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RESEARCH ARTICLE



Learning for change: Integrated teaching modules and situated learning for marine social-ecological systems change

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ABSTRACT

Access to science-based environmental education is critical to improve rural coastal communities' adaptive capacity and resilience. Based on research in two rural, underprivileged schools in South Africa's southern Cape coastal region, we describe the process and lessons learnt in developing and deploying a series of integrated teaching modules for middle school (Gr 7-9) learners.

The modules' structure was informed by integrated curriculum design, and lessons were developed to augment the existing syllabus. Social and situated learning paradigms also informed the modules' development, with lessons and practical exercises drawn from the surrounding environment and community, as well as incorporating data from ongoing regional marine science research.

In a context of rural isolation, limited resources and a mistrust of outsiders amongst adult community members, the findings suggest that the modules may serve as building blocks of intentional learning to bolster adaptive capacity amongst both learners and the broader local community.


KEYWORDS


environmental education; integrated curriculum; middle schools; situated learning; social learning

Introduction

Worldwide, marine rural fishing communities are amongst the most vulnerable to increasing global and climate related variability and change (Badjeck et al., 2010; Islam et al., 2014; Ommer, 2007; Sales, 2009). South Africa's south coast has been identified as a global 'hotspot' of coastal warming, experiencing faster rates of marine temperature increase than the global average (Hobday et al., 2016) and recent research indicates that climate-related changes along the country's coastline are increasing the vulnerability of rural coastal communities (Sowman & Raemaekers, 2018, Martins et al., 2019). Many of these communities are isolated and beset by low levels of education and employment (STATSSA, 2012) struggling to access relevant knowledge and resources to improve their adaptive capacity. Under such circumstances, people's capacity to adapt is compromised, rendering them vulnerable to variability in different systems (Belhabib et al., 2016; Ding et al., 2017; Gentle & Maraseni, 2012). Further, many residents remain reliant on small-scale fishing as both a source of supplementary income and cheap protein (Isaacs, 2011; Isaacs et al., 2007).

The research presented herein takes as its focus two such disadvantaged rural communities in the southern Cape region of South Africa's Western Cape province; Vermaaklikheid and Melkhoutfontein

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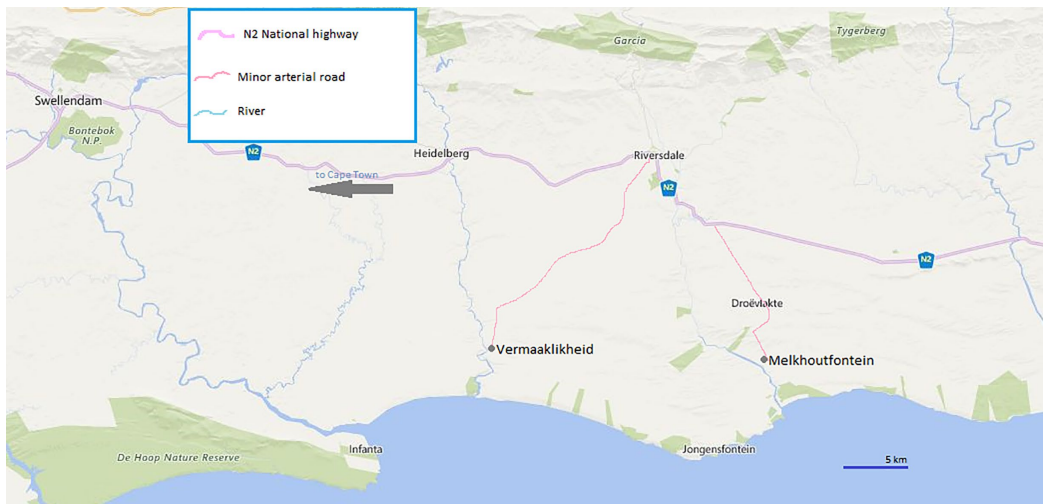


Figure 1. Map of the southern Cape indicating Vermaaklikheid and Melkhoutfontein.

Figure 1. Previous research in the region has found that changes in the local marine system have had considerable impacts on the livelihoods and wellbeing of these fishing dependent communities (Duggan, 2012; Gammage, 2015, 2019). Further, research in the region also suggests that these communities are limited in their ability to adapt to changing marine and climate conditions, with few means to improve this position (Gammage et al., 2017).

Given their vulnerable status, these communities need to learn about and plan for increasing marine and climate variability if they are to successfully adapt. Learning is an integral component in adapting to and addressing the complex social-ecological challenges coastal communities face, including declining fisheries, increasing marine and climate variability, and difficult management environments (Armitage et al., 2017). However, in the case of Vermaaklikheid and Melkhoutfontein, residents lack the knowledge and resources to do so. Further compounding the challenge of implementing community learning to support adaptive behavior, whilst some adult residents are interested in information relating to climate and marine change and variability, a long-held mistrust of outsiders and a resistance to intentional community education (Duggan, 2012, 2018) makes intentional learning exercises with adults difficult. The reason for this mistrust is in part attributed to a longstanding sense of marginalization by government (characterized by limited access to information and inequitable fishing policies and rights) compounded by geographic isolation (Gammage, 2015).

Despite adult community members' mistrust of externally facilitated community education, however, scoping fieldwork found that middle schools (Gr 7-9) offered an alternative entry point to share knowledge for adaptation. As the future generation of community leaders and changemakers, school learners represent an influential cohort of critical importance, who should be empowered through education that improves their adaptive capacity. Vermaaklikheid and Melkhoutfontein are home to one school each, and the scoping fieldwork found that both schools occupied trusted positions in the community, serving as central knowledge hubs from which information was disseminated into the broader community. When approached, teachers and students in both schools expressed an interest in participating in educational exercises related to climate and marine variability. In this context, the schools offered a way to build a foundation of adaptive knowledge and skills amongst learners, whilst initiating conversations and knowledge sharing with adults in the broader community.

Lending additional support to the schools' interest, discussions with teachers during the scoping fieldwork identified several perceived shortcomings in the Curriculum Assessment Policy Statements (CAPS), the government-standard curriculum for South African schools. Teachers felt that many CAPS lessons and exercises were disconnected from the local, rural context. An opportunity thus existed to

build the foundation for adaptive thinking and behavior via schools and open conversations with parents and other adult community members whilst addressing the shortcomings of the CAPS.

From the scoping fieldwork, it was apparent that a lack of finances and resources, and the CAPS structure would strongly influence the direction of the research and any potential approaches to learning deployed in the schools. In consultation with teachers and students, it was determined that a series of modules that augmented the CAPS curriculum to fill in perceived gaps and provide supplementary, hands on lessons, would best address the challenges and needs of the schools. Given their rural location and proximity to both estuarine and marine environments, the surrounding environment offered an affordable, accessible suite of teaching resources. Two paradigms of learning informed the ethos of the modules: social and situated learning. Both social and situated learning theories are based on an understanding that learning is a social process, taking place through interactions and observations of others in the real world, and reinforced through positive or negative feedback loops (Bandura & Walters, 1977; Lave & Wenger, 1991). In the context of climate and marine adaptation strategies, both have been suggested as tools for creating changes in group understanding and behavior (Berkes & Ross, 2013; Cundill et al., 2014; Pahl-Wostl et al., 2007) as individuals interact and share multiple perspectives, transferring ideas into broader networks (Reed et al., 2010), learning from and interacting with their surroundings (Krasny et al., 2009; Tidball & Krasny, 2011).

Social learning theory originated from the work of Bandura, who posited that “new patterns of behaviour can be acquired through direct experience or by observing the behaviour of others” (Bandura & Walters, 1977, p. 3). It is by internalizing these observations, following Bandura (Bandura & Walters, 1977) that we understand how to replicate this behavior ourselves. That is, social learning is an iterative, reciprocal, and interactive process informed by social and environmental actors. In social learning theory, the adoption of new behaviors is also informed by the consequences (whether positive or negative) of enacting these newly observed and internalized behaviors, and the feedback of others (Bandura & Walters, 1977). Moreover, influential or authority figures play a significant role in reinforcing particular behaviors amongst learners (Fisher & Skowron, 2017). In this conception of learning then, the classroom represents a potentially positively reinforcing social space, providing myriad opportunities to learn through social interactions and receive positive reinforcement from authority figures (teachers) in an enabling environment. The provision of a positive learning environment, particularly one reinforced by a teacher, that supports adaptive capacity building and pro-environmental behaviors, for example, would imbue learners with a desire to reenact these behaviors in future (Besar, 2018). Typically, intentional social learning exercises focus on adults (e.g. Berkes, 2009; Finkbeiner et al., 2018; Suškevičs et al., 2018; Thompson et al., 2017). However, developing effective adult-focused social learning exercises can be challenging in some circumstances, such as in Vermaaklikheid and Melkhoutfontein, where adults’ mistrust of intentional learning offered by outsiders would limit participation.

A critical distinction between social and situated learning is the latter’s assumption that lessons cannot be abstracted from their surrounding environment (Lave & Wenger, 1991). That is, where social learning theorists suggest that it is possible to learn by observation of others’ successes and failures and apply these learnings in other situations, contexts and times, situated learning posits that if learning takes place outside of its authentic context (i.e. the environment in which it is normally applied or enacted), effective transfer of knowledge to learners cannot be expected (Besar, 2018; Fenwick, 2001).

Drawing from lessons grounded in real world situations, experiences, and the surrounding environment (Tidball & Krasny, 2011), rather than viewing students as passive recipients of knowledge, situated learning shifts the focus of traditional environmental education from knowledge driven by content and concepts toward knowledge driven by action (Krasny et al., 2009). In turn, this approach to teaching empowers learners to become active stewards, thereby building their resilience whilst facilitating improved education and learning (Ban et al., 2015; Tidball & Krasny, 2011).

Hilburn and Maguth (2011) suggest that three principles underpin successful, intentional, situated learning in a school environment: integrated teaching; interaction with surroundings; and a curriculum informed by local context. Integrated teaching involves the creation of links across subjects, described

by Fogarty (1991) as a ‘sequenced’ model of curriculum design, in which topics are taught separately in different subject classes, but arranged in a sequence such that lessons taught in different subjects relate to and complement one another, addressing an overarching theme. Interaction with the surroundings involves drawing from local examples, interactions, and practical lessons embedded in the surrounding environment (Hilburn & Maguth, 2011; Krasny et al., 2009). Developing a curriculum informed by local context involves a focus on local challenges and means of addressing these (Hilburn & Maguth, 2011). Critically, an interactive focus on learners’ surroundings and local challenges has also been shown to create connections that can extend into life outside the school (Drake & Burns, 2004), whereby learners shape and are shaped by their context, echoing Tidball and Krasny’s (2011) observations that social learning is an iterative process. We therefore hoped that an interactive component of the modules involving community engagement exercises would lay the groundwork for learning in the wider community.

The modules were also designed to address shortcomings identified in the CAPS curriculum, by supplying the schools with contextually informed lessons and practical exercises. Interviews and discussions in the schools during scoping fieldwork established that topics pertinent to local experience such as marine and climate change, overfishing, and estuarine and marine pollution were not sufficiently covered in the CAPS. Furthermore, teachers suggested that conventional CAPS lessons related to environmental concerns often contained generic, urban-centric examples far removed from the local rural, coastal experience, leaving students and staff feeling disconnected from the curriculum.

The CAPS curriculum displays what Fogarty (1991) refers to as a ‘fragmented’ model of curriculum design, with subjects taught discretely by different teachers. This provides learners with a fragmented understanding of the curriculum (Fogarty, 1991), with no linkages or overlaps demonstrated between lessons or subjects. Given the limitations of the fragmented model, the perceived shortcomings of the CAPS voiced in the schools, but their coterminous reliance on it, the intention behind the modules’ design was to augment the CAPS, and not replace it. Writing on the need for a more engaged and responsive South African school education system, Lotz-Sisitka et al. (2015, p. 32) cautions that a “curriculum that simply aligns with the CAPS appears to be inadequate”. A balance was thus sought in not deviating from the syllabus or disrupting teachers’ schedules, whilst creating engaging, contextually informed modules that did not simply replicate CAPS lessons. With these considerations in mind, the modules were developed according to a sequenced model of integrated curriculum design (Fogarty, 1991), integrating with and augmenting CAPS lessons at specific points in the syllabus.

Being under-resourced, geographically isolated, and lacking funds to purchase the supplementary materials suggested by the CAPS, learners were not often able to engage in a hands-on manner with subject matter. Many generic conservation, marine, and climate-related curricula are freely available (see for e.g. NASA ClimateKids 2019; Paytan et al., 2017) and appear to offer a solution. However, these generic curricula are generally dependent on multimedia and internet resources, designed to be taught separately after regular classes have ended, developed in contexts far removed from the rural southern Cape, replicating the challenges of the CAPS by drawing on examples not relevant to the local experience. The scoping fieldwork identified early on that access to multimedia devices and internet connectivity were severely limited in the schools. Additionally, the fieldwork indicated that whilst stressors tend to be the same across the south coast region (Gammage et al., 2017), the experiences of and reactions to climate and marine change were specific to the two communities.

In their study of problem- and project-based sustainability courses, Brundiers and Wiek (2013) suggest that sustainability education often fails to integrate practical, experiential components into the syllabus. Further, discussing the CAPS curriculum in particular, Lotz-Sisitka et al. (2015) suggests that a conventional emphasis on education about the environment (i.e. raising awareness), whilst important, overlooks opportunities for transformative social learning and sustainability education that equip participants with practical knowledge to address environmental challenges. Noting these calls to apply hands-on sustainability thinking in curricula led to the incorporation of immersive exercises in the modules.

In what follows, we describe an attempt to navigate mistrust and share knowledge with communities in collaboration with schools through the development of a series of integrated and situated teaching modules targeted at Gr. 7-9 middle school learners. The modules were also intended to open conversations in the broader local community on topics relating to local challenges brought about by changing climate and marine dynamics. We discuss the rationale and process of developing the integrated teaching

modules, some of the modules' outcomes in facilitating learning and community conversations, and describe challenges encountered.

Materials and methods

Field sites

Field work was carried out during 2013 and 2016 in two settlements, Vermaaklikheid and Melkhoutfontein. Both were first settled in the early 1800s by itinerant farm laborers who subsisted on agriculture and fishing (Louw et al., 2006; Steyn, 1996). Both towns have seen little infrastructure development over the past 150 years and were marginalized under the Apartheid system. Both are geographically isolated; each is some 40 km from the national highway, with no access to reliable public transport. Each is home to a single school, both of which teach the CAPS curriculum. Founded in 1977, Melkhoutfontein School is government-funded, has ~400 learners from Grades 1-9 and is staffed by eleven teachers including the principal. All lessons are taught in Afrikaans. Opened independently by local parents in 2008, Vermaaklikheid School is sporadically funded through charitable donations and, often being unable to adequately remunerate teachers, has a relatively high turnover of staff. Since opening, the school has attempted to secure official government recognition and funding by aligning itself with government policy, adopting the CAPS curriculum in 2013. With a total of 38 children from Grades R/Kindergarten to 9, Vermaaklikheid School is staffed by three teachers including the principal, with learners in the senior grades (7-9) taught simultaneously in a single class.

Whilst education levels are already low in the Western Cape Province, with a provincial average adult matriculation rate of just 28.6% in the 2011 National Census (Lehohla, 2012), the southern Cape shows even lower levels. The same 2011 census, for example, found that just 15.9% of Melkhoutfontein's and only 8.7% of Vermaaklikheid's adult residents had achieved a high school finishing certificate. Unemployment is also high in both towns, with Vermaaklikheid recording nearly 50% unemployment in 2011 compared with the national average of 25%, and Melkhoutfontein faring only slightly better (Lehohla, 2012). Internet penetration is extremely low in both towns and Vermaaklikheid, for example, had no internet access in the community or school when the fieldwork commenced aside from the school's principal, who possessed a laptop and relied on a cell phone and intermittent reception to access the internet. Melkhoutfontein School had recently received a donation of five refurbished computers but had no internet connection or funds to cover a connection fee. The limited opportunities resulting from this rural poverty, isolation and low education mean that many residents of both towns continue to rely on subsistence agriculture and small-scale commercial and subsistence fishing to supplement income and diet (Duggan, 2012; Gammage, 2015). In combination with their low levels of education and employment, this partial reliance on fishing renders the residents vulnerable to marine variability and change including declining catches and shifting marine, weather and climatic conditions (e.g., Blamey et al., 2015, Gammage, 2015; Duggan, 2012; Watermeyer et al., 2016, Ward, 2018).

Approach

Ethnographic participant observation, interviews, group discussions and feedback sessions formed the foundation of the fieldwork. Participant observation focused on the students and teachers in both schools and involved spending time in classes, observing lessons and student-teacher interactions around subjects including Mathematics, English and Physical Sciences. This component of the work was conducted over a total of six months between 2013 and 2014. In addition, a total of 12 teachers, 47 learners, 19 parents of learners, and 14 adult community members participated in semi-structured interviews and group discussions that were conducted in two phases. The first interview phase was conducted during the six-month fieldwork period in 2013-2014 and drew on semi-structured interviews with students and teachers (a total of 32 students and 9 teachers) to identify gaps in the CAPS curriculum and to discuss topics felt by both groups to warrant attention. Topics included: challenges in the CAPS; lack of teaching materials; teaching and communication challenges; lessons and methods that worked successfully; and subjects that needed supporting materials or contextualization. This phase also included nine open-ended group

discussions with teachers after hours (between three and six teachers present in each). An additional group discussion involved only students (20 learners with a teaching assistant present), and another discussion was held with a mix of students and teachers.

Once an overview of the challenges and topics requiring attention had been established, lesson planning began. At this stage of the first research phase, the work drew on the concept of lead users, those end users who will most benefit from, and are motivated to inform the design of a product or service (Harhoff et al., 2003; Morrison et al., 2004). This participatory approach is intended to create a final product which is both suitable for purpose and taken up as intended (Fliess & Becker, 2006; Ozer, 2009) and involved working with teachers and learners throughout the process to incorporate their feedback and insights in determining appropriate lessons structures, contents and exercises. The lead user approach saw students and teachers consulted to identify problem areas in the CAPS curriculum as well as topics felt to warrant augmentation and/or a connection to the local context. An example of this was graphs in Mathematics – a problem area identified by students and teachers alike in both schools. Following the lesson planning, follow-up meetings were held with participants to determine whether all topics had been adequately accounted for. These follow-up sessions were held with students and teachers separately to mitigate against learners deferring to teachers or not feeling confident voicing their opinion in front of them. The results of these meetings were provided to students and teachers together, anonymously, in a single feedback session.

The second phase of interviews was conducted between 2015 and 2016 over a period of four months. This work focused on gathering participants' feedback and refining the modules and individual exercises and lessons and incorporated both individual and group discussions with the same students and teachers consulted in the first phase. This fieldwork period also served as a means of overseeing the modules' deployment in Vermaaklikheid School's syllabus. Additionally, as part of the second phase, 19 semi-structured interviews were conducted with parents of learners to gather their feedback. After concluding the first year of the modules' teaching in 2016, feedback sessions were held in Vermaaklikheid to refine lesson organization and content. At this time, semi-structured interviews with 14 adult residents were also held, focusing on conversations between themselves and the students facilitated by homework exercises. Respondents were asked, for example, whether they had interacted with the learners around school exercises and if so, what topics they had discussed. These respondents were also asked whether they would participate in future research around these topics. Finally, individual interviews with parents and other adult community members, and group feedback sessions with students and teachers were conducted in early 2017 to gather feedback on the modules and plan for their future use in the curriculum. Further to the semi-structured interviews and feedback sessions, over the course of the first and second phases of the fieldwork, a total of 24 informal conversations (12 in each phase) were also facilitated with teachers and parents to better understand the local context, challenges and gather feedback. Except in Vermaaklikheid School (where most conversations with students were in English) all other interviews and conversations in Melkhoutfontein and Vermaaklikheid were conducted in Afrikaans and translated into English by the researcher, who is bilingual.

Results

The research results are presented below as per the two phases of fieldwork. The first phase describes the modules' development based on the lead user approach that incorporated teachers' and learners' suggestions regarding content. We also provide an overview of the challenges encountered in this process. In phase two, based on the interview feedback from learners, parents, community members and teachers, we identify aspects of the situated and integrated process that facilitated the success of the modules in Vermaaklikheid School, and their role in stimulating discussions with parents and other adults in the broader community.

Phase 1: Creating the modules

The situated approach to the modules' development included the aforementioned integrated lesson approach, biodiversity surveys of the school's surroundings and practical exercises designed to explicitly link classroom lessons to outdoor observations, outside research projects in the region, and community engagement.

To ensure the modules adhered to established didactic structures, the development process incorporated experts at critical stages including the scientific outreach co-ordinator for the University of Cape Town's Marine Research Institute, a respected senior Cape Town high school science teacher as well as several other Cape Town middle school teachers. Given teachers' concerns around teaching experimental material, particularly during the examination periods in the second and fourth terms it was agreed that a supplementary curriculum could neither replace the CAPS, clash with the syllabus, nor run the whole year. Individual integrated modules were therefore taught over periods of one to five days in the first and third terms of 2015, and first term of 2016. The education experts suggested that the modules should focus on just two subjects; Mathematics and Science. However, consultation with the participants in Melkhoutfontein and Vermaaklikheid highlighted the potential value of English and Art in the modules. In relation to these four subjects, topics identified as requiring attention included: climate change; terrestrial and marine ecosystems; biodiversity; food webs; data handling; public speaking; English comprehension; relevance of Mathematics beyond the classroom; pollution; the marine environment; global warming; ocean acidification; and rising sea levels and marine temperatures (Appendix, Supplementary material).

Challenges and adaptations in the process

The selection of grades for which to structure the lessons was determined largely by Vermaaklikheid School's understaffing issues. With Grade 7 to 9 learners taught simultaneously in the senior classroom, communicating lessons effectively across the spread of ages and cognitive abilities was a high priority. Fitting the modules within the CAPS structure and syllabus was a challenge, particularly as most CAPS teachers specialize in one subject and the curriculum follows a tight schedule throughout the year. Developing the modules in a sequenced model of integration (Fogarty, 1991) was intended to address this challenge by allowing them to fit the CAPS syllabus as well as with the areas of specialization of the teachers. Despite this, Melkhoutfontein's principal explained in a 2015 interview that as a result of a recent series of low assessment scores across all Grades, the South African Department of Basic Education had placed strict controls on the school. This effectively limited teachers' ability to deviate from the CAPS or incorporate additional material into their syllabus. Discussions with Melkhoutfontein's teachers in 2015 also indicated concerns regarding the time required to integrate and implement experimental modules in their syllabus or translate lessons from English into Afrikaans. Ultimately, it was not possible to overcome these challenges within the timeframe of the fieldwork and Melkhoutfontein School was unable to implement the modules in their curriculum.

Another challenge encountered was both schools' lack of resources and teaching materials. This resulted in the modules being formulated to keep required resources to a minimum. Teaching materials from a range of sources were consulted to ensure that lessons were up to date with current didactic approaches and adapted to the local context and needs. Materials published by Conservation International (Quesada et al., 1999) and the New South Wales Office of Environment and Heritage (Papp & Thompson, 2003) were instrumental in informing the structure of the outdoor surveys and exercises. Whilst these are older resources, they contain field-tested practical exercise templates which were readily adapted to the local context.

Phase 2: Factors contributing to the modules' success

a) Integrating subjects, media and topics

Whilst Melkhoutfontein School was unable to adopt the modules, Vermaaklikheid School successfully implemented them in the first term of 2015. The lessons integrated different teaching media, including videos and slideshows downloaded to a USB memory stick by the researcher and shown to students on the principal's laptop. The use of these supplementary teaching materials enabled the learners to more readily understand concepts from different perspectives and foster their interest:

...we read about it then if I don't understand something, the video will show it differently. Then when we wrote a test on it, or did a poster I understood it... We don't do those things ever, so it's nice to see the things from the lessons in real life. (Gr. 9 learner LVZ)

Given the mix of grades taught simultaneously in Vermaaklikheid School Gr. 7-9 class, the use of different audio-visual media also helped the younger learners in the class to more easily grasp concepts and keep pace with their older classmates:

I like the videos...some things are difficult and then I see my (Gr. 9) friend is doing the work but I must ask teacher... The videos are nice because I can see things and then I can understand them. (Gr. 7 learner BVF)

Similarly, the sequenced model, addressing an overarching shared theme across subjects, rendered topics easier to understand:

It makes sense for me to see how the lesson we learnt in English about water temperatures – how that is also something that is important in Science and then using the numbers in Maths – that for me made it easier to see how it is actually all one thing. (Gr. 9 learner LVZ)

b) *The value of a situated approach*

The situated aspect of the modules, drawing from examples and research in the local environment, encouraged the learners to understand how classroom lessons were applicable to real-world challenges. An example of this was the integration of data from a marine citizen science water temperature measurement project in the region with mathematics lessons, prompting one learner to observe:

We also saw how Maths is helpful when you are working. I like the story of the fisherman taking the sea's temperature and then we are using the temperature to make graphs and those graphs can show you what is changing in the sea – I can see (where) the numbers come from and why it is helpful for the scientists. (Gr. 8 learner VVM)

In an isolated setting, the creation of these mental links to the outside world also represented an important step in encouraging learners to see themselves as embedded within a larger system.

c) *Relating lessons to context*

Outdoor exercises as part of the modules served to create tangible links between classroom lessons and real-world examples. Biodiversity surveys in the school surrounds, and pH measuring experiments linked with lessons on ocean acidification and related changes, for example, were intended to equip the students to better understand pressing local social-ecological issues. Where the schools had identified a lack of contextually relatable examples in the CAPS textbooks, feedback from learners in 2016 indicated that relating abstract concepts to concrete examples in their surroundings in this way rendered topics more readily understandable:

I liked the exercises outside...you can touch something and see it in your hand then it makes a lot of sense to me. With books, it's sometimes harder. (Gr. 8 learner SVF)

Similarly, another learner suggested that the engagement with their surroundings reinforced the lessons and made them more relevant:

When we could go out into the (playground) and do a (biological) survey...for me, to see how the lesson in the classroom is real in the nature right here outside, that was interesting...we learnt about the food webs and about the environment but if you can then afterwards go and really see it...it makes it easier to understand some things. (Gr. 9 learner LVZ)

In a 2016 interview, the principal suggested from the teacher's perspective that the use of tangible examples from students' daily lives enabled them to more readily engage with the subject matter:

(The modules have) made a huge difference to teaching things like graphs which the kids didn't like before. A lot of the little ones didn't get it, you know? ...using the exercises and the data from here...it's something they can relate to... (Principal ZVL)

Further, linking classroom lessons to observations of change in the local environment had the consequence of stimulating learners to consider their role in protecting their surroundings. As an example of this, one of the students discussed his class's plan to tackle a local pollution issue:

We have learnt that the sea is important for us and our community. I never thought about it before really – we just get the fish and eat it but thinking about how the river pollution can be bad for the fish and how we can eat that fish... That makes me think about how people must stop pollution in this river... We are going to do a clean-up of the river by the (public slipway) (Gr. 8 Learner MVL)

The decision to conduct the clean-up was motivated by the students alone, after observing the state of the slipway on the riverbank in their free time. This undertaking highlighted the value of the situated approach in motivating students to go beyond simply learning about a problem, relying on their newfound knowledge and skills to take action.

d) Outcomes beyond the school

Discussing the role of the school in local affairs in a 2013 interview, Vermaaklikheid School's principal suggested that classroom lessons often filtered through to the community via conversations between learners and their families and friends:

...you see, these children, they go home, and they talk with their siblings and the old people listen as well (laughing) we sometimes hear about what we've taught them months ago at a community meeting. (Principal ZVL)

Capitalizing on the school's role as a local information hub, the modules were thus structured to facilitate conversations and information sharing beyond the school. For example, homework exercises tasked students with interviewing parents and community members about fishing and marine changes.

In 2016, interviews with Vermaaklikheid's adult residents and parents suggested that their interactions with students had stimulated conversations around concepts such as marine and climate variability and change:

My daughter told me about the climate change – you hear it every so often on the (television) but I never knew what it really was ...I am a fisherman but in the past maybe 10 years...all the places we fished before are empty. The wind blows so strong now we can't get out the river mouth as much... It is interesting to think now how what my daughter is learning in class I am seeing when I am working. (Parent of two learners, MVH)

The feedback indicated that the process had been reciprocal, with learners both gathering and sharing information in their community:

I also liked speaking to my daddy about fishing...he caught lots of fish (in the sea) and my brother used to (catch) lots but now it's less. (Gr. 8 learner VVM)

Yes, I learnt a lot from speaking with my uncle about (fishing). He told me how it has changed a lot since when he was my age. (Gr. 8 learner SVF)

These interactions also had the effect of stimulating discussion between adult community members:

...the kids told me about it when they came to ask me about fishing...I told them it's totally different now...I was talking to (another parent) about it – he has a boat. It used to be an easy lifestyle – now it's (hard). (Parent of two learners in the Gr. 7-9 class, retired fisher ZVC)

In these interviews, adults indicated an interest in discussing topics such as climate and marine change further, in particular how they might mitigate against changing fishing and climatic conditions. With many supplementing their income or food through small-scale agriculture, as fishing had declined, interest in farming had grown.

(My nephew) came with his friends to me asking about the fishing. I told him it's been bad here for years now. We hardly go out anymore... We still only really know fishing... What must I farm? Is there a thing I must grow that will make a success or provide food for the people here? These things we want to know, but (the government) does not tell us. (Resident AVJ)

Follow-up interviews with Vermaaklikheid teachers in mid-2016 indicated that the modules had integrated with the CAPS without interrupting the syllabus or demanding additional time from students. In Vermaaklikheid, the long-term success of the modules was also evident in their continued usage in the school after the conclusion of the fieldwork, with only quarterly telephonic contact with the teachers necessary to sustain the process.

Discussion

In the context of Vermaaklikheid and Melkhoutfontein's low education and employment levels, and history of marginalization and mistrust of outsiders, there is merit in working with schools as trusted knowledge spaces in the community. As enabling, positive spaces, classrooms offer an affirming environment to support learners' adoption of particular behaviors (Bandura & Walters, 1977). Additionally, schools may act as catalysts for social learning by serving the role of trusted clearing houses of knowledge in their community, acting as 'bridging organisations' (Berkes, 2009) that lift learning from the level of the individual to that of the community. Learners approaching community members as part exercises in the modules, for example, did so with the backing of their school and its trusted reputation. It is this implicit trust in the school which may render community members more likely to listen to the learners and willing to learn as well as share their knowledge.

Taking a slow, engaged approach tailored to facilitate learning informed by local conditions and requirements is also key. To this end, it has been suggested that involving participants in the development process helps ensure a result that is relevant and readily adopted (Neale & Corkindale, 1998; Ozer, 2009, see also Jeppesen & Laursen, 2009). However, whilst this approach worked in Vermaaklikheid, the struggle of Melkhoutfontein School's to implement the modules in their syllabus highlights several challenges, including the fact that conditions in such vulnerable communities are often highly dynamic and apt to change unexpectedly. The constraints imposed by the Department of Basic Education on Melkhoutfontein School following its academic performance review at the start of the fieldwork was a key factor limiting the school's ability to implement the modules. In addition to limiting the teachers' ability to deviate from the CAPS or incorporate additional material into their syllabus, the constraints meant teachers were concerned about the experimental nature of the modules, and the time required to translate lessons from English into Afrikaans and integrate these into their syllabus. This scenario echoes Satchwell and Loepp's (2002) findings that when schools' academic performance is low or on the decline, teachers and administrators can be understandably wary of adopting a new or unknown approach to teaching. Additionally, the commitment of the Vermaaklikheid School staff to engage in the process versus their more experienced Melkhoutfontein colleagues may also be explained by the findings of Simms (2013) research on experimental curricula, which showed that experienced teachers are often less likely to adopt a new curriculum if it requires a testing phase or challenges the established curriculum structure.

The isolation of Vermaaklikheid offered both a need and opportunity to encourage the students to think at broader scales, and assume a role as active participants in a system undergoing change, a foundation upon which social learning might be built (Johnson, Dana, et al., 2012b). Where learner VVM, for example, spoke of changes in the ecosystem and the "fisherman taking the sea's temperature", or learner MVL described a sense of understanding the connection between the health of the river and that of fish caught in the sea, the students' feedback suggested an expanded worldview in which their thinking about the impacts of broader system changes beyond the village on their lives, and *vice versa*, had deepened.

Learner LVZ's suggestion that links between subjects rendered the graphing of water temperatures more understandable, for example, or learner BVF's feedback regarding videos and posters reinforcing readings reiterated the value of relating subjects to one another (Satchwell & Loepp, 2002). Vermaaklikheid learners' responses to being taught with support from a range of media also speaks to the value of the integrated approach in allowing teachers to build a more comprehensive picture of a topic through the use of supporting media (Hennessy et al., 2007; Stanciu, 2016). Whilst overlap between the classroom and the outdoors is established didactic practice in many schools internationally and also in some affluent South African schools, Vermaaklikheid learners had not previously been exposed to such methods. By encouraging them to engage with their surroundings in conducting practical exercises and addressing real-world challenges (Johnson, Duffin et al., 2012a), the natural world became a source of example and fascination, an extension of the classroom. Making the connection between classroom and practical, outdoor experiments in this way was unprecedented in Vermaaklikheid School. The process of engaging practically with problems relating to the subject matter enabled learners to develop their own knowledge of a subject by reflecting on the issue, conceptualizing a solution and using experimentation and their experiences to address it (cf. Armitage et al., 2008). As suggested by learner SVE, linking

classroom lessons to tangible examples in the local environment and experience also served to render the lessons more accessible (Hilburn & Maguth, 2011; Krasny et al., 2009), enabling students to understand connections between classroom learning and real world phenomena.

The process of interactive learning emphasized in the modules focused on local issues and means of addressing these and is characteristic of both situated and social learning (Budwig, 2015; Hilburn & Maguth, 2011). Situated learning also requires an integration across subjects (Hilburn & Maguth, 2011), a step achieved through the use of Fogarty's (1991) integrated curriculum design, with the modules structured such that topics were taught across subjects. Further, it requires interaction between students and their local community and environment (Hilburn & Maguth, 2011), evidenced in the feedback interviews with learners, parents and community members. Going beyond rote learning, connecting classroom lessons with hands-on, outdoor exercises encouraged students to adapt their knowledge (Budwig, 2015). These exercises also served to reinforce lessons with tangible examples as described by learner SVF, deepening the learning process. By engaging in practical learning and interaction with their surroundings in this way, students' worldview and capacity to act are developed and expanded, laying the foundation for more pro-environmental behavior (Budwig, 2015; Johnson, Duffin et al., 2012a; Johnson, Dana, et al., 2012b). This in turn may result in improved community-level adaptive capacity as learning and changes in adaptive behavior at the level of the individual spread through interactions to become embedded in the larger local community (Reed et al., 2010). Class discussions following the conclusion of the food web and ecosystem modules encouraged students to ask what they could do to better their environment. Their surroundings thus became sources of learning, echoing Hilburn and Maguth (2011: 28) assertions that learning should be place-based, in that it emphasizes "the use of local resources, people, and environments to engage students in learning about and bettering their community". It is this transition from rote learning toward adaptive expertise that can result in behavioral changes and action (Budwig, 2015; Johnson, Duffin et al., 2012a) and encourage participants to consider their place and influence in the broader system (Hilburn & Maguth, 2011). True situated learning then, is not simply education about the environment, but for it, manifesting as changes in thinking and action (Krasny et al., 2009). Perhaps the strongest indication of this shift in attitude and behavior toward active stewardship was the learners' decision to undertake a clean-up of the public slipway described by learner MVL.

Social interactions in the surrounding social environment were of equal importance. In Vermaaklikheid, the results of the fieldwork indicated that the modules played a role in opening conversations within the broader community and sharing knowledge on marine and climate-related challenges, with adult respondents voicing an interest in discussing topics related to climate and marine change in greater depth in the future.

Moreover, the exchange of information facilitated through the modules was reciprocal, with students not only spreading information but also learning from family members. This level of interaction between children and relatives or influential community members is a vital step in the social learning process, whereby children take on behavior and understanding influenced by figures of significance in their lives (Fisher & Skowron, 2017). For example, when learners VVM and SVF suggested enjoying learning about fishing and the observed changes from their father and uncle respectively, this suggested both a transfer of knowledge and a reinforcement of classroom lessons. By engaging with mature practitioners (fisher family members) on a daily basis, learners are already engaged in peripheral participation (Lave & Wenger, 1991), a hallmark of situated learning. Learners HVF and VVM, for example noted a newfound interest in family members' experiences of fishing, whilst in turn, parent MVH acknowledged that his experience resonated with his daughter's explanations of climate change. The focused nature of the conversations facilitated by the modules deepened such interactions. The follow-up interviews with students and adult residents also suggested that both groups had shared knowledge and perceptions through the interactive homework exercises. These interactions are important catalysts of future community learning (Hilburn & Maguth, 2011; Johnson, Dana, et al. (2012b). Community members' desire to know what plants to farm in addressing a changing climate, for example, suggests the possibility for future conversations and broader pro-sustainability learning and adaptations in Vermaaklikheid. In turn, these interactions highlighted the role of the school as a trusted source of knowledge in the community, and a potential means by which to lay the foundation for intentional learning in pursuit of enhanced community adaptive capacity. With this said, this role brings considerable responsibility to the schools in ensuring that any

information they provide continues to be grounded in sound research and data. Here the continued role of the researcher is key not only in motivating the continuation of the process, but also in ensuring the veracity of information spread through the school.

Conclusion

We have described the process, outcomes and challenges experienced in the development and implementation of a set of integrated teaching modules for Gr. 7-9 students. Within a context where marine and climate change have profound and increasing impacts on community wellbeing, the intention of the work was to stimulate knowledge and information sharing beyond the school boundaries, in support of future community social learning and adaptive capacity. This was complicated by a history of marginalization, vulnerability and mistrust that created a situation where adults were resistant to conventional community learning exercises. In Vermaaklikheid, the results highlighted the role that schools can play as trusted spaces to further conversations in the broader community. Particularly where conventional options for learning are limited, situated education in schools may serve to facilitate conversations around social-ecological challenges beyond the school boundaries. The results suggest that an integrative, situated approach to education can augment a discrete, rote learning-based curriculum such as the CAPS with practical lessons embedded in the local social-ecological environment, improving access to knowledge and moving beyond typical 'top-down' approaches to community environmental education. Further, the place-based, problem-centric approach to teaching, using the local social-ecological system and broader community as points of stimulus, interaction, and intrigue can provide learners with new understanding and behavior, as well as reinforcement by others, encouraging them to think and enact new behaviors, as in the case of the students' river clean-up.

The (partial) success of this initiative depended on proceeding slowly and carefully with open dialogue and genuine respect for and attention to local circumstances and needs. Circumstances on the ground may be used to good effect in structuring lessons that are meaningful and make a difference in students' lives, for example by incorporating changing marine water temperatures and fishing-related changes into the modules as a means of opening a conversation around the increasing challenges facing the local fishery. Further, the role of the researcher as both facilitator and mediator in driving the process forward is key, as are teachers in sustaining the process in the long-term. However, even with buy-in from teachers and students, top-down challenges such as time constraints and pressure to conform to a strict syllabus are still potential stumbling blocks, as evidenced in Melkhoutfontein School.

In a context of rural poverty, where options for learning are limited, and reliance on and vulnerability to changing marine and climate systems is high, it is imperative that communities understand and be equipped to deal with changing social-ecological conditions in the face of limited resources. In situations characterized by mistrust, where adults can be resistant to conventional approaches to community education, we suggest that there is value of working with schools as centers of knowledge dissemination. With proper oversight and contents planning, lessons and practical exercises may serve as building blocks of intentional learning to bolster adaptive capacity amongst both learners and the broader community. To this end, a situated and integrated teaching approach offers a means of enhancing the existing curriculum whilst fostering adaptive capacity amongst the individuals who will form the next generation of adult stakeholders and community leaders.

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