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Perceptions, outcomes and attitudes experienced by scholars on stream bio-monitoring through the implementation of the mini-SASS method, using a social learning lens: KwaZulu-Natal, South Africa

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Abstract

One way of undertaking experiential learning is through the mini-SASS method used as an event of a larger social learning process. The mini-SASS method is used to indicate the ecological condition, at a point in a stream by identifying the macro-invertebrates found at that location. The macro-invertebrates are assigned a sensitivity score which indicates the taxonomic group's tolerance to pollution. The averaged sensitivity scores of the macro-invertebrates identified are used to determine the ecological condition of the river. This method is said to be user friendly and can be carried out by civil society and scholars. The aim of the project was to determine the perceptions, outcomes and attitude experienced by 12-year-old learners when conducting mini-SASS. The research was guided by the Mintzberg model of learning, which involves a cyclic process including theoretical knowledge, practical implementation followed by reflection. The mini-SASS method was perceived in a positive light by the learners and teacher whose attitude was enthusiastic and the outcome was considered by the learners, teacher and researcher to be a success.

Keywords mini-SASS; macro-invertebrates; Mintzberg Model of Leaning; school learners; social Learning; bio-monitoring

Introduction

Environmental concerns are often identified and managed using a two-pronged approach; first, scientific, to determine the nature and extent of the problem and second, the management approach using stakeholder participation including Non-governmental Organisations (NGO's), the government, the private sector and civil society (Sarkar et al., 2007). This two-pronged approach can be applied to environmental problems such as pollution including waste management and water quality degradation (Keen, Brown, and Dyball, 2005) usually as a result of anthropogenic factors (Cooper et al., 2007) and allows for a holistic understanding of environmental problems such as the state of water resources (Keen, Brown, and Dyball, 2005). It has been argued by Keen et al. (2005) that for effective environmental management to occur there has to be stakeholder participation, as they are involved in the solution formulating process. However, we cannot ignore the scientific rigour of sampling which unfortunately often comes at a relatively high financial and human capacity cost. One possible methodology to overcome this is by allowing stakeholders, such as civil society members, to self-regulate natural resource conditions or monitor environmental health such as the state of water resources that are near them and with which they engage daily. This idea where members of society participate in scientific research is known as citizen science (Cooper et al., 2007). The notion being that the methods are appropriate and uncomplicated enough to be used by civil society but still scientifically rigorous. These field-based methods are crucial for real-time identification and possible on-site resolution of stream ecological health (Hill et al., 2008). In some cases, community members seek advice from scientists about problems they face to aid in participatory action research. In most cases however scientists identify problems and projects and then recruit large numbers of community members to aid in the collection of data (Cooper et al., 2007).

Generally stream health problems are complex including both social and environmental aspects, which should be understood interdependently taking specific understanding and knowledge into account and developing a common community perception of the issues through social learning (Hill *et al.*, 2008). This social learning process can be incorporated with notions of experiential learning which combines theoretical learning with aspects of doing and experiencing (Hill *et al.*, 2008). According to Bonney et al. (2009), educating community members involved in the participation and data collection process is important for them to gain a better understanding of the research at hand as well as the scientific method. The definition of social learning has evolved with contemporary thinking with one of the earliest being Miller and Dollard (1947 in PahlWostl and Hare, 2004) who describe social learning as the process of observation of an individual's behaviour. Thus, the replication and imitation of the individual's behaviour by the observer depends on the rewards or punishments associated with the behaviour when it was observed (Muro and Jeffrey, 2008). Others define social learning as the process of observation (Pahl-Wostl and Hare, 2004; Pahl-Wostl *et al.*, 2007), where learning occurs by an individual observing another individual and their interactions within a group situation. However, these definitions were seen as too narrow and did not encompass all aspects of learning. The development of the definition by Wenger (1998 in Pahl-Wostl and Hare, 2004) broadens the concept, describing social learning as a 'community of practice' where the primary component of learning is through participation (Wenger, 2002; Pahl-Wostl *et al.*, 2007). The process of participation to facilitate learning has been modified where participation is used to bring about a change in society through collaboration and joint efforts with a migration towards a common goal (Keen, Brown, and Dyball, 2005). Learning can also be facilitated through the process of experiential learning. Experiential learning is a process that is often incorporated together with outdoor activity. Experiential learning uses real-life situations and examples to inform the learning process. The main objective of experiential learning is to learn by physically doing a task or from experiences (Adkins and Simmons, 2002). This compliments the process of social learning and the Mintzberg model of learning which incorporates aspects of thinking and doing to enhance the learning process.

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In this paper, the mini-SASS method (Graham et al., 2004), is the focus of the experiential learning to determine water quality by identifying macro-invertebrates found within a water body. The mini-SASS method was developed by Graham et al. (2004). The mini-SASS method posits that the presence or absence of certain macro-invertebrates within a particular water body determines the ecological health of that particular water source. This method is easy to use, and yields results that are as accurate and comparable to the more rigorous and robust South African Scoring System (SASS) method from which it is derived (Dickens and Graham, 2002; Graham et al., 2004). We apply social learning to the environmental monitoring method of mini-SASS as it involves stakeholder participation and learning occurs through understanding the concepts behind the method and its practical implementation. Before the implementation and interpretation of the mini-SASS by society, as with other methods of environmental management, some form of learning or training has to occur. One such method of learning is through a social learning theory framework, such as the Mintzberg model of learning (Mintzberg, 2004), which describes the iterative process of learning as that of a combination of theoretical aspects, practical implementation and the process of reflection (Mintzberg, 2004) (Figure 1).

The model has to be engaged continuously over many iterations over time to result in social learning, a one-time pass through the model will only bring about learning. The theoretical aspects of the model (step 1 in the model) can be identified as classroom instruction for conceptual input where teaching is conducted with the aid of presentations or lecture sessions to pass on information prior to field experience (Figure 1). At this step, information is transferred from the 'teacher' to the 'learner'. The information is then absorbed by the learner but at a superficial level (Mintzberg, 2004), which can be improved through the use of practical exercises to reinforce and illustrate what has been learned (step 2 in the model) (Mintzberg, 2004). This second pedagogy is known as case studies to broaden exposure to concepts (Figure 1), during which time theoretical knowledge is imparted. However, these practical exercises are considered artificial as replications of 'real world' situations are made without physically being in that particular situation or environment.

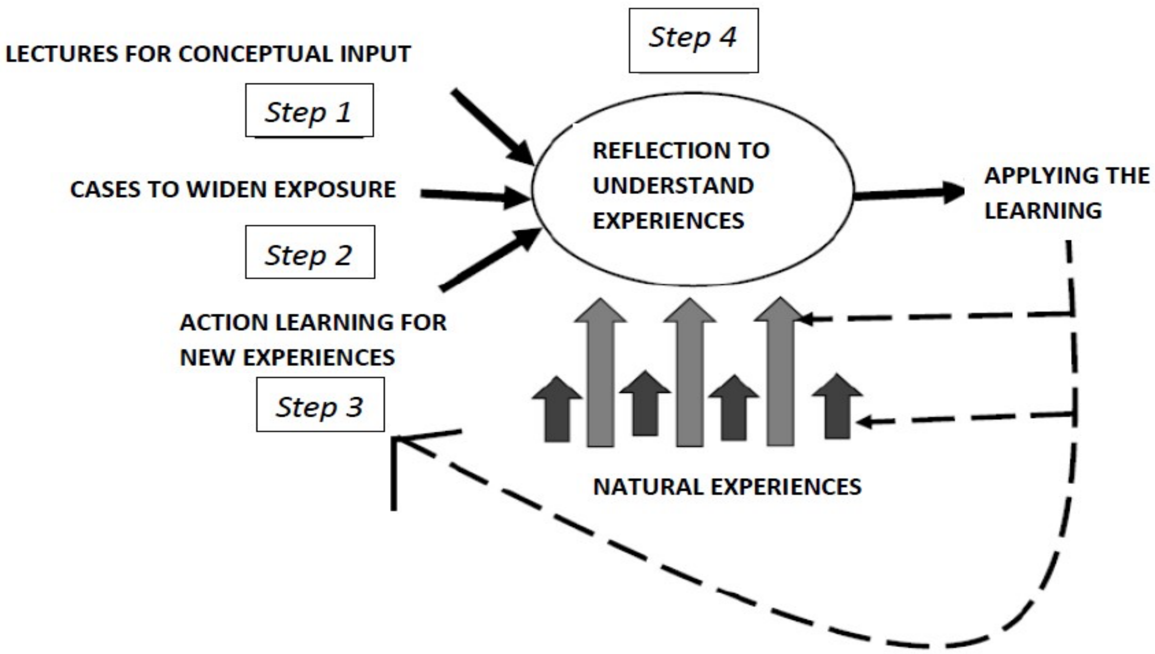

Figure 1: The Mintzberg Model of Learning Experiences (after Mintzberg, 2004, p. 267)

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The third pedagogy of the Mintzberg Model of Learning which reinforces what has been theoretically learned is action learning (step 3 in the model), This phase relates to the practical implementation of knowledge that was theoretically learned (Mintzberg, 2004) (Figure 1), in other words learning through experiencing (Hill et al., 2008). Once theoretical knowledge, together with case studies and application of the learning (step 3 in the model) has occurred, a process of reflection or debriefing occurs (step 4 in the model) (Figure 1).

Methods

The Mintzberg Model of Learning guided the action learning case study conducted as part of a university research project at a local primary school with learners (age 11–12 years) in KwaZulu-Natal, South Africa in collaboration with an environmental consulting firm involved in the development of the mini-SASS method. The school, situated in an urban area, has a strong environmental ethic that undertakes environmental projects with the pupils, such as adopting a wetland system on which the learners have planted indigenous trees and removed alien invasive vegetation.

The mini-SASS action learning case study was implemented at the school in three phases guided by the Mintzberg Model of Learning; a theoretical explanation of the method to the learners in classroom presentations (Step 1), a practical demonstration (step 2) followed by 'hands-on' experience (applying the learning step 3 in Figure 1) at stream sites. These stream sites displayed a diversity of habitat types to reflect the heterogeneity and robustness of the technique. To achieve this a stream running adjacent to a sports field used by the school was chosen. This site was chosen due to its proximity to the school. The school is considering adopting this body of water which the students can be responsible for. A reflection process consisting of a debriefing session conducted both in-field and back in the classroom to obtain perceptions and attitudes of the learners and teacher on the learning process and practically implementing the mini-SASS method was conducted. This process was indicative of the reflective aspects of the Mintzberg model (Step 4 in the model) (Figure 1).

The practical implementation of the mini-SASS by the learners was fulfilled at the field sites. Learners were divided into five groups, each consisting of 6 learners, each facilitated by an adult instructor from the university or the environmental company at optimum sampling sites along the stream. The mini-SASS was conducted following field techniques described by Graham and Dickens (2004). The purpose of the mini-SASS was for the learners to engage with and learn the technique of the mini-SASS method in terms of sampling, identifying invertebrates and using these results to determine the ecological condition of the stream. This was done in the hope that the learners will be motivated to adopt the stream and become responsible for its condition. The results were uploaded onto the mini-SASS website to be used in the broader realm of citizen science. The mini-SASS method was also used as a practical in-field activity to iterate the Mintzberg model and the process of social learning.

The debriefing session included interviewing the class teacher and carrying out a short survey in which all 30 learners wrote their answers to a set of questions, in examination style at their desks. The questions posed to the teacher by the interviewer sought to determine their perceptions on conducting the mini-SASS and the perceived advantages and limitations associated with the process, for the learners. The feasibility of including the mini-SASS in the school curriculum and the need for prior knowledge such as the ability of the learners to use dichotomous keys was discussed during the interview process with the teacher (Table 1). Teacher interview questions were grouped into seven themes (see Table 1) and linked to the Mintzberg model of learning. The responses (Table 1) by the teachers to the interview process were tabulated against the Mintzberg steps by grouping the interview questions into themes. Column 3 indicated the step at which the

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teacher interview questions fall within the Mintzberg Model of Learning (Table 1). The learner surveys were performed to determine the perceptions and level of enjoyment when learning and conducting the mini-SASS.

Results

The unanimous perception of the class teacher that was interviewed was that, at primary school (age 11 – 12 years) level, the mini-SASS is considered an appropriate learning tool for understanding the concept of water quality and allowing the pupils to 'get their hands dirty' (Applicability of mini-SASS and Ease of application – Table 1). The teachers felt that there were many advantages including; ease of implementation by students and the use of the dichotomous keys that linked in with concepts covered in the classroom (Advantages of the tool- Table 1). During the process of reflection, it surfaced that safety around the river was one of the challenging aspects of conducting the mini-SASS. These safety concerns were site-specific such as access to rivers in areas with steep banks, slippery stones and deep-water levels which should be addressed in the site selection stage and did not relate to the method per se (Disadvantages of the tool- Table 1). The class teacher recorded no limitations to the learning process; rather they were positive, stating that they considered the method to provide a sound inexpensive indication of ecological health that is not too scientifically challenging to be used at the educational level of Grade 7. The teacher felt that the implementation of the mini-SASS as an extra-curricular activity was an excellent idea, as it reinforces what has been learned during the classroom situation. In addition, the mini-SASS method could be implemented as an extra-curricular activity by learners in their communities and amongst family and friends. Such activities will enrich the application of learning in the Mintzberg model, growing the learners' natural experiences (Annual extracurricular implementation at the school - Table 1). The teachers did feel that the actual process of conducting the mini- SASS should be explained in more detail when presenting theoretical information and then also explained more on-site where enhanced visualization and contextualization enhance understanding. Another suggested improvement was the use of images of other pupils conducting the mini-SASS in the field (Improvement to implementation- Table 1). These practical approaches form part of the 'case studies' (Step 2 in Figure 1) within the Mintzberg model. Furthermore, it was suggested that some prior knowledge on the use of the dichotomous keys and computer skills would enhance the implementation of the mini-SASS method (Need for prior knowledge and resources – Table 1).

Finally, it was determined that the lack of available resources and the internet, used to upload the results, may pose a problem at the data uploading stage for schools that lack this technology but does not hinder the implementation of the mini-SASS method in any way. This hindrance could be overcome by using diagrams and images to indicate the process of data uploading which then can be done by the facilitator at a later stage.

The teachers and learners also felt that not only is the mini-SASS simple and easy to learn and implement but it is cost-effective in comparison to other methods of testing water quality. It was suggested that at schools with limited resources other than technology, pupils can make their nets to catch macro-invertebrates and that access to rivers is usually free. The general feeling was that if crucial resources such as nets, dichotomous keys, sheets, and knowledge from the teacher are available, then the mini-SASS process is a good method of determining stream ecology (Need for prior knowledge and resources- Table 1).

Table 1: Teacher interview questions and their position on the Mintzberg Model of Learning

Question #	Themes	Position of Mintzberg model of learning
1. Was it easy to understand the mini-SASS method and its potential for indicating water quality?	Applicability of mini-SASS	**Theoretical:** lectures for conceptual input (step 1)
2. Do you think the use of mini-SASS to determine water quality is feasible to conduct at a school level?	Applicability of mini-SASS	**Theoretical:** lectures for conceptual input (step 1)
3. When physically conducting the mini-SASS method was it as easy to carry out as explained in theory?	Ease of application	**Practical:** action learning (step 3)
4. Are there any advantages of carrying out the mini-SASS method at a school level?	Advantages of mini-SASS	**Reflective:** learned and natural experiences (step 4) **Practical:** action learning (step 3)
5. Are there any disadvantages to conducting mini-SASS at a school level?	Disadvantages of mini-SASS	**Reflective:** learned and natural experiences (step 4)
6. Do you as an educator think it is a good idea to implement mini-SASS at school as an extracurricular activity? Why? Or Why not?	Annual extra-curricular implementation at the school	**Practical:** case studies (step 2) **Practical:** action learning (step 3) **Reflective:** learned and natural experiences (step 4)
7. Can any improvements be made to the manner in which the method was introduced and carried out at the school?	Improvement to implementation.	**Practical:** case studies (step 2) **Reflective:** applying the learning (step 4)
8. Is it necessary for the learners to have any prior knowledge e.g.: what macro-invertebrates are, how to use a dichotomous key etc. for it to be more successful?	Need for prior knowledge and resources	**Reflective:** applying the learning (step 4)
9. Is this method in your opinion better to be implemented and applied to schools with better resources or can it be applied to any school?	Need for prior knowledge and resources	**Reflective:** applying the learning (step 4)

The sensitivity scores yielded by conducting the mini-SASS according to the method illustrated by Graham and Dickens (2004) ranged from 22 to 41, which indicate that the quality of the water in the stream was critically modified. This was according to information tables provided on the mini-SASS scoresheets downloaded from the mini-SASS website. The score was derived by first collecting invertebrates and then identifying them using dichotomous keys provided on the mini-SASS website. Each identified invertebrate has an associated sensitivity score. These sensitivity scores were added and averaged. Once this score was obtained, the ecological status of the river was determined. These data were uploaded and represented on Google Earth on the mini-SASS website (www.minisass.org).

The written answers from the learner surveys to determine their responses relating to the conduct of the mini-SASS process were tabulated below (Table 2). On being asked (question 4) if the field-based exercise presentation was easy to understand and useful in terms of field preparation and conceptualization, 80% of the learners stated that the presentation was easy to understand and beneficial to learning about the mini-SASS method and 94% of the learners found the mini-SASS method easy to conduct (question 1). Seventy-four per cent of the learners thought that water quality testing should be conducted on a more regular basis (question 5). In response to whether they considered the monitoring tool useful (question 6), 90% were positive, while 7% unsure. 84% of the learners felt that the mini-SASS was enjoyable to conduct while 16%

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did not enjoy the experience (question 7). On being asked how to improve upon the approach, 87% had no suggestions and enjoyed the experience as it was, while 13% of the learners felt that certain changes such as a more in-depth dichotomous key instruction or a practical demonstration thereof at the river before learner implementation would help (question 8) (Table 2). The survey results revealed that the learners found the most exciting aspect of conducting the mini-SASS to be finding the macro-invertebrates in the river (Table 3), while the most difficult aspect overall was identifying the macro-invertebrates using the dichotomous keys (Table 4). The teachers responded positively and supported the learner's observations that the method was easy to use and understand when it was explained theoretically and then demonstrated in the field. Furthermore, they noted the potential of mini-SASS for indicating water quality and as a tool to teach ecological concepts.

Table 2: Learner responses to the survey questions asked relating to the conduction of the mini-SASS method

Question #	Yes	No	Maybe
1. Was the mini-SASS method easy to conduct	94%	6%	
2. What were the most exciting aspects of conducting the mini-SASS	See Table 3		
3. What were the most difficult aspects of conducting the mini-SASS	See Table 4		
4. Was the theoretical presentation conducted before the practical aspect east to understand?	80%	20%	
5. Should water quality monitoring occur on a more regular basis?	74%	19%	7%
6. Was the monitoring tool useful?	90%	3%	7%
7. Was the mini-SASS enjoyable to conduct?	84%	16%	
8. Should the mini-SASS teaching be improved	13%	87%	

Table 3: The most exciting aspects of conducting the mini-SASS experienced by the learners

Exciting aspects when conducting mini-SASS	Percentage of Learners
Identification of macro-organisms	13
Finding macro-invertebrates	59
Having fun in the river	23
Using the clarity tube	3
Uploading the data on the mini-SASS website	3

Table 4: The most difficult aspects of conducting the mini-SASS as experienced by the learners

Difficult aspects when conducting mini-SASS	Percentage of Learners
Identification using the dichotomous key	48
Calculating sensitivity scores	7
Catching the macro-organisms	23
Safety around the river	19
Cleaning the nets	3

Discussion and Conclusion

The primary steps of the Mintzberg model of Learning; namely the theoretical aspect, practical implementation and reflection, were partially iterated and successfully practised through the use of the water quality monitoring technique, mini-SASS, with school learners. The theoretical aspect of the learning process was conducted through a classroom presentation that started the day's proceedings. During this stage, a process of theoretical information transfer occurred in which the learners were informed about managing our water resource, the necessity for water quality monitoring and how to disseminate this information via social media such as the Internet. Mini-SASS and its potential as a citizen science tool were discussed.

Discussions also took place around the mapping of mini-SASS results and uploading them to Google Earth so that they assist in civil society awareness. Learner enjoyment was vital for this stage (reflection and applying the learning) to be successful, thus the presentation was interactive, involved many images and was conducted in an informal manner that afforded the learners a relaxed learning environment. In the survey, most of the learners enjoyed the presentation slides and felt that the presentation was beneficial as it explained optimum sampling sites as well as the method in which the mini-SASS was to be conducted. However, some of the learners responded that the prior briefing was not enjoyable and stated that they had no interest or understanding and did not find the presentation beneficial.

These findings reinforce the advice of Ellström (2001) who states that not only is learner interest important for this stage to be successful but also resources such as the availability of time to learn, the willingness of learners to learn and their ability to grasp new concepts has to be taken into account. This is reiterated by Bonney et al. (2009) who determines the impact these citizen science projects have on their participants by taking into account the number of participants, their understanding of the scientific problem at hand and their attitudes towards science. Reed (2008) suggests that an important aspect of social learning is participation as it allows for two-way dialogue and information transmission between experts/decision-makers/policymakers and stakeholders aiding in natural resource management. Therefore, for the participation to occur within this school situation there needed to be communication and two-way understanding between the mini-SASS facilitator and the learners. Participation is vitally important in creating a greater understanding of the mini-SASS method and eventually a more comprehensive experience. For effective participation to occur emphasis should be placed on the outcome rather than the amount of participation (Reed, 2008). As expected, the field-based experience was enjoyed by most learners, with several learners who did not understand or appreciate the theoretical classroom aspect commenting on the positive field experience. Those that did not find the mini-SASS enjoyable in the field attributed it to the poor behaviour at the river by some of their fellow learners and not the process or technique. This feedback was somewhat surprising, nevertheless most valuable as it illustrates the need for a disciplined learning environment. There was evidence of frustration at not finding invertebrates and also not being able to identify macro-invertebrates (through the use of dichotomous keys).

Once the theory of the mini-SASS method was presented and practically implemented, reflection occurred taking into account both learned and natural experiences. The presenter helped to remind learners of the natural experiences from the past which were relevant to their deeper understanding of the processes in the Mintzberg Model of learning. It was interesting to note that during the debriefing it transpired that what was a negative experience for some learners was perceived as exciting and enjoyable for others, for example, the use of the dichotomous key for the identification of macro-invertebrates was enjoyable for some, whilst others struggled with both the concept and utilization of the keys. Past experiences of learners are important at this step of the reflection, for example, if learners have a natural affinity for the outdoors and nature then the mini-SASS practical implementation tended to be a more rewarding experience. For those less experienced or exposed to the natural environment, particularly of urban streams, it provided quite a challenge and all new experiences. These experiences will take some getting used to and need re-enforcement. Furthermore, more time needs to be spent on post-field experience reflections. Learners that did not enjoy the outdoors and getting dirty found the mini-SASS method more challenging.

The process of reflection was also used to determine what learners felt could be done to improve upon the experience of conducting mini-SASS. The responses were overwhelmingly positive towards the mini-

SASS. However, the learners felt that a more challenging stream or stream sections with regards to conditions and hence reflected in macro-invertebrate abundance and species diversity should be selected for learners of higher grades. Some learners believed that the dichotomous key could be more detailed. These observations, through the process of reflection, demonstrate critical thinking in terms of improving the implementation of the mini-SASS method at a Grade 7 level. These responses were positive and pleasantly surprising as they indicated that the learners engaged with the methods that they were being taught. Upon interviewing the teacher it was evident that all aspects of the Mintzberg Model of Learning were fulfilled during the mini-SASS implementation process, namely; the classroom theory; field-based implementation; and reflection through a debriefing process. Step 2 of the Mintzberg model, case studies, was not fulfilled in its entirety. However, during the initial presentation process pictures and results from previously conducted mini-SASS methods were shown as a way for the students to envision the process and get an understanding of how this process was conducted by other learners of similar ages. The mini-SASS implementation process was fulfilled by invertebrate categorizing to determine the condition of the river; uploading the data and finally, the interviews and surveys that were conducted with the learners and teacher. A possible reason for the ease of use, suggested by the teacher, was the appropriateness of the theoretical presentation before fieldwork (ease of application). The overall assessment was that the classroom presentation was informative, but more emphasis needed to be placed on describing the steps to carrying out the mini-SASS method. This could be further enhanced by a practical demonstration at the river before the learners were provided with an opportunity to carry it out.

The potential of mini-SASS to determine water quality was visible even though some prior knowledge such as the use of dichotomous keys was needed. This was not perceived as a major constraint as the key could be explained ‘on-site’ in sufficient detail and it was observed that some learners used the pictures provided, directly, to identify the invertebrates as opposed to following the dichotomous keys process. The teachers also felt that the learners at this young age are impressionable, therefore encouraging them to become aware of the environment and the state of water resources in particular enables a generation that is environmentally aware and concerned. Such a development would possibly result in positive change in terms of environmental protection in the future. Using the mini-SASS method at a Grade 7 level encourages river health awareness and skills at an early age. The teachers felt that children at Grade 7 age are idealists. In other words, they feel they can 'make the world better' and with this attitude, the mini-SASS method provides them with a means to strive towards such ideals. One teacher felt that if schools undertake such monitoring then the health status of nearby streams would become more widely known, in particular to the learners who in turn feel that they have a responsibility towards that stream and take extra caution in ensuring that the activities they conduct cause no harm to streams. Once the steps of the Mintzberg model have been followed, the application of the learning can occur together with the cyclic process of the Mintzberg model of learning. Such cycles/iterations could occur on an annual basis (or more frequently) with the knowledge that each year the reflection and learning become more advanced due to increased understanding of the environment, macro-invertebrates and the use of dichotomous keys, by the learners. It is postulated that the application of learning strengthens each year as the learners become more environmentally aware and attempt to improve the ecological condition of the stream from the previous year's mini-SASS score. If the learners look upstream in the catchment to find causes of pollution and seek to address these (then their learning and interest) in the annual river health improvement, could escalate significantly. The value of using the mini-SASS method to determine water quality can only be appreciated and understood once the mini-SASS method has been theoretically learned and practically implemented once again indicating the application of the learning process.

In conclusion, the implementation of the mini-SASS method was a success. It can be said with confidence that learning occurred by both thinking and doing. This resulted in positive participation, efficient implementation and a willingness to succeed in the process on the part of teacher and learners. Whilst the Mintzberg Model of Learning was not used in its entirety since no second iteration, that is, another mini-SASS and step 2 of the Mintzberg model was not conducted in its entirety, it can be concluded that the Mintzberg Model does provide an effective framework for understanding action learning in the implementation of the mini-SASS technique. The mini-SASS method was received enthusiastically by the school who indicated their hope of conducting mini-SASS fieldwork on an annual basis to monitor nearby stream quality.

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