The incorporation of the USA 'Science Made Sensible' program in South African primary schools: a cross-cultural approach to science education

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Abstract

The Science Made Sensible (SMS) program began as a partnership between the University of Miami (UM), Florida, USA, and some public schools in Miami. In this program, postgraduate students from UM work with primary school science teachers to engage learners in science through the use of inquiry-based, hands-on activities. Due to the success of the SMS program in Miami, it was extended internationally. The SMS team (two Miami Grade 6/7 science teachers and two UM postgraduate students), one- hundred ninety-five learners, and five South African teachers at two primary schools in Pretoria, South Africa, participated in this study. A quantitative research design was employed, and learners, teachers, and UM postgraduate students used questionnaires to evaluate the SMS program. The results show that the SMS team was successful in reaching the SMS goals in these South African schools. More than 90% of the learners are of opinion that the SMS team from the USA made them more interested in the natural sciences and fostered an appreciation for the natural sciences. All the South African teachers plan to adopt and adapt some of the pedagogical strategies they learned from the SMS team. This article includes a discussion about the benefits of inquiry-based learning and the similarities and dissimilarities of USA and South Africa's teaching methods in the science classrooms.

Key words: Science Made Sensible, United States, South Africa, learners, teachers, postgraduate students, natural sciences, hands-on, inquiry-based learning

Introduction

Globally, educators are faced with the challenge of making science sensible. Perhaps Albert Einstein put it best when he stated "*the fundamental ideas of science are essentially simple and may, as a rule, be expressed in a language comprehensible to everyone*" (Einstein &

Infeld, 1966, p. 27). But this is seldom honored. Scientific concepts sometimes are made much more complicated and confusing than necessary due to some educators not relating to their audience. For example, there is a tendency for some educators to fall back on excessive technical jargon. Learner[1] achievement and interest in science begins a steady decline during primary school when instruction is rote and poorly presented (Osborne et al., 2003). Research shows that there is a connection between having positive background experiences with science and the development of interest in science (Bulunuz & Jarrett, 2010).

In 2007, Science Made Sensible (SMS), funded by the National Science Foundation (NSF), began as a partnership between the University of Miami (UM), Florida, USA and Miami-Dade County Public Schools[2]. The SMS program pairs postgraduate students in the science, technology, engineering, and mathematics (STEM) disciplines with local primary school science teachers. Each postgraduate works with his/her teacher partner for one continuous academic year in Grade 6, 7, or 8 science classrooms. They strive to make the science education experience interesting and exciting for primary school learners. Postgraduates and teachers work together to develop lesson plans, focusing on inquiry-based, hands-on activities that are connected to core concepts in the sciences. When possible, they integrate the disciplines of mathematics, biology, chemistry, and physics in the lessons. By engaging learners in the practices of science, we can help them begin to understand what science is and how scientific knowledge develops and advances (National Research Council, 2011).

Traditional instructional approaches have little impact on the development of learners' scientific reasoning abilities (Bao, et al. 2009). In contrast, many researchers including Benford and Lawson (2001), Gerber, Cavallo and Marek (2001), and Zimmerman (2000) reported that inquiry instruction can promote scientific reasoning abilities. To develop a society of scientifically literate individuals, educators need to foster an interest in and understanding of science at a young age. This requires the effective communication of scientific concepts through hands-on, inquiry-based class activities.

The SMS program is based on a hands-on/minds-on learning model (Haury & Rillero, 1994). Its basic premise is that when students are physically involved in science they are more likely to be mentally engaged. The theoretical framework of this study was drawn from three main areas of the literature: inquiry-based approach, hands-on activity, and minds-on learning.

The work of the theorists Piaget and Vygotsky was blended into the philosophy of learning known as constructivism (Cakir, 2008), which was used to shape instructional materials. Constructivism implies that learners need opportunities to experience what they are to learn in a direct way and time to think and make sense of what they are learning (Tobin, 1990). Loucks-Horsley et al. (1990, p. 48) are of the opinion that "*exemplary science learning is promoted by both hands-on and minds-on instructional techniques – the foundations of constructivist learning*". Constructivism-based instructional materials are commonly classified under the name of 'inquiry-based' and include hands-on activities as a way to inspire and engage learners while concretizing science concepts (Minner, Levy & Century, 2009). Hands-on learning activities are consistent with learner-centred strategies based on a constructivist learning-teaching approach (Taraban, Box, Myers, Pollard & Bowen, 2007). Inquiry-based learning refers to the pedagogical approach that uses the general processes of scientific inquiry as its teaching and learning methodology (Ketpichainarong, Panijpan & Ruenwongsa, 2010). Not only does it promote science content, but it also promotes learners' habits of mind, creative thinking, problem-solving ability, science process skills and understanding of the nature of science (Hofstein & Lunetta, 2003; 2004). Kubicek (2005) emphasized that inquiry-based learning should include the basic abilities of conducting a scientific investigation as well as an understanding of how scientists do their work. But DeBore (2004) makes the important point that inquiry-based learning does not require learners to behave exactly as scientists do.

The SMS program is designed to address the interrelated problems of scientists' failure to communicate sensibly, school teachers' lack of grounding in science, and the decline between Grades 4 and 8 in science and mathematics scores in the USA (Gonzales, Williams, Jocelyn, Roey, Kastberg & Brenwald, 2008). These problems are recognized, but they are often considered independent issues and addressed separately. With SMS we address these problems systematically.

SMS has three overarching goals: 1) improve the communication and teaching skills of postgraduate students, 2) enhance the professional development of primary school teachers, and 3) advance the scientific curiosity and learning of primary school learners. Each academic year, ten UM postgraduates and ten Miami-Dade County primary school science teachers are selected to participate in SMS. During the summer before an academic year begins, these selected participants engage in a two-week summer institute at UM. Each day of the institute has a different topic, such as written and oral communication skills, cooperative learning, team building, metacognition, directed discussion and effective questioning, promoting and assessing critical thinking, problem- and case-based learning, and formative and summative assessment. All the postgraduates and teachers work together to develop both skills and inquiry-based lesson plans that meet Next Generation Sunshine State Standards[3]. At the end of the institute each postgraduate is paired with one teacher with whom he/she collaborates with during the academic year. The SMS teams incorporate the lesson plans they developed during the institute into the science curriculum.

Expertise in a specific field does not mean necessarily that one is good at helping others understand that field (National Research Council, 2000). Universities train postgraduates how to do scientific research, but not how to communicate it. With SMS, we train postgraduates to be effective communicators by teaching them how to make science more sensible; we use primary schools as their training ground. The SMS program helps them become abler science communicators that will benefit them wherever they find themselves professionally– in academia, public school teaching, government service, or non-government organizations. The postgraduates' presence in the primary school classroom benefits teachers who possess too little scientific knowledge and, as a result, are uncomfortable with inquiry-based activities. This, in turn, sparks learner excitement. The teachers and learners give the postgraduates a gift, too: mental clarity and oral simplicity.

This is now the 8th year of our SMS program in Miami. Teacher (n=27), postgraduate (n=40), and learner (n=1252) evaluations were conducted at the end of each year of the program. In the evaluations, teachers emphasized that they related to the postgraduates as peers and not teaching assistants. The teachers seem to take enormous pride in the fact that postgraduates were conducting cutting-edge research and that they shared their experiences with the learners. The teachers felt that: 1) the postgraduates brought an increased level of scientific expertise and flexibility into the classroom, 2) having a postgraduate in the classroom allowed for more one-on-one interaction with students, 3) working with a postgraduate allowed a deeper level of coverage of the concepts being taught, and 4) the postgraduates help students see science in practice. The teachers unanimously agreed that the postgraduates have had a significant impact on increasing learner performance. Eight-five percent of teachers strongly agreed that, after the program, they knew science well enough to replace lecture presentations with labs on almost any subject in the primary school curriculum. And at the end of each year's program, all teachers strongly recommended that SMS be continued. Evaluation results revealed that over the course of the SMS program the majority of the postgraduates agreed or strongly agreed that after participating in SMS they felt adequately prepared to explain their research and present basic ideas about their field of study to non-scientists or the general public. Learners reported that having a postgraduate in the classroom helped them to understand science, and the majority said they would like a postgraduate to work in their future science classes.

Due to the success of our SMS program in Miami, we were eager to extend our program internationally. The goal of SMS in South Africa was to learn about South Africa's educational system, to develop inquiry-based natural sciences lesson plans in collaboration with South African primary school teachers that could be used in both Miami and South Africa classrooms, and to share pedagogical techniques used in the classroom. A detailed description of the SMS program in South Africa can be found in Lelliott et al. (2012). We chose South Africa as our international destination for two reasons. First, UM already had existing research partnerships with South African universities and informal science institutions. Second, in both countries, there is an achievement gap, specifically a disparity in test scores and persistence rates (Clark, 2014), between different ethnic groups. According to the 2014 NSF Science and Engineering Indicators report, White learners in Grades 4 and 8 in the USA performed approximately 12% higher on the National Assessment of Educational Progress exam than their Black counterparts in mathematics and science. In comparison, data from the National School Effectiveness Study that randomly tracked a national cohort of leaners for three years, beginning in Grade 3 in 2007, shows that mean literacy scores for learners in former Black African schools are less than half of those for learners in historically White schools (Taylor & Muller, 2014 in Clark, 2014).

The educational divide in both countries, coupled with language barriers (three languages in Miami and 11 languages in South Africa), inadequate teacher training, and lack of educational resources, could eventually result in shortages of individuals in STEM fields in both the USA and South Africa. The SMS team is committed to ameliorating this situation, and we were delighted to be warmly accepted into the South African primary school system.

In August 2011, funded by the NSF, the SMS program director, two SMS postgraduates, and two SMS primary school science teachers participated in SMS in South Africa. The team collaborated with Grade 6 and 7 natural sciences teachers at two public primary schools in Pretoria, Gauteng Province. The teachers worked together to create and implement inquiry-based, hands-on lesson plans in the classroom. At the end of the program, participating learners, postgraduates, and teachers were evaluated. The purpose of this study is to determine how successful the team was in reaching the SMS goals in South African schools. In addition to reporting the learners', teachers', and postgraduate students' views regarding the SMS program, similarities and differences between USA and South African teaching methods[5] in the classroom are discussed.

Research questions

The following are the research questions that guided the data collection and research methods:

- Was the USA team successful in reaching the SMS goals in South African schools?
- What were the most successful, and least successful, elements of the program as evaluated by the learners, teachers, and postgraduate students?
- What were the benefits of the SMS team's inquiry-based approaches in the natural sciences classrooms?
- What are the similarities and differences between USA and South Africa's teaching methods in the natural sciences classroom?
- What were the best practices for designing, planning, facilitating and delivering an inquiry-based learning task?

Research methodology

Sample and participants: In this study the positivist research paradigm, a survey approach, and a purposive sampling method were used. One-hundred ninety-five learners at two primary, public schools in Pretoria, Gauteng Province, South Africa participated in this study. For referencing purposes, the sample schools will be referred to as Schools A and B. School A is an urban and former Model C school. The school is situated in a middle class area. The staff is predominantly White and only a few teachers are Black or Mixed-race. More than 95% of the learners in this school are Black (Sotho, Xhosa, Zulu). The class sizes are relatively small with no more than 30 learners in a class. The language of instruction is English. The parents are responsible for paying school fees. School B is a township[6] school. The residents in this densely populated township belong mainly to a low-income group. All the staff is Black. One hundred percent of the learners are Black (Zulu). The class sizes are large with up to 40 learners in a class. The language of instruction is English, but there are problems in understanding the teachers. Computers in this school are antiquated. In the natural sciences classes, learners do not sit at desks, they stand all day long at tables. Parents do not contribute to school fees.

The participants of the USA SMS team consisted of two UM postgraduate students, two Miami primary school science teachers, and the program director. Miami science teachers and postgraduate students were paired with Grade 6/7 natural sciences teachers of the two Pretoria schools. Grade 6/7 natural sciences classes were selected because the Miami teachers already have experience teaching Grade 6/7 classes in the USA. Five Pretoria Grade 6/7 natural sciences teachers were involved in the study: three teachers at School A and two teachers at School B. At school A, two teachers obtained a Higher Education Diploma (HED). Both have three years of teaching experience in the natural sciences. The third teacher with a Master of Education degree (MEd) has 10 years of teaching experience in the natural sciences. The three South African teachers at School A were joined by a postgraduate in her third year of a PhD program in UM's biology department and a USA teacher with a Doctor of Education degree (EdD) who had over 25 years of experience teaching 6th and 7th Grade natural sciences in Miami inner city schools. At school B, one of the South African teachers has a HED and 20 years of experience in teaching Grade 7 natural sciences. The other teacher obtained a Baccalaureas Educationis (BEd) and has 12 years of teaching experience in natural sciences. These teachers partnered with a postgraduate also in her third year of a PhD program in UM's biology department and a USA teacher with a baccalaureate degree after her first year of teaching Grade 7 natural science in Miami as part of the Teach for America Program. The USA SMS team designed and delivered various lesson plans in collaboration with the South African teachers and shared pedagogical techniques used in the natural sciences classrooms. The international team shared pedagogical techniques and created and implemented new lesson plans on 'heat transfer' at School A and 'temperature change' at School B. In August 2011, the SMS South African program lasted, in total, eight continuous school days.

Data-gathering instruments: The learners', teachers', and postgraduate students' questionnaires (written in English) contained both open-ended and closed-ended questions. Ethical clearance was approved by the Faculty of Education Research Ethical Committee.

The research met the ethical guidelines laid down by the university for human educational research, including voluntary participation, informed consent, confidentiality, anonymity, trust, and safety in participation. The responses yielded demographic data as well as information on the learners', teachers', and postgraduate students' personal experiences of the SMS South African program. Each of the learners', teachers' and postgraduate students' questionnaires included a Likert scale section. In each case the participants were required to tick one of five options on the scale to indicate to which extent they agreed or disagreed with each statement: (1 = strongly disagree, 2 = agree, 3 = neutral, 4 = agree, 5 = strongly agree).

Data collection strategies: Single questionnaires were completed voluntarily during routine classes at the end of the SMS South African program. Participation was voluntary and participants did have a choice as to whether they wanted to submit the completed questionnaire or a blank form. The learners', teachers', and postgraduate students' questionnaires took about 30 minutes each to complete.

Data analysis procedure: The responses to the open-ended questions were analysed both qualitatively and quantitatively. In the case of qualitative analysis, open-ended questions were analyzed by means of open-coding (Strauss and Corbin, 1990). The responses to the closed-ended questions were analysed using frequency counts. These Likert responses were reduced to two: agree ('strongly agree' and 'agree' combined) and disagree ('strongly disagree' and 'disagree' combined). Descriptive statistics (e.g. frequencies) of the survey data were used to elaborate and enhance the discussion. Results are presented as percentages rounded to whole numbers. Mann-Whitney U tests were also used to compare the mean rank scores of the learners' responses to the different statements for each school.

Validity and reliability: The questionnaires' content validity was face-validated by two experts in the field of sciences, who are competent to judge whether the questionnaire reflects the content domain of the study. Based on the feedback of the pilot study and from the experts, the questionnaires were revised. Redundancies and ambiguities were removed to improve the clarity in the formulation of certain items in the questionnaires. The reliability of the learners' questionnaire was tested using Cronbach's alpha coefficient (Cohen, Manion & Morrison, 2007). The reliability of the questionnaire was acceptable with a Cronbach's alpha coefficient of 0.72.

Findings and discussion

Biographical information

In total, 195 questionnaires were returned. Of these 71 (36%) at School A and 124 (64%) at School B (Table 1). The majority of learners (102; 52%) were in Grade 6 while 58 (30%) indicated that they were Grade 7 learners. Thirty-five (18%) learners did not indicate which Grade they were in. The majority of learners (106; 54%) were female. Two female Miami teachers, two female UM postgraduate students, two male and three female South African teachers participated in this study. Both of the UM postgraduates students are pursuing PhD degrees in biology at UM.

Table 1: Demographic traits of participants

Schools	**Learners (n=195)**	**Grades***	**Teachers (n=7)**	**Postgraduate students (n=2)**
School A (n=71)	33 boys 38 girls	63 (Gr.6) 8 (Gr.7)	2 SA males 1 SA female 1 USA female	1 USA female
School B (n=124)	56 boys 68 girls	39 (Gr.6) 50 (Gr.7)	2 SA females 1 USA female	1 USA female

* 35 learners in School B did not indicate which Grade they were in

Experiences of the participants

- *Learners*

Learner responses to statements 1 to 4 were significant at the 0.05 probability level ($p < 0.05$) (Table 2). In other words, learner responses to these four statements differed significantly between the two schools. However, for both schools the majority of the responses for each questionnaire statement were in the ‘strongly agree’ category (Table 2). Table 2 shows the breakdown of learners’ responses to statements concerning incorporation aspects of the SMS program in two South African primary schools. From the results, it appears that the learners generally are in favour of linking the SMS team in their educational environment. The majority of the learners were sure (either ‘agree’ or ‘strongly agree’) that having the SMS team from the USA in their classrooms helped them understand science (statement 1). School

B had a higher percentage (99%) of positive responses than School A (90%). Many learners had the same opinion (either 'agree' or 'strongly agree') that the SMS team from the USA made them more interested in science (statement 2) e.g. School B (100%) and School A (94%). The learners were optimistic (either 'agree' or 'strongly agree') in having the SMS team from the USA in their classes because this team helped them appreciate why science is important (statement 3). All the learners of School B agree (100%) with this statement, followed by School A (90%). The statement "I would like a scientist to work in my future classes" elicited positive responses from 100% of the respondents in School B and 88% in School A.

Table 2: Responses of learners in two schools concerning the incorporation of the SMS program in South African natural sciences classrooms

Statement	**Responses (%)**				
	Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
1. Having the SMS team (scientists and teacher) from the USA in the classroom helped me understand science	48 (A) 92 (B)	42 (A) 7 (B)	10 (A) 1 (B)	0 (A) 0 (B)	0 (A) 0 (B)
2. The SMS team (scientist and teacher) from the USA made me more interested in science	62 (A) 89 (B)	32 (A) 11 (B)	6 (A) 0 (B)	0 (A) 0 (B)	0 (A) 0 (B)
3. Having the SMS team (scientists and teacher) from the USA in my class helped me appreciate why science is important	55 (A) 92 (B)	35 (A) 8 (B)	10 (A) 0 (B)	0 (A) 0 (B)	0 (A) 0 (B)
4. I would like a scientist to work in my future science classes	68 (A) 94 (B)	20 (A) 6 (B)	10 (A) 0 (B)	3 (A) 0 (B)	0 (A) 0 (B)

A = School A; B = School B

Four thematic categories emerged from the open coding of the learners' responses to the question "*What was* the *best part about having the SMS team from the USA in your classroom?*" (Table 3). The main explanation for the learners' positive responses (42%) related to 'Doing hands-on activities/experiments'.

The following comments reflect some learners' positive reactions:

> "*I'd like to say to you that you made me love science. Now I want to be a scientist. I want to discover more about the world and be able to know all the answers*" (learner in School B)
> "*I liked the fact that the SMS team made science fun*" (learner in School A)
> "*We understand the work better and we just wanted to come back to the class*" (learner in School A)
> "*The best part that I enjoy is to learn that science is important*" (learner in School B)

Table 3: Learners' responses indicating the best part about having the SMS team in their classrooms

Categories elicited from learners' comments	**Percentages (%)**		**$\bar{x}$ (%)**
	School A	**School B**	
Doing hands-on activities/experiments	35	49	42
Learned how to apply or understand science	34	47	41
They made science fun	23	1	12
They made me appreciate science more	8	3	5

- *Teachers*

The South African teachers agree (either 'agree' or 'strongly agree') that having Miami postgraduate students and teachers in their classes was a constructive experience. They contended that they gained knowledge of the educational system in the USA by interacting with the SMS team. Furthermore, they said that they will be able to incorporate some of the SMS activities into their classroom. Some teachers have adopted and adapted the pedagogical strategies (i.e. cooperative learning, inquiry-based learning, assessment) they learned from the SMS team. On return trips to South Africa, the program director has observed our South African teacher partners using the lesson plans first introduced to them through SMS. The teachers felt the learners benefited from the activities of the SMS team and they are of opinion that the visit by the SMS team had a positive impact on their teaching.
The South African teachers made positive comments such as:

> "*They really made an impact on my many years of teaching experience*"
> "*I noticed that they do a thorough plan and research of the activities and so I am encouraged to use the internet for more information when planning an activity"*
> "*I will definitely use the SMS activities in my classes and will share the knowledge I gained with other teachers from neighbouring schools understand its importance, and I think they will value it more than before*"
> "*They motivated the learners and some want to become scientists*"
> "*I really needed to be empowered on scientific issues and I gain a lot*"
> "*I have gained different ways of dealing with concepts that were difficult for me to tackle*"

The Miami teachers were in agreement (either 'agree' or 'strongly agree') that their experiences teaching with South African teachers were positive. One teacher said: "*This experience has been life changing*." They have the same opinion that their many years of teaching experience gave them a greater appreciation for the common challenges in teaching in Pretoria schools. The Miami teachers agreed that their teaching experience in South Africa gave them new insight into how to make science more sensible in Miami. Furthermore, both teachers felt they benefited professionally from teaching in the South African science classrooms.

The following is a comparison of the Miami-Dade County Public School (MDCPS) and the South African public school system in Pretoria, from the viewpoint of the two Miami teachers. The Miami teachers observed numerous differences between the school systems that were enlightening and provided great learning opportunities for them as teachers. They were most impressed by the differences in the sense of community, curriculum, and methodology between the MDCPS and the South African schools.

The Miami teachers agreed with the postgraduate students that the sense of community embodied in a school is one of the most valuable assets it can have. It is this feeling, shared by the learners, faculty, and administration, that unites the stakeholders together to reach a similar goal of education. One Miami teacher stated: "*We were beyond impressed by the sense of community we witnessed in Pretoria*." The teachers work together, share resources and responsibilities, and the adults at that school function as a team. The learners respond very well to that environment, respecting and loving all the teachers at the schools. Learners at various Grade levels would accept praise, discipline, and instruction from all teachers and administrators in the school. That sense of community is much weaker in MDCPS. One teacher made the following comment: "*Many of our learners do not feel safe or invested at school, and it was a new experience witnessing a family-like environment at a public school.*"

A second observed difference was the educational curriculum, or the documents that outline exactly what the students are to be taught. In MDCPS, the curricula are very structured and specific, and the expectations of what teachers are meant to teach are very clear. Those documents are made by the school board and distributed to all public schools in the USA. The curriculum in South Africa was vaguer. There were no precise instructions or expectations of how the learners were meant to express their knowledge. In the Miami teachers' opinion, the MDCPS curriculum is much more conducive to streamlined instruction and student mastery.

Lastly, the methodology between science instruction in Miami and South Africa is very different. The curriculum used to deliver instruction in South Africa relied heavily on memorization. Teachers would lecture, learners would take notes, and then learners were expected to memorize and recall facts. In Miami the instruction is much more process-based. Miami teachers require learners to think analytically, and the goal is for learners to understand systems of science. This helps them apply their knowledge in different situations. In South Africa the learners had some difficulty responding to open-ended prompts and applying the facts they learned in new situations.

Overall, both education systems have clear strengths and are quite different. The South African system has the strength of a strong school community, which is a safe and loving environment for the learners. The Miami system has strengths in the form of a detailed curriculum that facilitates interactive teaching. Miami's system also has the distinct advantage of implementing problem-based learning and teaching learners analytical skills.

- *Postgraduate students*

The postgraduate students were in agreement (either 'agree' or 'strongly agree') that their collaboration with South African teachers was a fruitful learning experience. One postgraduate commented: "*Best experience I've had in academia. It opened my eyes to the rest of world, taught me invaluable lessons in science teaching, and broadened my research horizons*." Although they are not professional teachers, they agreed that their teaching experience gave them a greater appreciation for the common challenges in teaching in Pretoria and Miami schools. Another postgraduate explained: "*I learned how to use pictures and diagrams to communicate my ideas to students struggling with English*." The two postgraduate students felt that they benefited professionally from teaching in the South African natural sciences classrooms and that their teaching experience in South Africa gave them new insight into how to make science more sensible in Miami schools.

The following is a comparison of the MDCPS system and the South African public school system in Pretoria from the viewpoint of the two UM postgraduate students. These students contended that although South African and USA primary school science curricula focus on similar concepts, there are stark contrasts in the development and implementation of lesson plans and teaching methods. South African schools are characterized by more flexible teaching methods and a greater sense of community among teachers and learners. Whereas, in USA schools, teachers focus their efforts on preparing learners for a standardized test and must rely on school counselors to be their learners' support system. For example, at school B in South Africa, a learner's only parent died and his teachers visited the learner's home. When they arrived, they found the learner living in a shack with a dirt floor, no bed, no running water, and a coal stove with no food. The teachers felt a sense of responsibility towards this learner and went around the community collecting pillows, blankets, and food, and ensured the learner was able to continue attending school. In contrast, the USA school system delegates the responsibility of learners' welfare to school counselors, Department of Children and Family Services, and teachers, often resulting in confusion as to who is responsible for a learner. Inevitably, learners fall through the cracks. For example, an SMS postgraduate student brought a learner to the guidance counselor's office for bullying, and the counselor openly hesitated to provide counseling for the learner because she was backlogged with so many other learners' issues.

The postgraduate students were of opinion that the absence of standardized testing in South Africa allows for greater flexibility in teaching while the standardized tests in USA schools produce a more guided and thorough education. Teachers in the USA receive weekly pacing guides and ample online resources, such as PowerPoints, discovery education videos, online lab simulations, and funding for laboratory equipment. Because the two South African schools lack such resources, they indicated that they felt limited in their ability to illustrate complex concepts. For example, attempting to explain seasonality and weather patterns with only a whiteboard and limited supplies was a challenge, especially when compared to the resources available in USA schools. One postgraduate student commented "With little resources available, my SMS teacher and I stepped out of our comfort zone and learned how to use simple everyday things to teach scientific ideas such as a water cycle (bowls, hot water, ceran-wrap)." Another example of a postgraduate student using low-cost materials to explain a science topic was the use of hard-boiled eggs to illustrate the layers of the earth and introduce the concept of plate tectonics. Although teaching for Florida's standardized test, called the Florida Comprehensive Assessment Test, initially appears to be constrictive, in reality it provides teachers with solid objectives that guide the learners' science education.

The postgraduate students also found that South African and USA schools teach similar curricula with varying degrees of flexibility and resources. South African schools supplement their lack of resources with their sense of community and emotional support of learners. Whereas, USA schools are able to teach well-developed lesson plans utilizing their abundant resources.

SMS program and the achievment gap in South Africa.

Rogan and Aldous (2005) comment on how educational policies in South Africa completely changed after Nelson Mandela was elected president ending apartheid, and the newly adopted curriculum embraced learner-centred pedagogies. Dudu and Vhurumuku (2012) report on a case study that suggests that when teachers introduce practical investigations they vary in their effectiveness. Ramnarain (2011), in another case study, also found that the implementation of practical science investigations is more difficult in a township school previously designated for Black learners than in a former Model C[4] school previously reserved for White learners due to resources, language, and physical constraints within the classroom. He suggested that four factors affected the lower quality of science teaching in township schools contributing to the education gap: physical resources, school management, background of students and community perception of the importance of education.

The USA SMS program primarily addressed the physical resource issue by engaging students in low-tech hands-on activities. The SMS participants were responsible for determining which supplies would be needed for their planned activities, purchasing those supplies, writing lesson plans according to the Curriculum Assessment Policy Statements (CAPS), and creating worksheets. School B is poorly resourced and has very little supplies. Therefore, it was necessary to help this school with low-tech supplies such as batteries. Bush and Glover (2009) emphasized the critical role that school principals play in the management of teaching and learning. It is imperative that principals encourage their teachers to participate in professional development activities which will enhance learning at their schools. The SMS program director reinforced the importance of student centred-learning by spending time with school principals at A and B. The principal at School A appeared to take a stronger leadership role in managing teachers and learning at the school than his counterpart at School B. The SMS team was not able to address student background particularly difficulties with language. The SMS team did have problems communicating in English with some students at School B and had to rely on teachers speaking to learners in Zulu. We were not able to address the issue of community ethos about the value of education. However, anecdotally we found that the response rate of parents signing a release form giving permission to have their children participate in a questionnaire did not appear to be different between schools.

Best practices

As part of the SMS training program in Miami, UM postgraduates and Miami primary school science teachers participate in a two-week summer institute at UM where they learn about communication skills in the classroom, problem-based learning, and how to develop and evaluate inquiry-based science lesson plans. Therefore, the USA SMS team participants had this set of pedagogical skills prior to participating in the SMS South African experience.

Before the USA SMS team travelled to South Africa, they initiated contact, via email, with the South African teachers with whom they would be partnering. Upon their arrival in South Africa, the USA SMS team met with the South African primary school science teachers at the University of Pretoria. They further discussed the goals of the program and the science topics that were scheduled to be taught during the SMS team's time in the classroom, and they outlined the team's daily activities in the classroom. The SMS team is aware of the South Africa curriculum policy that science teachers are encouraged to source low-cost materials from the home, rather than purchase such materials. However, parents of students in School B still cannot afford even low-cost materials. The implementation of the lesson plans was led by the USA SMS teachers and postgraduates, with participation by the South African teachers. Following implementation of the lesson plans in the classroom, electronic copies of the lesson plans were provided to each of the South African teachers, and the lessons have continued to be implemented. The lesson plans also were distributed to all participants of the

SMS program in Miami, where they also are being used in the classroom. The USA SMS teams were pre-adapted to deal with large class sizes because a typical class in Miami consists of 40 to 50 learners.

From our experience, it is clear that future participants would benefit from more preparation time. A one-week institute in South Africa, similar to the one conducted in Miami, would be most useful to enhance the SMS South African experience. The increased time to get to know each other, develop a partnership, and discuss personal teaching methods before entering the South African classrooms would allow all participants to contribute equally to the design and delivery of lesson plans. In the future, for additional formative assessment we intend to administer pre- and post-tests of learners to evaluate learning gains. For summative evaluation, we will track learners that experienced SMS with a teacher and compare their persistence rates in high school with learners of the same teacher who did not experience SMS.

We do not want to be presumptious in assuming that pedagogical inovations that are employed in the USA will be equally effective in South Africa. Yet there seems to be an undeniable convergence internationally of having learners and students learn by doing. Ramnarian (2010) in contextualizing curriculum reform in South Africa points out the new emphasis on students undertaking scientific investigations replacing standard cookbook exercises. Thus, the challenge in both countries is to shift the paradigm from teacher-centred learning to learner-centred learning.

Concluding remarks

We view the SMS program in South Africa as a case study in the same vein as Bush et al, (2011), Ramnarain (2011), and Dudu and Vhurumuku (2012). We cannot generalize at this point until we increase sample sizes and track students who have participated in the program through high school and beyond. Nevertheless, we are pleased with the preliminary success of our SMS program in South Africa. The SMS model in two different educational contexts has its challenges. According to the teachers and postgraduate students there are major differences in the educational systems between the USA and South Africa. We tried to prepare the SMS team by having an orientation on such differences led by a South African educator. The short duration of the SMS program in South Africa is another limitation. We extended the interaction through email correspondence between the USA and South African

SMS participants to discuss units of instruction. There are elements that have been sustained, including group work and inquiry-based learning. For example, teachers still are using the 'water cycle' and 'layers of the earth' lesson plans (mentioned previously) developed through SMS.

In spite of the challenges, all of the South African teachers strongly agreed that having the SMS team in their classrooms was a very encouraging experience, and they could introduce the SMS activities into their future science classrooms. As for the SMS team, generally participants agreed that their teaching experience in South Africa was positive, and they left with a better appreciation for the common teaching challenges in the city centres of Pretoria and Miami. The Miami teachers and postgraduate students who worked with South African teachers on curricula for both countries all had a rare experience: that of pondering the cross-cultural appeal of science and the commonalities that make it teachable in radically different settings.

The learners of both schools were very satisfied concerning the incorporation of the SMS program in South African natural sciences classrooms. Comparing the response frequencies to all the questionnaire's statements, the learners of School B were slightly more positive than School A. However, learner satisfaction may not be entirely due to the SMS pedagogy intervention. The presence of the USA SMS team created an excitement within the classroom. Learners were very inquisitive about what life is all about in the USA. Most learners in this inquiry-based learning program have exhibited increased creativity, communication skills, critical thinking skills and decision making based on their hands-on science activity experiences. Moreover, it helped them develop a positive attitude towards science.

In South Africa, Higher Education is urging tertiary institutions not only to become socially responsive in regard to community development, but also to produce new knowledge and graduates who are responsive citizens. One method of achieving this is through school-university community service initiatives. It is recommended that the principles of the SMS program can be adopted by the Higher Education System and elaborated not only in more South African primary schools, but also in secondary schools. In this process communities are learning to work with universities and universities are also learning to work with communities.

Our future plans are for South African teachers to visit Miami primary schools to get first-hand experience of the USA SMS program and to extend the SMS South African program to six weeks.

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Endnotes

[1] Learners: a term used in South Africa to indicate persons educated in schools
[2] Dade County Public Schools: the largest public school system in Florida, USA
[3] Next Generation Sunshine State Standards: competencies in science mandated by the state of Florida that students must learn
[4] Model C school: According to apartheid policy, a Model C school was designated for White learners
[5] Teaching methods: e.g. inductive or deductive teaching methods
[6] Township: township is generally associated with a peri-urban area (suburb)

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