE
2004. *Proceedings of the 11th International Organisation for Science and Technology Education [IOSTE] Conference, 25-30 July, Maria Curie-Sklodowska University, Poland*. Lublin: Maria Curie-Sklodowska University Press.

JEGEDE O J & G AIKENHEAD
1999. Transcending cultural borders: implications for science teaching. *Journal for Science and Technology Education* 17(1): 45-66.

KIM H-B & D L FISHER
1999. Assessment and investigation of constructivist science learning environments in Korea. *Research in Science and Technological Education* 17(2): 239-49.

LINKSON M
1999. Some issues in providing culturally appropriate science curriculum support for indigenous students. *Australian Science Teachers' Journal* 45(1): 41-8.

MALCOLM C
2005. *Learner-centred science education – thoughts from South Africa.* Durban: C Malcolm.

MALCOLM C, L KOWLAS, M STEARS & N GOPAL
2004. Evaluation of the Western Cape Primary Science Programme: Stage 3, 2003. Unpublished report, Centre for Educational Research, Evaluation and Policy, University of Durban-Westville.

MCCUTCHEON G
2001. What in the world is curriculum theory? *Theory into Practice* 21(1): 18-23.

MCROBBIE C & K TOBIN
1997. A social constructivist perspective on learning environments. *International Journal of Science Education* 19(2): 193-208.

OSBORNE J & S COLLINS
2001. Pupils' views of the role and value of the science curriculum: a focus-group study. *International Journal of Science Education* 23(5): 441-67.

OSBORNE R & P FREYBERG
1985. *Learning in science: the implications of children's science.* Auckland: Heinemann.

PEACOCK A
1995. Access to science learning for children in rural Africa. *International Journal of Science Education* 17(2):149-66.

POSNER G
1992. *Analysing the curriculum*. New York: McGraw-Hill.

RODRIQUEZ A J
1998. Strategies for counter-resistance: toward socio-transformative constructivism and learning to teach science for diversity and for understanding. *Journal of Research in Science Teaching* 35(6): 589-622.

SCHREINER C & S SJØBERG
2007. Science education and youth's identity construction – two incompatible projects? Corrigan *et al* (eds) 2007: 1-17.

SJØBERG S, C SCHREINER & K K STEFÁNSSON
2004. The voice of the learners. International perspectives on S & T based on the ROSE project. IOSTE 2004: 43-44.

STEARS M
2009. How social and critical constructivism can inform science curriculum design: a study from South Africa. *Educational Research* 51(4): 397-410.

STEARS M & C MALCOLM
2004. Learners and teachers as co-designers of science curricula. Unpubl presentation at the Southern African Association for Research in Mathematics, Science and Technology Education (SAARMSTE) Conference, 12th annual meeting held at University of Cape Town, January 2004.

STEARS M, C MALCOLM & L KOWLAS
2003. Making use of everyday knowledge in the science classroom. *African Journal of Research in Mathematics, Science and Technology Education* 7: 109-18.

TAYLOR J
2001. Using practical context to encourage conceptual change: an instructional sequence in bicycle science. *School Science and Mathematics* 10(3): 117-24.

TEPPO M & M RANNIKMÄE
2004. Relevant science education in the eyes of Grade 9 students. IOSTE 2004: 219-20.

THOMAS E
1997. Developing a culture-sensitive pedagogy: tackling a problem of melding 'global culture' with existing cultural contexts. *International Journal of Educational Development* 17(1): 13-26.

WALLACE J & W LOUDEN
1998. Curriculum change in science: riding the waves of reform. Fraser & Tobin (eds) 1998: 471-85.

ZARRY L
2002. A multicultural science curriculum: fact or fantasy? *Educational Research Quarterly* 25(4): 3-10.