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Creating sustainable physical sciences learning environments: A case for decolonised and transformative learning

Abstract

There is an urgent need for transformation and decolonisation of teaching and learning of physical sciences. This need is evidenced by, among other factors, the alarming rate at which learner enrolment in physical sciences and science education, in general, is decreasing. Central to these causes is apparent, persistent below-expectation learner performance in science education, which, in turn, causes scepticism about the quality of teaching and learning, and questions about the quality of support given to teachers to sustain the required level of learner performance. Thus, decolonisation and transformation of teaching and learning should persistently pursue meaningful and functional knowledge creation. To this end, service-learning projects for teaching and learning physical sciences hold promise. The main reason for this consideration resides in the empowering capacity and resultant decolonising and transformative nature of the created knowledge. Thus, using service-learning projects to create knowledge that is meaningful and functional is equivalent to creating sustainable physical sciences learning environments. Bricolage's principles of multiple perspectives and multiple theories served as a useful lens for scrutinising the diverse knowledge of the participants. Van Dijk's socio-cognitive critical discourse analysis was pivotal for analysing, interpreting and making sense of participants' prevalent knowledge and experiences. The principles of participatory action research and free attitude interviews were applied as an approach and technique for data generation. The major finding suggests that using service learning projects to create sustainable (physical sciences) learning environments, contributes substantially to decolonising and transforming teaching and learning.

Keywords: *Decolonisation, transformation, empowerment, sustainable education, sustainable physical sciences learning environments, meaningful learning, functional learning, critical cross-field outcomes, service-learning projects*

1. Introduction

The idea that education, and therefore teaching and learning, are contextual, enjoys global acceptance. However, some cultures dominate teaching and learning discourses, to the extent that other cultures are subjugated and excluded (Cortese, 1999; Hall & Tandon, 2016; Le Grange, 2008). It is this subjugation and exclusion of some cultures

from teaching and learning discourses that underscore the need for decolonisation and transformation. Power differential realities in respect of dominance and subjugation of cultures exacerbate tensions about epistemology and ontology of knowledge processes unnecessarily. Le Grange (2008) states it aptly, namely, that ontological and epistemological frameworks underpinning the knowledge creation process are still unchanged. This paper presents an attempt to contribute to changing the still unchanged epistemological and ontological frameworks underpinning the knowledge process of physical sciences.

In pursuit of the envisioned change, teaching and learning of physical sciences are given considerable attention. In this regard, Higgs (2007) warns that, by failing to be direct about teaching for self-reliance and emancipatory purposes, we subtly perpetuate continued subjugation of ontological and epistemological considerations grounded in communal principles. Subsequently, the question that arises is, to what extent is the teaching and learning of physical sciences grounded on communal principles? Inclusivity/inclusion is a communal principle of note in this study. Cortese (1999:2) highlights an important consideration for inclusivity by indicating that, "the environment is not a competing interest; it is the playing field on which interests intersect". Similarly, this paper argues for consideration of physical sciences learning environments as an intersubjective space, where diverse and multiple perspectives, theories and interests intersect/synergise to sustain quality teaching and learning.

However, in the case of the Republic of South Africa, physical sciences aims to "prepare learners for future learning, specialist learning, employment, citizenship, holistic development, socio-economic development and environmental management" (DBE, 2011a:6). This aim is problematic, especially considering the concerns raised by Cortese (1999:2) regarding the estimated "2 billion jobs needed" to address unemployment in the world over the next 20 to 30 years. Cortese's problem, which is worthy of earnest consideration, is that, "our response to this situation has been irresponsible and dangerously inadequate" (1999:2). This irresponsible and inadequate response was confirmed later, in part, by a study that found that physical sciences teaching and learning practices were overly teacher-centred and examination-oriented. These approaches contributed significantly to teachers choosing and using teaching strategies that focused on learners' academic achievement, and in the process, abstracted the learning of physical science (Tlali, 2013). How, then, do we prepare learners to face an uncertain future in relation to employment, considering that there may be no jobs available? How do we teach and learn physical sciences for socio-economic development and environmental management for sustainability?

Teaching and learning physical sciences for socio-economic development and environmental management for sustainability have the potential to simultaneously transform and decolonise education. Transformation and decolonisation of teaching and learning could be subtly derailed by the prevalence of, among other trends, domination and exclusion of learners' cultures from learning environments; divorcing teaching and learning from socio-economic development and environmental management; thus, rendering learning meaningless and less empowering; and focusing on competing interests, instead of on interests that are complementary and mutually synergising. Mahlomaholo and Netshandama (2012:37) articulate the state of transformation of education in South Africa by stating that the "shadows of the horrific racist apartheid past which are still lingering in practice" frustrate transformation. This paper attempts to provide prospects for dealing with this frustration of transformation of teaching and learning of physical sciences through the creation of sustainable physical sciences learning environments.

Thus, the paper also argues for the strengthening of school-community coordination through service-learning projects in order to create empowering (Biesta, 2010) and meaningful learning spaces that have the capacity to facilitate the generation of functional/relevant knowledge. In pursuit of empowering knowledge, this paper asks and responds to the following question: How can the physical sciences epistemological framework(s) underpinning knowledge processes be transformed to create empowering, meaningful and functional knowledge? The aim is to demonstrate how service-learning projects (Hatcher & Erasmus, 2008; Kiely, 2005) underpinned by communal principles (Cortese, 1999; Higgs, 2007) offer prospects for transforming the epistemological framework for the creation of empowering and meaningful knowledge. In this sense, the aim is to facilitate the creation of sustainable physical sciences learning environments in order to contribute to the decolonisation of teaching and transformation of the learning of physical sciences.

2. The lens

The question asked by this article is evidently complex. It warrants critical interrogation of inherent realities based on multiple perspectives and multiple theories (Steinberg & Kincheloe, 2010; Kincheloe & Berry, 2004) of participants from diverse backgrounds. The complexity of reality, in this instance, emanates from the mutual inclusivity of and interdependence between transformation and decolonisation of teaching and learning, with their inherent, inescapable power differential realities.

Furthermore, there is a need to comprehend pertinent physical sciences pedagogical content knowledge (Toplis, 2015), and to deconstruct learners and teachers' various and alternative conceptions of scientific concepts, principles and laws, with a view to construct "new" knowledge that is contextually acceptable (Foster, 2011). In addition, the opportunities and challenges relating to the sustainability (Spencer, McClelland & Spencer, 1994) of the knowledge created are worth insistent consideration.

The focus of this article is not to reduce the participants' diverse experiences and knowledge about decolonising and transforming learning to any one perspective, or to numerals, in order to universalise "newly" learnt knowledge beyond its contextual bounds and scope (Kiely, 2005). Instead, the emphasis is on the meaningfulness and functionality of the knowledge created. Thus, by interrogating this "reality" through the lens of bricolage, this consideration of participants' multiple perspectives relies on the creation of intersubjective communicative actions (Kemmis, 2008; Van Dijk, 1995; Wicks & Reason, 2009), where the most logical and convincing evidence-based argument prevails. In this sense, considerate use of service-learning projects for creating sustainable physical sciences learning environments becomes plausible.

Bricolage enables and is consistent with the creation of the intersubjective communicative actions that this argument relies upon. To this end, Foster's averment about bricolage is instructive. Foster claims that bricolage is a "technical metaphor for a cognitive and creative process: the composition and generation of mythical discourse" (Foster, 2011:358). The mythical discourse Foster (2011:359) clarifies through its "characteristic feature of mythical thought", which,

> *on the practical plan, is that it builds up structured sets, not directly with other structured sets, but by using the remains and debris of events … or odds and ends…, fossilized evidence of the history of an individual or a society.*

In this paper, the debris of events and possibilities are constrained and thus contextualised by the "means of production" (Foster, 2011:363) of water-services-related challenges that often baffle schools and communities. Responses to this challenge should not be limited to the academic needs of learners, but need to be simultaneously inclusive of the provision of responsive services to the community. Responses, in the form of project-based teaching that serves to address learners' academic needs, and community needs, are construed as "fossilized evidence" (Foster, 2011:363) of shifts and changes in the ontological and epistemological underpinnings referred to earlier.

Berry's (2004:103) views about the structure of bricolage, that it "works inwardly, playfully, complexly and rigorously", supports its relevance to this study. Furthermore, Berry (2004:103) remarks that bricoleurs are often overwhelmed, "by the plethora of issues and lack of explicit directions, linear steps or structure", because bricoleurs have "to engage the bricolage without falling back on positivistic, empirical, monological structures or depending on well-known research discourses and methodologies". The significance of this consideration resides in the importance of understanding reality, if possible, in its complexity. It negates the reductionist and monological approaches and methodologies that tend to coerce knowledge creation in ways that are amenable to manipulation and application out of context. To this end, this paper considers Bricolage as having the ability to guide the adopted participatory action research and free attitude interview principles as the approach and technique respectively for generating data, as well as Van Dijk's socio-cognitive critical discourse analysis.

3. Service-learning project potential

Using service-learning projects for teaching and learning has significant potential to contribute to achieving the general aims of the South African curriculum, as espoused in the CAPS documents (DBE, 2011a). In the case of physical sciences, a teaching and learning approach based on service-learning projects can be impactful in relation to preparing learners for "socio-economic development and environmental management", while engendering the notion that problem-solving contexts are inclusive and should not be treated in isolation (DBE, 2011b:8). Thus, service learning affords the opportunity for equitable and simultaneous achievement (Kincheloe, 2008) of multiple socio-economic and academic aims and objectives.

Importantly, teaching and learning based on service-learning projects enable learners and teachers to access diverse modes of knowledge creation that are relevant and functional in diverse contexts. It makes inclusivity possible and enables contributions that focus academic discourses on what matters most, as opposed to contestations against and for supremacy of one culture, namely, the Western culture, over indigenous knowledge systems. The reflective and comprehensively inclusive parameters of service-learning projects are useful and compelling for responding to the academic and socio-economic needs of learners, and society in general. These parameters include conceptualisation of the project, determination and articulation of project outcomes, development of project plans, implementation and regular appraisals and reviews of the various levels or stages of the project performance (Meredith & Mantel, 2006). Using projects for teaching and learning is not unique to this study.

4. Service-learning projects in context

There is sufficient evidence in the literature that attests to the multiple purposes and benefits of using projects for teaching and learning. For instance, the Australian project, To Hold Our

Earth Firmly, shows how access to and inclusion of indigenous knowledge can be achieved (Hickling-Hudson, 2006). Evidence of the feasibility of accommodating diversity and giving a voice to otherwise subjugated persons for purposes of mutual comprehension of development across diverse knowledge backgrounds is provided by the Tanzanian Jipemoyo (*Take Heart*) project (Swantz, 2008). It is also provided by the basic extension skills training (BEST) project in Botswana (Gboku & Modise, 2008) and South Africa's Community Higher Education-Service Partnership (CHESP) project (Hatcher & Erasmus, 2008; Thomson *et al.,* 2010). These projects enable us to learn about community-school coordination through project-based learning.

Parker *et al.* (2009) explain how community service learning is used for teaching and learning purposes in Australia. In the case of South Africa, community service in high schools is reportedly taking place without a clear framework or model in the curriculum (Hatcher & Erasmus, 2008; Perold *et al.*, n.d.). CHESP represents one of the many community-higher education service-learning models that exist in South Africa and from which we can learn. Thus, in the absence of a model for schools in South Africa, this study presents a service-learning project called Plug-a-leak, which serves to contribute to closing this gap. This type of project serves to augment the limited resources that are available for teaching and learning; it also seeks to engender a sense of social responsibility through the academic learning process.

The service-learning project uses progressive learning theories that are inclusive and subjective and that recognise the role of experience and reflection (Kottkamp, 1990) in knowledge creation; are considerate of the role of culture, politics and other influences on people's experiences of knowledge creation and development of their abilities and they recognise the importance of content (Toplis, 2015). In this sense, the creation of sustainable physical sciences learning environments through service-learning projects aims to attain critical cross-field outcomes and the general aims of the curriculum envisioned for South Africa (DoE, 2003; DBE, 2011a, DBE, 2011b).

5. Method

The Plug-a-leak service-learning project was designed to be executed by participants from diverse backgrounds who were interested in, able to and felt obliged to contribute their experiences, resources and knowledge to responding to the research question. The participants gave their consent to participate in the project after the disclosure and discussion of ethical clearance given by the ethics committee of the university involved. For instance, issues of the anonymity of participants and using information and data generated strictly to respond to the research question were pivotal.

A coordinating team that facilitated the execution of this project was established. It comprised 14 learners, who coordinated 14 learner study teams, three teachers of physical sciences, mathematics and English first additional language, the municipality's environmental health practitioner and water services manager, the school governing body chairperson, a retired school principal and teacher of mathematics, a retired university lecturer and a school management governance and development (SMGD) official.

The study adapted and used the principles of participatory action research (Kemmis, 2008) as an approach in respect of the following: to conduct a situation analysis; to compile the service-learning project plan; to implement the plan; to reflect and iteratively appraise the project and to adjust the plan accordingly. These actions took place simultaneously. For instance, the planning

phase reflected on the implementation of other projects and was based on the experiences and knowledge of the participants. Similarly, the implementation phase has elements of reflection and planning. Using the principles of the free attitude interview (Meulenberg-Buskens, 1997) as technique, the team used broad questions to initiate discussions and participation by the participants on a range of issues. Central to the discussions were issues that were consistent with socio-economic development, environmental management (DBE, 2011b), transformation and decolonisation of teaching and learning (Hoggan, 2016; Mezirow & Associates, 2000). The purpose was to determine epistemological considerations underpinned by principles of inclusivity and sustainability in order to empower learners. In the same vein, the principles of Van Dijk's socio-cognitive critical discourse analysis (Van Dijk, 1995) were used to analyse, interpret and make sense of the issues that emerged.

The method explained above is arguably akin to the qualitative case study method as explained by Baxter and Jack (2008).

5.1 Tools and processes

The coordinating team meetings were essentially intersubjective spaces for generating data through processes of reflection and self-reflection (Steinberg & Kincheloe, 2010). These meetings considered and rigorously discussed inputs from the participants as per the project baseline and revised plans and tracked progress. Through these engagements, the coordinating team facilitated the development of other instruments and ratified them through relevant processes before using them. For instance, a senior physical science teacher and the head of the department of science education at the school subjected learners' worksheets on pertinent physical sciences content to be learnt from the Plug-a-leak service-learning project to participants' consideration for comments and input, "moderation" and assessment.

The 70 Grade 10 learner participants worked in study teams comprising not more than five members each. Each study team appointed a coordinator from among the learners to facilitate the coordination of team learning activities with the support of a parent and a teacher. Vygotsky's (1978) notion of the zone of proximal development was instructive in this regard. The roles and responsibilities of the learner study teams were developed in conjunction with the learners with a view of instilling a sense of ownership and respect of the ownership.

6. Data analysis and findings

I organised the data according to the parameters of the service-learning project and, in the analysis of data, prioritised and integrated aspects of transformation, decolonisation, environmental management and socio-economic development. The following constructs are preferred: service-learning project identification, conceptualisation of service-learning project, service-learning project implementation and reflection.

6.1 Service-learning project identification

Service learning projects offer opportunities to learn while serving and to serve while learning (Kiely, 2005). In this sense, service-learning projects become spaces where social development, environmental management, transformation and decolonisation co-exist. Thus, service-learning project spaces deal with these realities complexly, rigorously and simultaneously (Kincheloe & Berry, 2004) as they (service-learning project spaces) relate to creating sustainable (physical science) learning environments. Sustainable physical sciences learning environments are adept at creating knowledge that is meaningful and functional

(Hickling-Hudson, 2006). Such knowledge is empowering (Biesta, 2010) and extends beyond the boundaries of formal school and laboratory. The sustainability of these environments is derived from mutual respect among the participants, who feel obliged to contribute to transformation. In this sense, sustainable physical sciences learning environments are inclusive and instil a sense of social responsibility, in view of the aim of physical science as propounded in the CAPS document (DBE, 2011b).

The coordinating team's situation analysis engagements, which identified pertinent service-learning projects for this study, established that the learning of science deviated from the best practices outlined above and related to the creation of sustainable empowering (physical science) learning environments (Mahlomaholo, 2010). This was evident from the following summaries of reasons given for the passive attitude of the majority of learners (68 of the 70 learners) regarding challenges related to water services (drinking water and sewerage):

> *Water-related challenges, such as leaking taps and burst water and sewerage systems, are the sole responsibility of the municipality. I have nothing to do with them.*

The sentiment expressed above was corroborated by the following statement, given by all 70 learners concerned in response to a question that sought to establish whether the learners knew what to do when confronted by such encounters:

> *I do not know what to do when I encounter a leaking tap, burst water or sewerage pipe. Even if I know I do not involve myself. No one will pay for my involvement.*

The two learners who offered a different response to the first question, expressed concerns about wastage of water, which, they said, they would report to municipal officers, especially if the problem occurred close to their homes. The data suggests that learners had a carefree attitude to challenges relating to water services. The expressions, "sole responsibility of the municipality" and "I have nothing to do with them", suggest that the learners considered municipal water services to be the municipality's responsibility and not theirs. Furthermore, they did not consider themselves as having the capacity to respond to such challenges and they were not really interested. The absurdity of this attitude is that they are direct beneficiaries of the service, at school and at their respective homes.

The lack of knowledge that the learners referred to in the second excerpt is arguably broad and leads to a variety of conclusions among the different members of the coordinating team. The environmental health practitioner's perspective was that pollution of the environment through sewer spillages had the potential to destabilise the ecosystem (Lyle, 1994) and affect life and living negatively. The school governing body chairperson and a human rights lawyer provided a legal perspective, namely, that water pollution amounted to a socially unjust act and, as such, is punishable by law upheld by the public. The SMGD official supported this view, stating that the socially unjust act pointed to a possible shortcoming in teaching and learning because it defeated the purpose of natural and physical sciences (DBE, 2011a). The mathematics teacher presented an economic perspective, using financial mathematical considerations to state that it made no economic sense for the public to pay for installation of water services systems and provision of water, only for them to uncaringly waste it and cause health hazards. From a technical services point of view, the maintenance of water and sewerage systems is costly and demanding. In some instances, special devices have to be designed and made to remove foreign objects from the sewerage system.

For the coordinating team members, the learners' passivity and lack of knowledge regarding what appeared to be a glaring social problem, was cause for concern. The team viewed the learners' act of doing nothing in this context as subtly supporting acts that were potentially wasteful of public resources (e.g. funds used to purified water), destructive to natural resources (e.g. scarce water resources and the ecosystem by sewage) and hazardous to human health (e.g. sewerage blockages where people live). It was as if learners did not care who was on the losing side. Furthermore, these considerations suggest that issues of environmental management and socio-economic development might have been taken for granted during the teaching and learning processes.

6.2 Conceptualising the service-learning project

The conceptual stage of a service-learning project seeks to clarify the aim and scope of the project. It delineates the specifications and parameters within which the project is to operate, while being considerate of the risks and threats that might jeopardise the successful realisation of the project outcomes (Meredith & Mantel, 2006). In this study, the envisioned service-learning project was claimed to have the capacity to transform and decolonise the teaching and learning of physical sciences by creating sustainable, empowering learning environments. Thus, the creation of empowering knowledge, that is, useful knowledge that eases learners' interaction with the world of work where actual life- and living-enhancing changes are sought, is paramount. In this case, matters relating to environmental management and socio-economic development were imperative.

During situation analysis sessions, the participants brainstormed possible projects that could respond adequately to the expectations set out earlier. The project had to meet numerous objectives that spanned academic learning outcomes and provision of service, while simultaneously responding to issues of inclusivity, creation of knowledge that learners could use beyond the confines of formal schooling and that addresses environmental management and socio-economic issues. The diverse objectives were, understandably, overwhelming to participants (Berry, 2004). During these engagements, the project, which was ultimately dubbed the *Plug-a-leak* service-learning project, enjoyed majority support, based on subsequent collective explications of the extent to which it met the scope that had been set out:

> *Let us go out in the community to identify water leakages from which we can collect information that can be used to convince the property owners in line with the identified and agreed scope, why it was necessary for them to be sensitive to water losses and wastages.*

"Going out in the community," meant that learner participants were also expected to leave the traditional classroom. The possibilities of not learning other subjects were imminent. It also posed a number of other risks, which included safety, being time consuming, exposure to delinquencies and rejection by the Department of Education, community members and parents. The project seemed to be an awareness campaign that lacked a practical skills component that could relate to socio-economic development. In the same vein, it appeared to fall short of physical sciences academic learning-related aspects. It was because of the apparent negative aspects that the participants considered refining the articulation of the project.

It became apparent that it was not going to be cost effective to limit the scope to identification of leaks, but that plugging the leaks, where possible, had to be included. This shifted the

thinking of participants to positive and critical thinking mode, and they identified mechanisms that responded adequately to the identified limitations of the project. To this end, the following agreements in respect of the role of participants in addressing the challenges were instructive:

> *Let us request people from amongst us [participants] to help address the problems we experience… We must be smart and base our requests on criteria which are in line with the person's interest, availability, potential and that is aligned to his or her work engagements… We should consider requesting help from public and private businesses in cases where we encounter a problem that is beyond our capacity.*

The sentiments expressed seemed to be based on values of humility and mutual respect for the people. This conclusion was inferred from the use of concepts such as "help" and "smart", which described the character of the requests to be made. The requests were to be simple and understandable, clear, measurable, achievable, realistic and time-bound. These request traits were mindful of the duration of the project. In addition, the data suggest that, even during the conceptual stage, the process of reflection is imperative. This suggestion emanates from the consideration that the mitigating strategies were fundamentally reflections on how to address the challenges identified. It can also be seen as an analytic process. The suggestion to request businesses to assist, suggests that service-learning projects should be as inclusive as possible. It is also evident that such inclusion would be intentional and beneficial to the project.

The above analysis points to the emergence of problem-solving and decision-making practices. A conceptualisation process conducted in this fashion has the potential to teach learners to think beyond their means of production (Berry, 2004), failure of which tends to limit their scope of operation. The source of the rich contribution of ideas was the multiple experiences and perspectives of the participants – issues relating to risk identification, assessment and mitigation originated from participants who have management skills, such as the SMDG official, school governing body chairperson and human rights lawyer as well as the environmental health practitioner.

7. Implementation of the service-learning project

Implementing the service-learning project affords the opportunity to determine the extent to which the project has been conceptualised. It creates spaces for practical alignment of theory and practice, academic learning and provision of social service. In the latter instance, the services provided and the academic learning content learnt serve as a springboard for each other.

The Plug-a-leak service-learning project worksheet covered a number of physical sciences concepts and principles that pertained to the services provided. I focus on the leakage of a toilet cistern at one learner's home. Asked how she identified the position of the water leak, she explained that they had searched for the leak for the past 12 months. A plumber had also failed, as their diagnosis of a leak was not accurate. He (the plumber) replaced the washers, which were worn out. The learner, Ntswaki, said that we (Ntswaki and family),

> *collected leaking water behind and below the cistern using a one litre container that became full in four hours… This was inconveniencing, because every four hours someone was to be there to empty the container…. we poured out the water down the drainage system.*

The data suggest that the learner and her parents could not plug the leak that caused them the inconvenience of having to keep a close guard and to empty the container every four hours, only to throw away (waste) 1 000ml of clean water every time. Furthermore, interrupting one's work to "empty the container" was unproductive and uneconomical, hence, "inconveniencing". Doing this six times per day suggests that water to the value of R10.20 was being wasted per day (at a cost of R1.70/litre).

The worksheet asked learners to use the flow rate of water in kilograms per hour and in grams per minute to express the relationship between the volume of water lost and the time it would take to lose this amount of money. They then had to plot it graphically and interpret the graph, indicating how the sustained loss of water would affect their household water bill. The graph seemed to have provided the learners with a good picture of the seriousness of the problem. This was evidenced by the urgency with which the affected learner invited her colleague(s) to help her locate the leak and to plug it immediately.

The exercise demonstrates the application of mathematical skills to solve scientific problems in real-life situations. The advantage of doing so was that practical measurements of volumes and mass of water could be determined to verify the mathematically calculated masses and volumes. Thus, progression of the learning of science, from concrete determination and application of concepts, to abstract levels, was demonstrable.

One learner, Thabiso, suggested that, "*water in the cistern needs to be coloured in red or any visible colour*", so that they could see the flow of leaking water. The location of the leak was subsequently identified successfully. Ntswaki was also involved and taught how to fix a minor leak. It was apparent that unless the exact location of the leak was known, the problem could not to be solved. Thabiso was asked to explain how he came up with the idea to colour the water. His answer was traceable to the learners' experiences and knowledge, which all other learners possessed too, though they had considered it as irrelevant, because it (knowledge) emanated from different contexts.

Learning through a service-learning project enables learning outcomes to have depth, breadth and relative stability (Hoggan, 2016). For instance, including learning activities pitched at different cognitive levels ensures depth, while integrating accounting, economics, mathematics, science and technology, ensures breadth. The application of the same principles across different cognitive levels, and providing opportunities for proposing practical solutions from real-life situations have the capacity to optimise the chances that the outcomes learnt will be relatively stable and, therefore, sustainable.

8. Reflection

Reflection and self-reflection serve to unearth knowledge that is empowering and meaningful (Hatcher & Bringle, 1999). Reflection takes place during each stage of a service-learning project. Reflection focuses on enhancing project management parameters and specified project outcomes and serves to unearth the participants' learning points and experiences.

The following sentiments were expressed during the reflection session that followed the implementation of the Plug-a-leak project. The participants shared their newly acquired experiences, identifying the high and low points of the project, and suggested means of improving instances that were not as pleasing as expected. Sello shared his excitement with the rest of the team:

> *Sir, I worked with… where we fixed a leaking tap. It was so simple! The washer was worn out. I simply replaced it with the help of…. It costed R10.20 per day and the washer was far less than R10.00.*

Ntswaki, who was exposed to a similar experience when she was involved in the replacement of the pressure ball of a cistern, remarked with excitement:

> *I feel like I would be doing injustice to myself and the community if I cannot do anything to help reduce the water losses in our area. Maybe we should join hands, Sello, to form a joint venture [laughing] and specialise in these trades.*

Even Sebotsa, who did not participate in the training in minor repairs, was enthused by the amount of money she could earn as a professional plumber. She said,

> *I can only imagine the amount of money spent wastefully and fruitlessly due to unaccounted water losses. I think this affords one an opportunity to explore plumbing profession and make money.*

According to the data, at least two learners had undergone training in minor plumbing repairs. Data suggest that Sello and Ntswaki were actively involved in the actual use of relevant plumbing tools while doing the minor repairs. The data further suggest that their experience of handling minor repairs aroused their interest in the possibility of learning a trade. Evidence of this interest is the suggestion to establish a "joint venture" and Sebotsa's desire to explore plumbing as a profession. These business interests are significant for the environmental management and socio-economic development perspectives of these learners.

As anticipated, the act of doing actual plumbing repairs is indicative of a shift in thinking that may be related to a shift in pertinent epistemological and ontological underpinnings. This observation is made against the background of popular perception that white-collar jobs are more desirable, which seems to be challenged by these learners' preference for a joint venture in plumbing as a means of production worthy of pursuit. The influence of multiple perspectives emanating from technology, science, accounting and economics cannot be overemphasised. Similarly, the significance of reflection and self-reflection in interrogating data in an attempt to unearth the realities associated therewith should not be taken for granted. In essence, this consideration of participants' multiple perspectives justifies the need for reflection on all processes and stages of the knowledge process.

9. Findings

The study found participants' diverse perspectives and experiences helpful for guiding all facets of the service-learning project, from dissonance to the decision to pursue service learning, service-learning project identification, conceptualisation, implementation and reflection. This process required consideration of participants' diverse perspectives to integrate learning of physical sciences and other school subjects with aspects of socio-economic development and environmental management.

The study also found that it was imperative to involve all participants from the conceptual stage, during which critical decisions are made about a service-learning project. In this instance, the decision was based on, among other matters, the need to interrupt the apparently "carefree" attitudes about and a lack of responsibility for municipal water services. In the same vein, the conceptualisation of the service-learning project was found to have contributed to

teaching and learning how to develop an implementable, well thought-out plan in collaboration with others.

The implementation of the Plug-a-leak project eased access to and use of different media for and approaches to teaching and was found to have the capacity to instil an interest in learning. It was also found that teaching through service-learning projects does not end up as teaching and learning for its own sake, but that it responds to real-life problem(s) while exposing learners and teachers to new experiences.

Reflection, which takes place at every stage of the project, was found to have the capacity to maximise learning and teaching potential. Insistent use of project parameters provides opportunities and facilitates the evolution of the breadth, depth and relative stability of learning outcomes (Hoggan, 2016), which, in turn, can transform and decolonise teaching and learning. The use of service learning projects in this manner has the potential of being sustainable in that it does not depend on one person. Sensitivity to possible negative effects of threats and risks is, however, advisable.

10. Conclusion

Service-learning projects should be geared to creating sustainable (physical sciences) learning environments that are inclusive and respectful of diversity and have the capacity to change the epistemological and ontological frameworks that underpin the knowledge creation process. Bricolage has the potential to guide the use of such service-learning projects, such that meaningful, useful and empowering knowledge is extracted from the multiple perspectives of the participants.

11. Recommendations

The study recommends that

- considerable attention should be given using service-learning projects for teaching and learning of physical sciences;
- a clearly defined service-learning framework should be developed for schools and time allocated for implementation;
- service-learning projects are used in conjunction with current continuous assessment activities and are documented for possible inclusion and use to inform the framework for schools; and
- the underpinnings of service-learning projects are geared to transformation and decolonisation of teaching and learning by focusing on the creation of sustainable physical sciences learning environments.

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