Attitudes to science when doing kitchen chemistry at science clubs

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ABSTRACT

The South African grade 9 Natural Sciences curriculum suggests the use of everyday science to introduce the usefulness and the relatability of science to learners. Many learners, however, seem to have a negative attitude towards science learning and science as an entity. This study is an intervention that sought to ascertain the attitudes of grade 8 and 9 learners in under-resourced schools in South Africa after they had carried out kitchen chemistry hands-on practical activities at science clubs in under-resourced township schools. The learners were interviewed about their experiences, and university student volunteers at the science clubs were also interviewed. An inductive-deductive thematic approach was used to analyse the qualitative interview data. The findings of the study revealed that the learners had a more positive attitude toward science after they had been engaged in the kitchen chemistry hands-on practical activities. Additionally, the integration of everyday knowledge promoted conceptual understanding and improved the performance of the learners. The interviews with the student volunteers revealed aspects that they thought would improve learners' attitudes to science. Science clubs run by university student volunteers could assist in promoting a positive attitude to science among learners.

KEYWORDS

kitchen chemistry; acids and bases, attitudes, science clubs, volunteers

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INTRODUCTION

A plethora of research has highlighted a decline in the number of learners choosing science subjects in secondary schools across the world, such as in the United Kingdom,[1] Europe,[2,3] in India[4] and Australia.[5] In South Africa, there has been a marginal increase in the number of learners writing the National Senior Certificate (NSC) examinations over the past five years (Table 1).[6] However, in 2021, only 23% of a total of 733 917 learners who sat for the NSC examination, [7] wrote Physical Sciences. Of those who wrote Physical Sciences in 2021, 53 378 (27.1%) achieved 50% and above (as calculated by the author from the graph on page 211 in the NSC Diagnostic report). [6] A significant factor, which influences the way learners perform in Science, Technology, Engineering and Mathematics (STEM) subjects is the learners' attitude towards science. It has been shown that learners' attitudes towards these subjects have declined.[8,9]

Learners' attitudes towards science are influenced and developed through their experiences with science. Thus, to ensure that learners perform well in science and are interested in pursuing it, it is important to develop programmes that will help them build positive associations with science.[8] These programmes should promote positive associations such as motivation, enjoyment and helping the learners see the relevance and applicability of science to everyday life.[10] In response to the declining attitude of learners towards science, and therefore a decline in the achievement in science-related subjects, a number of interventions have been developed to influence positive learner attitudes towards science.

One of the most common programmes developed and used, is science clubs.[11] It is not the science clubs *per se*, but rather the activities at the science clubs that play a significant role in bringing excitement, enjoyment and motivation to do science. At science clubs, learners can engage in, for example, hands-on practical activities which can stimulate interest and excitement.[12]

In the study described in this article, the aim was essentially to influence township school learners' attitudes towards science using hands-on practical activities in out-of-school science clubs. The activities involved kitchen chemistry, and the science clubs were run by Rhodes University student volunteers who were knowledgeable in science concepts. Kitchen chemistry refers to the chemistry of the everyday activities performed in households, such as cooking and cleaning.[13]

LITERATURE REVIEW

Attitudes

Attitudes towards science refer to the perceptions of the usefulness or the applicability of science, based on one's opinions or beliefs.[14] This is related to whether one can see the link between science as an entity and the scientific tools used to solve real-life problems. [15]

It has been found that attitudes towards science and science achievement were directly proportional to each other.[16, 17] The reason for this is that a positive attitude towards science sparks interest and cultivates motivation to engage actively with the science.[18]

Out-of-school science clubs

Science clubs provide learners with informal spaces to engage in science activities and with support that promotes a positive attitude toward science.[19] Science clubs also promote enjoyment of science and foster a positive attitude towards science by incorporating activities which show how science is related to the everyday life of the learners.[20]

Out-of-school science clubs can be instrumental in making science more accessible to learners from disadvantaged socio-cultural

Table 1: National Senior Certificate achievement rates in Physical Sciences[6]

Year	No. wrote	No. achieved at 40% and above	% achieved at 40% and above
2017	179 561	75 736	42.2
2018	172 319	84 002	48.7
2019	164 478	85 034	51.7
2020	174 310	73 982	42.4
2021	196 968	88 164	44.8

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backgrounds since the science can be made relevant to their everyday lives, [21] showing respect for their knowledge and practices.[22,23]

Science clubs may be facilitated by university students who do this as part of the Community Engagement programmes at universities. This is particularly important for the under-resourced schools in South Africa.[20,24] In fact, it is imperative that universities form relations with schools to support learners' education.[25]

Hands-on practical activities and kitchen chemistry

Learners learn better when they are involved in practical, hands-on activities, and more so, when the activities are related to their everyday experiences.[26] Notably, in under-resourced schools in South Africa, the reality is that schools lack the resources to do curriculum-based practical activities with the learners,[27] and the prescribed experiments have no relevance to what the learners experience in their everyday lives. This lack of opportunity of doing practical science and experiencing the science in meaningful real-life contexts might lead to a sense of disempowerment.[28] Thus, doing kitchen chemistry hands-on practical activities at science clubs can provide the opportunity for the learners to learn chemistry, using materials that they encounter at home.[21] Learners learn to recognize that the items used, possess chemical properties.

Kitchen chemistry hands-on practical activities require easily accessible materials and equipment that most learners have at home.[29] In this study, all the experiments made use of household items, or easily accessible materials to explain the concept of acids and bases.

METHODOLOGY

Participants

The study was conducted at four different science clubs in Makhanda, a rural city in South Africa. Three of the science clubs were attached to three public, under-resourced secondary schools and the fourth club is run independently of schools and has been a Community Engagement project of the University.[20,24] The clubs at the schools ran one afternoon a week at each of the schools and were associated with the Student Volunteer Programme of Rhodes University. The main objective of the clubs was to improve the learners' understanding of science-related concepts, as well as to assist the learners with their Expo projects.

For the purposes of this study, the club activities comprised a series of kitchen chemistry hands-on practical activities and discussion sessions, based on the grade 8 and 9 Natural Sciences curriculum. University science student volunteers ran the sessions at the clubs. Before each activity, volunteers were briefed by the researcher as to what the activity entailed and what the expectations were. Moreover, the purpose for these sessions was to ensure that any misconceptions that the volunteer students came with, were addressed beforehand so that these were not passed on to learners involved in the science club. All interview questions (see Supplementary Material) were piloted with learners and students before the participants were interviewed.

The learner participants in this study were grade 8 and grade 9 members of the science clubs. In total, 20 learners attended all three sessions of this project. After all the sessions had been completed, individual, semi-structured interviews were held with eight learners to gain an in-depth understanding of their attitudes and to check whether these attitudes could have been influenced by the use of kitchen chemistry hands-on practical activities or not. Questions were asked in English, but the learners were allowed to respond in either English or their home language, isiXhosa. Additionally, individual semi-structured interviews were also held with three student volunteers to elicit their views on improving learners' attitudes towards science. The interviews with the volunteers were all conducted in English. All these research activities involving the participants (learners and volunteers) complied with the consent and assent permission protocols, as required by the University's Ethics committee. After an information session, parents/guardians of the learners signed consent forms for the learners' participation, and learners signed assent forms. The Eastern Cape Department of education and the principals gave gatekeeper permission.

The learners, led by university science student volunteers, performed three hands-on practical activities which focused on the topic of acids and bases in the grade 8 and 9 curriculum.[30,31,32] These hands-on practical activities were modified to use household ingredients to link with the learners' everyday life experiences. The hands-on practical activities conducted with the learners were:

- the acidity of household substances, using red cabbage as an indicator;[32]
- the acid-base reactions of carbon dioxide, using turmeric as an indicator;[30] and
- acid-base energy transfer reactions[31] using different household materials.

FINDINGS and DISCUSSION

All data from the semi-structured interviews with eight learners and three student volunteers were inductively coded and grouped into themes, to determine whether the hands-on practical activities that apply kitchen chemistry, had influenced the grade 8 and 9 learners' attitudes towards science.

Learner interviews

The themes that emerged from the interviews held with the learners are discussed below.

Theme 1: Development of the attitude sub-constructs

The study concentrated on three sub-constructs of attitudes, as described by Fraser,[33] namely: enjoyment of science activities, interest in science and perception of science as an entity. After the intervention, the learners gave positive accounts in relation to these three sub-constructs. A number of learners said that they enjoyed the kitchen chemistry hands-on practical activities. The following excerpts are examples of learners' enjoyment, which leads to a positive attitude towards learning science.[33]

> *"…To me science is fun …"* (L1)

> [I enjoyed them...] (Translation from isiXhosa, L4)

> *"…and I also got shocked and excited when I saw colours change in the experiment..."* (L7)

Perception of science is one of the sub-scales[33] used to describe attitudes. A positive view of science implies a positive attitude towards science. Learners who see how important science is in society, and how they are a part of it, are more likely to want to do science in their lives.[8]

Learners' positive perceptions of science are illustrated in the following excerpts:

> *"…it's great to learn new things and have a better understanding of what happens around us…* [It is relatable to real life because, it is about what happens around us and research helps us to understand the world around us.] (Translation from isiXhosa, L1)

> *"I see it as a new way to explore things."* (L4)

> *"Science isn't just life science or physical science but also social science… It's great, it's nice, it's transforming…"* (L8)

These excerpts illustrate that the learners were able to see the usefulness of science, and how science relates to their everyday life and to the world as a whole and to view science in a positive light.

Some of the learners joined the club because they were interested in science (the third sub-construct) and in a career in the sciences. [33]

Examples of what learners had to say about a career in science after the intervention are shown below:

> *"I could consider it..."* (L5)
>
> *"I see it a subject that I love and would do even in future among other subjects."* (L4)
>
> *"Yes, I would like to be a scientist yeah.* [Yah, I really want to be a scientist.] (Translation from isiXhosa, L1)

The aim of this study was to influence learners' attitudes toward science, to encourage them to pursue science in high school and science careers after completion of grade 12. Some felt, after the intervention, that they could consider a career in the sciences, even though, initially, they had not considered science-based careers. Based on this interest in science careers, we can say a positive attitude has been developed in the learners.

Theme 2: Learning with understanding

The kitchen chemistry hands-on practical activities were designed for the learners to see that science is relatable to their lives and can be applied in real-life situations. Most of the learners felt that they learnt a lot from them. The learners further expressed that they could relate their schoolwork to their everyday lives, and they could apply that knowledge in activities they did at home.

> [I didn't know vinegar and bleach can result in steel wool rusting, I thought that only happened after you've used it to wash pots.] (Translation from isiXhosa, L5)
>
> [They helped a lot because I know acids and bases because at the beginning I didn't know them, then we used food elements from home, so it's easy to separate acids and bases and to test them.] (Translation from isiXhosa, L7)

When learners are able to see the relationship between their everyday lives and science, they are most likely to develop a positive attitude towards science.[10]

Theme 3: Confidence in Natural Sciences

The learners who came to the science clubs indicated that they needed help with Natural Sciences at school. After the intervention, most of the learners expressed that they had received the help they needed with their studies and their marks had improved. The following quotes are examples of what the learners had to say about the help that they received at the club:

> [It helps me with things I don't understand in class. I get to understand them in the science club] (This is a translation from the learner's home language, isiXhosa) (L3).
>
> *"It helps me, let's just start there, it helped me a lot, especially last term, I mean my marks improved drastically, in maths I got a level 7 and in science, I also got a level 7."* (L8)
>
> *"At the science club for an example, we learnt about things that we hadn't done in class yet, so the volunteers taught us. So, by the time we learnt about them in class, I now knew everything I needed to know about them."* (L1)

The integration of everyday knowledge and resources, such as those used in kitchen chemistry, motivates the learners who make connections and build a deeper conceptual understanding of science.[34] For example, one of the learners said:

> *"At the beginning of the year, I didn't do so well in Natural Sciences, I got level 4. My teacher told me to join the club, I did and I began to understand my work better, worked more and studied more. I got level 6 and I am now aiming for level 7.* (L1)

When learners perform well in science subjects, motivation to work harder is enhanced, which leads to development of positive science attitudes.[35]

Additional findings

The assumption at the beginning of the study was that the learners would find the kitchen chemistry hands-on practical activities relatable and interesting and, therefore, develop a positive attitude towards science as an entity. Indeed, from the interviews, the learners could relate to the practical activities. However, some learners expressed the opinion that despite doing kitchen chemistry, they would still like to go to a laboratory and do the conventional experiments using the materials and equipment with which they are not familiar. For example, this is what some of the learners said when asked whether they preferred using easily accessible materials or using chemicals in a laboratory:

> [I prefer lab stuff to learn new things, but with things that I know also for understanding but I prefer lab stuff to learn new things and do new experiments, like knowing the products of some reactions.] (Translation from isiXhosa, L1)
>
> [….the things I am used to help, but I would love to go to the lab too and look at the stuff I am not used to and be able to know how these things relate to each other.] (Translation from isiXhosa, L7)

It could be deduced that both laboratory-based experiments and kitchen chemistry can be used to improve the understanding of schoolwork and to motivate learners to do science beyond school.

Learners related science to working in a laboratory and mixing chemicals to develop new ideas. The idea of being in a laboratory, dressed as scientists in lab coats with goggles is what they feel is science, or what it means to be a scientist. This view, even with the use of experiments with everyday materials, did not change. Instead, they would prefer if it were used together with the 'conventional laboratory-based science'. All these, together, affect the learners' attitudes, and so a positive attitude can be achieved by engagement in both conventional and kitchen chemistry practical activities.

Interviews with the university student volunteers

Individual, semi-structured interviews were held with three volunteers who were all studying science at university. The aim of the volunteer interviews was to find out, from their perspectives, what factors could affect grade 8 and 9 learners' attitudes towards science. Each of the themes is discussed below.

Theme 1: Practical engagement

The volunteers expressed that they themselves had not always felt positive about science and pursuing science careers when they were at school. They claimed that doing activities that are 'outside' of the normal classroom setting helped them in developing their attitudes towards science. They spoke from their experiences and what they wished could have been done when they were still at school and which could be done with the learners who are still at school. The following excerpts are examples of what the volunteers had to say about being in science clubs:

> *"…Science clubs, we get there, do experiments and they get wowed thinking oh, this is this and that and especially experiments that are so small and simple ….So, it put that spark again of like science rather killing it by just sitting in the desk the whole day ….*" (V1)
>
> *"…I feel like in a lot of schools, they don't really get that much exploration, like doing science for fun, it's always a lot of science for tests, for the exam. It's never science of, oh yeah, I just wanna*

find out if this flower has this compound you know, it's never really like, the science club gives you that curiosity, you are more aware of a lot of things that you wouldn't have been in class… (V2)

The volunteer student further reflected that:

….but I believe in more of letting them [learners] explore on their own. Like, give them the knowledge that they have and then let them use that, apply it to something else that they have passion in, or something that they like because I know, my, my, my love for chemistry really developed from that, applying the things that I liked." (V2)

The volunteers claimed that doing science outside the normal classroom setting helped them learn, to explore other things and brings about excitement and curiosity to do more. Practical activities, or experiments was a reason for the development of the volunteers' attitudes towards science

"… I am more engaged, I have to do more practicals on it, that's when I started to actually enjoy this thing, when I do more practicals, but back then I really wanted to go into entrepreneurship and business, but then when I got here [university], I started to develop the love for science." (V1)

They claimed that experiments are 'fun' and helped them to enjoy learning science. These volunteers enjoyed science experiments so much that they now have a positive view of science and are pursuing science careers.

These volunteers stated that it is important to keep learners captivated and motivated in class. Learners' age, activity and attention span should be taken into consideration when science is taught. One volunteer, speaking from his experience in facilitating science club activities, said that:

"…kids at a young age are actually more into touching, than sitting and listening to you. They are more energetic and having them to go out there and giving them use small microscopes to actually go around and look for small stuff, mix chemicals, small chemicals, builds in them the excitement of chemistry or the excitement of science." (V1)

Theme 2: Influence of other people

The volunteers expressed that teachers and volunteers, or any of the people involved in the science learning process, influence the attitudes learners have towards science. They suggested that the interactions we have with people on any subject result in building associations. These associations determine how we view the specific subject. In the science clubs, the learners interacted with fellow learners and the volunteers, as one volunteer put it:

"…I think science clubs actually improve the attitudes of learners towards science because… when they actually gonna get students who are fresh, who are almost the same age as them… So, you are getting relevant people who just did what you are doing now, so they have more understanding of the times compared to the ones who have been doing this for so long." (V1)

Whereas teachers might not always engender a good attitude towards science:

"…and I would describe mine as negative and it's because the teachers went about it in a way that was either incredibly strict or, I think there was just some part of them that was, probably mean people, mean spirited people, but then I associated the subject with them instead of the course content and that is a big problem." (V3)

The volunteers felt that the characteristics of the teacher/facilitator and the teaching methods used, determine whether the learners will be willing to listen or not, and even how much information the learners can absorb. Additionally, it is easier to listen to and relate to someone who is close to you in age because they understand the way that you think and can explain concepts in a way that you understand.

"….. I think the involvement of science clubs can actually help their attitude more than a lot if you have volunteers that are actually enthusiastic themselves about science …and when you get there as a volunteer,…you putting that exciting of, ' when I get into university, I will study this……" (V1)

The volunteers also commented on the support and guidance given by teachers and facilitators of science as of utmost importance when it comes to development of attitude in learners. The volunteers said that, sometimes, learners encounter some special person who can make them see their potential and push them in the right direction. This motivates the learners to do better in science. One volunteer said that,

"…I believed that I could do science because that's what I was drawn to… I started to enjoy chemistry towards the end of the year… The way she handled it was so much better." (V3)

There is also the perception that science is difficult. The volunteers suggested that learners need teachers who will guide them in their learning and ultimately help them see that doing science is possible. The following quote from a volunteer is an example:

"…if somebody can be there to just open up that window so that you can see things, it's not that these things are hard, it's not that these things are undoable, it's just that we need guidance on what to do, yeah." (V2)

Theme 3: Use of familiar content

According to the volunteers, seeing how science relates to your everyday life is important in developing a positive attitude towards it. They said that science tends to be very abstract, and it becomes difficult to associate with something you cannot see yourself using in your life. Thus, in order to understand better, and even begin to identify as scientists, it needs to be taught using examples that we can be able to relate to. Examples of quotes from the volunteers:

"…I ended having a better grasp on some of the concepts… because what she would do,…she would basically introduce us to a topic and then she base it to everyday life which definitely helped me because it no longer became an abstract thing you know, uhm, I could now see it in action every day, ….. she would give us an example and one of the ones that always sticks with me is when she explains a glass of water with ice in it, you know energy going in and out of a system." (V3)

"…more positive impact if the science clubs do these experiments which are IK [Indigenous Knowledge] because I will first introduce IK in schools and actually bring more excitement…, I am doing so it's better if I am doing the experiment and I understand the experiment itself so that I can link it with the theory I got in class." (V1)

"…Science is something that happens over there at the university in a special lab …. I use this stuff at home, I drink this stuff, I eat this stuff, ….. Science is so much closer to them, it's easier to work with and by doing that it breaks down that fear of science because you now are comfortable with ….. it's not something special that scientists do, we actually working with it" (V3)

The volunteers suggested that, when we perceive aspects of our lives around us as being scientific, and some kind of 'chemical reaction', it helps us to question life, or even try to explain what is happening.

"*…they can even get home and start explaining and sharing their science, like explaining what vinegar is and what it can be used for, so it actually pumps them into getting into this science*

mood … it will help them relate more with the experiments happening because they can see things that they see every day and then also open more curiosity on them to seeing everything scientific and trying to explain everything." (V1)

CONCLUSION

The study found that when learners were engaged in kitchen chemistry hands-on practical activities, during science clubs, they became confident in learning about acids and bases. They understood their schoolwork better and their performance improved. This then motivated them to do more. Ultimately, they developed a positive attitude towards science.

The practical activities at the science clubs helped learners to learn with understanding. They were able to relate their schoolwork to their everyday lives and to understand the world in which they live. They were able to construct new knowledge about science, by building upon the knowledge that they already had. This changed their view on science and developed a positive attitude. The learners even expressed an interest in pursuing science-related careers.

The findings from the interviews with the student volunteers showed that attitudes towards science can be influenced when learners participate in science clubs where they do chemistry hands-on practical activities. Science is more practical than theoretical, and engaging in practical activities give learners an idea of what science is about, and what the life of a scientist is like. When engaged in this manner, learners can then develop a positive attitude in science. The engagement can be anything that takes them out of the classroom setting.

The other factor that the volunteers spoke about was the enthusiasm, the support and the motivation of the people involved in the delivery of science. This could be teachers at school and volunteers in clubs. These people are responsible for showing the learners that science is exciting and enjoyable. The enthusiasm and motivation of the student volunteers, who are closer in age to the learners, rubbed off on the learners and motivated them to do science. The support that the volunteers gave, helped learners develop confidence in themselves and encouraged them to do science.

The study also showed that the volunteers felt that the use of familiar content had a role in the attitudes that learners have towards science. When taught with substances with which they are familiar, learners are able to grasp concepts and understand the work, and when they understand, they are motivated to do more.

The study recommends that everyday science, such as kitchen chemistry should be integrated into the science lessons for Grade 8 and 9 learners. This helps learners bring context to the science that they are learning at school and can cultivate a positive attitude toward science at school. However, the conventional hands-on practical activities could also be carried out to help learners have fun and experience science in a laboratory. The study also recommends that science teachers pay close attention to the energy or attitude they bring to class when teaching science because learners pick up on that and build associations with the subject. Furthermore, student volunteers who run science clubs could play an integral role in building positive attitudes in the learners.

SUPPLEMENTARY MATERIAL

Supplementary information for this article is provided in the online supplement.

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