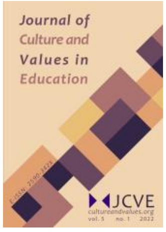

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The STEAM vs STEM Educational Approach: The Significance of the Application of the Arts in Science Teaching for Learners' Attitudes Change

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ABSTRACT

This article critically examines existing literature on the importance of incorporating the arts into the teaching and learning of science subjects in schools. It explores the significance of the STEAM educational approach as an option in science teaching and learning that might provide a range of benefits to STEM learners. STEM is an acronym for Science, Technology, Engineering, and Mathematics while STEAM stands for Science, Technology, Engineering, Arts, and Mathematics. The argument in the article is focused on why leveraging such skills as creativity, problem-solving, critical thinking, communications, self-direction, initiative, and collaboration, which are inherent in the arts, to strengthen the effective teaching and learning of science within the STEAM educational context is important for STEM learners. The STEM educational approach to science teaching and learning employs an interdisciplinary approach to problem-solving aimed at equipping learners with 21st century skills such as critical thinking, creativity, problem-solving, self-direction, initiative, collaboration, effective communication, and morals. It also aims at providing them with the opportunity to apply these skills through the practices, contexts, and processes of hands-on activities. These are targeted at understanding science and viewing science differently, which might enable them to participate in a STEM-career pathway. However, the framework for STEM does not fully support an understanding that creativity can exist in science and that science can be taught in multiple ways, including application of the arts. STEAM, on the other hand, is grounded in a transdisciplinary approach to science teaching and learning. It explores the application of the arts in science teaching and learning. This is aimed at improving the confidence, attitudes, and interests of learners in science through new approaches to problem-solving which might strengthen positive attitudes towards science. This approach incorporates the common processes of science and arts, which includes discovery, observation, experimentation, description, interpretation, analysis, evaluation, wondering, visualising, exploring, and communication.

KEYWORDS
STEAM; STEM; arts in science teaching; learning; positive attitudes; puppetry art.

INTRODUCTION

"Overemphasis on rote learning and rigid, dogmatic adherence to rules of discipline are not only deterrents to learners… they are fundamentally incompatible with the true nature of science" (Schmidt, 2011, p. 441). This statement argues that learners' negative attitudes and declining interest in science may be attributed to a fundamental flaw in the approaches and tools employed in the teaching and learning of the subject. These approaches, according to Schmidt tend to constrain learners and limit their creative potential excellence in science. Furthermore, they do not reflect how science should be taught. To further highlight the shortcomings of these teaching approaches, the scholar adduces that the incorrect application of models of teaching and learning science have done much to cultivate perceptions of science as a non-creative endeavour (Schmidt, 2011).

Having an understanding that creativity can exist in science supports the perception that science can be taught in multiple ways, including the application of the arts. This will enable learners to see the overlap in practices between art and science (Tsurusaki et al., 2017). For instance, learners need creativity and imagination to form mental images of entities such as electrons or atoms, invisible to the naked eye (Turkka et al., 2017). This necessitates a need for the adoption of an approach to science teaching and learning that challenges the learners' creativity and increases their curiosity in relation to science.

There are two main approaches that aim at effective science teaching and learning. These are the STEM (Science, Technology, Engineering, and Mathematics) educational approach and the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach. The STEM educational approach aims at motivating learners through practices, contexts, and processes that will enable them to participate in science activities that lead to STEM-career pathways (Connors-Kellgren et al., 2016; Ring et al., 2017). It employs an interdisciplinary approach to problem-solving and equips the learners with 21st-century skills, as well as the opportunities to apply these skills (Vennix et al., 2018) through the provision of hands-on activities targeted at understanding science and encouraging the ability to view science differently (Vennix et al. 2018).

According to Kim and Kim (2016), affective competency is critical, and so is the quality of the teachers. It is therefore suggested that teaching science through approaches that connect STEM and the art disciplines, the STEAM approach, might illustrate and expose the learners to the creativity of science by highlighting its overlap with the arts, as was earlier stated (Tsurusaki et al., 2017), which might enhance science teaching and learning. The STEAM educational approach employs a transdisciplinary approach to problem-solving. This has the potential to engage learners more deeply (Cook et al., 2017) because creativity and imagination are required in science to visualise and express abstract concepts (Turkka et al., 2017).

One explanation regarding the increase of motivation, with the integration of the arts into science teaching, is the fact that the arts enable multiple ways to express and explore scientific content (Turkka et al., 2017). The STEAM approach, therefore, might allow learners to engage with science content through the arts (Tsurusaki et al., 2017). This has been found to increase learners' science efficacy and creativity, and so maximise their interest and motivation in science. This, in turn, helps to improve their competitiveness (Kim & Chae, 2016). The STEAM educational approach, therefore, encourages learners to take the initiative in their learning (Kim & Kim, 2016). This implies that it encourages learners to solve challenging problems themselves, which might increase their science learning efficacy (Kim & Kim, 2016), as well as their confidence (Kim & Chae, 2016).

Perception plays a vital role during any activity, and what is perceived is influenced by the teacher's instructions, previous experiences, and the knowledge of the learners. Therefore, perceptions regarding educational objects can be very different in science and arts (Turkka et al., 2017). For instance, observing a pot of melting snow could be perceived as the transformation from solid to liquid in science, or the conversion from the visible to the transparent in the arts (Turkka et al., 2017). But since both science and arts require observation for adequate interpretation of observed phenomena, it has, therefore, become imperative to enhance learners' active learning through the creation of an open learning atmosphere, where learners can interact with the content being taught using art as a teaching tool.

The arts have been used in the school system for a long time, especially in primary schools, where materials such as clay, wood, gold, and silver have enriched the teaching environment (Najami et al., 2019). According to Najami et al. (2019), art-based pedagogy focuses on process-oriented and reflective experiences and draws on a broad range of applied theatrical strategies which can develop learners' creativity, abilities, and aesthetic awareness. The application of the arts, therefore, becomes crucial because it can enable learners to develop creative thinking and scientific communication skills, as well as address their affective learning outcomes (De Beer et al., 2018). The arts will enable inspiration and novelty as well as the development of cognitive and social growth. It will also enhance creativity, reduce stress, and make science teaching enjoyable (Sousa & Pilecki, 2013). The next section will discuss the two educational approaches, STEM and STEAM, from point of view of the existing literature.

THE STEM EDUCATIONAL APPROACH

STEM employs an interdisciplinary approach to education that focuses on authentic learning processes. This requires inquiry, imagination, questioning, problem-solving, creativity, invention, and collaboration (Myers & Berkowicz, 2015). It emphasises the importance of 21st-century skills such as critical thinking, agility, initiative, effective communication, and morals. It also supports accessing and analysing information, as well as opportunities to apply the information and concepts learned in the field of science (Tsakeni, 2021; Vennix et al., 2018).

The STEM educational approach is anticipated to prepare learners to acquire thinking abilities which will enable them to become creative and analytical thinkers (Aldahmash et al., 2019). According to Aldahmash et al. (2019), the goal of an integrated STEM curriculum is to increase learners’ acquisition of knowledge and provide society with highly qualified scientists, technologists, engineers, and mathematicians, which is crucial for technological growth in the 21st century. The STEM educational approach is also anticipated to provide opportunities for learners to experience, engage, and solve real-world problems. This can be attributed to problem-solving being central to the four disciplines of STEM (Vennix et al., 2018).

Researchers have shown that the STEM educational approach has fallen short of its expectations, as there is still a shortage of STEM graduates and professionals (Hillman et al., 2016; Tsakeni, 2022). Moreover, the number of learners choosing STEM careers is declining when the demand for people to fill scientific positions is rapidly increasing (Hillman et al., 2016). The poor performance of learners from the USA in science and mathematics is also a concern that points to the need for improved STEM education (Rogers & Sun, 2019).

The shortcomings of the STEM educational approach in providing the solution to improved learner performance in science, coupled with overall learner underperformance, is a cause for concern. This is indicative of a system that cannot provide the learners with the knowledge and skills needed for academic success (National Academy for Science, 2012, online; Rogers & Sun, 2019) in the 21st century. This lack of capacity may be attributed to many factors, including the teacher-centredness of some teaching strategies in which knowledge and assessment-centred environments are prioritised. This contrasts with crucial STEM skills of collaboration, communication, and problem-solving (Rogers & Sun, 2019).

Herro and Quigley (2017) adduce that the STEM educational approach has not provided the much-needed knowledge to help learners to acquire the skills and attitudes needed to spur critical thinking in the learning of science. This failure can be attributed to the focus that STEM education places on mathematics and science. They further argue that it is not content-based and not really aligned with real-world situations.

The most prolific challenge to STEM education at present is to overcome the barriers that inhibit learners from succeeding in the STEM curriculum (Rogers & Sun, 2019). The solution to this problem may lie in learning through the proper blending of disciplines. This might allow the learners to solve problems set in a real-world context. They might learn new concepts from different fields, especially the arts, to develop positive attitudes towards science and is the viable solution for individual learners and for STEM education (Bush & Cook, 2019).

THE STEAM EDUCATIONAL APPROACH

The difference between STEM and STEAM lies in the inclusion of 'Arts' in STEAM. It employs a transdisciplinary approach to develop multiple perspectives that inform deliberation on a problem. A transdisciplinary approach begins with the problem and, through the process of problem-solving, brings to bear the knowledge of those disciplines that contributes to a solution (Meeth, 1978). This approach also employs collective expertise from many disciplines to pose and solve problems rather than focusing on individual disciplines (Quigley & Herro, 2016). According to Herro and Quigley (2017), the STEAM educational approach's transdisciplinary model of learning science provides the learners the opportunity to learn and solve real-world problems. The adoption of a transdisciplinary approach also ensures that learners learn through a blend of disciplines because the arts create creativity (Bush & Cook, 2019).

The STEAM approach incorporates the application of theories, concepts, or methods across disciplines, with the intent of holistically developing the learners' knowledge and skills (Lattuca, 2001), and to foster thoughtful reflections on their creative processes (Guyotte et al., 2015). It utilises project-based learning as a vehicle for learning scientific concepts (Opperman, 2016) to expand the model of education from STEM to STEAM. It also incorporates teaching methods that build authentic higher-order thinking and creative problem-solving abilities in the learners (Kim & Kim, 2016).

The STEAM educational approach incorporates the arts to enhance science education through exposing the learners to the objective view offered by science as a complement to the subjective view of the world as espoused by the arts (Sousa & Pilecki, 2013). The arts may help learners to draw on curiosity, observe accurately, think spatially, perceive aesthetically, and work effectively with others (Sousa & Pilecki, 2013). It has been found to increase the scientific efficacy and creativity of learners. It also maximises their interest and motivation in science, which helps to improve their scientific competitiveness (Kim & Chae, 2016). This might contribute to a positive attitude towards science.

The framework for the STEAM educational approach incorporates the common processes of science and arts. These include discovery, observation, experimentation, description, interpretation, analysis, evaluation, observing, wondering, visualising, exploring, and communication, although there are differences in the manifestation of the processes in each of the fields (Fulton & Simpson-Steele, 2016). These differences can be linked to the emphasis that art places on combining knowledge and personal experience, while science focuses primarily on the search for objective evidence to generate knowledge (Conner et al., 2017).

The aim of the STEAM educational approach is the application of arts to improve learners' confidence, attitudes, and interest in science (Kim & Chae, 2016) through new approaches to solving problems. The goal of this transdisciplinary approach is aimed at powerful, authentic learning opportunities, which can help the learners to tackle challenging STEM fields needed in the future workforce (Jamil et al., 2017).

This is mainly because the STEAM educational approach is learner-centred as opposed to teacher-centred, which enables learners to see themselves as designers and creators (Cook et al., 2017). It encourages learners to discover how to create new things, see familiar things in a new way, combine things in non-traditional ways, and think independently and unconventionally (Jamil et al., 2017). This approach, therefore, focuses predominantly on how to leverage the arts to provide a range of benefits to STEM learners (Guyotte et al., 2015). It also recognises the power of the arts in engaging more diverse types of learners (Bush & Cook, 2019). This is possible because it draws on curiosity, the ability to observe accurately, to perceive an object in a different form, and to construct meaning (Sousa & Pilecki, 2013). This leads to expressing observations more accurately and working effectively with others (Bush & Cook, 2019; Herro & Quigley, 2017). Participating in arts-mediated science learning has been associated with a wide variety of positive outcomes, such as improved long-term memory (Sousa & Pilecki, 2013). It also enables learners to understand the importance of human connections and the expression of feelings, which influence attitude changes (Rothkopf, 2016). The integration of the arts in science lessons, therefore, has the potential to engage the learners more deeply (Cook et al., 2017) and influence their attitudes towards science.

The arts remain a medium for ideation or the conceptualisation, study, and exchange of ideas (Keane & Keane, 2017). The arts are a collection of skills and thought processes that transcend all areas of human endeavour (Sousa & Pilecki, 2013). They provide learners with opportunities to develop unique ways of knowing and interpreting the world (Keane & Keane, 2017). The arts also elucidate empathy, and this can be a powerful tool in helping to build learners' motivation and passion towards solving problems in science (Bush & Cook, 2019). The use of the arts in the teaching and learning of science adds an affective component to the complex STEM concepts and problems. This makes the learning of content in science more accessible (Smith & Paré, 2016) and more engaging (Bush & Cook, 2019), and it could reinforce learners' positive attitudes towards science. The STEAM educational approach, therefore, aims at the transformation of natural science teaching and learning to inform creativity (Fulton & Simpson-Steele, 2016), which may influence the attitudes of learners by minimising the barrier to knowledge practically (Marmon, 2019).

THE SIGNIFICANCE OF THE STEM TO STEAM SHIFT

The framework for the STEAM educational approach comprises problem-solving and creativity, which encourages learners to look for ways of solving problems on their own (Kim & Kim, 2016). The aim is to develop learners' creativity through the convergence of the arts and science, based on the idea of improving learners' interest in science through holistic arts education (Kim & Chae, 2016). The STEAM educational approach highlights creativity, emotional touch, and the convergence between the arts and science disciplines (Parket al., 2016). This will enable learners to experience immense satisfaction in solving a challenging problem on their own, thereby increasing their confidence (Kim & Chae, 2016). This is because both the sciences and the arts require discovery, observation, experimentation, description, interpretation, analysis, and evaluation (Fulton & Simpson-Steele, 2016).

According to Kim and Chae (2016), recent developments in science and technology have led to an increase in globalisation, convergence, and unpredictability, causing a need for future scientists to develop creative problem-solving skills and global expertise rooted in arts education. This has become necessary because STEM's focus on education based on science or mathematics is not enough. The inclusion of the 'A' of arts in STEM activities delivers a natural platform for transdisciplinary inquiry (Quigley & Herro, 2016), which will have a positive effect on learners' attitudes towards learning science (Yuksekyalcin et al., 2016). The STEM to STEAM shift emphasises the relevance of the arts and creativity within the traditional STEM fields (Marmon, 2019). Studies have found that creativity influences learners to attain higher levels of thought and the ability to navigate complex and stressful situations (Marmon, 2019) because critical thinking facilitates the innovation required to solve problems (ibid.). This might improve their attitudes towards science.

The transdisciplinary approach of STEAM provides multiple approaches to solving a problem, which may promote learners' positive attitudes towards science (Bush & Cook, 2019) and offer flexibility and peace of mind. The STEAM educational approach also advocates collaborative learning. This might enable the learners to synthesise ideas and work with one another to solve problems. It, therefore, complements the goals for 21st century learning, which focus on problem-solving through innovation, design, and creative thinking (Bush & Cook, 2019).

The purpose of the STEAM educational approach, therefore, is to apply the arts in the teaching and learning of science, in order to deepen the understanding rather than teaching any of the particular arts (Romagnoli, 2017) since applied knowledge leads to deeper learning. The shift from STEM to STEAM lays emphasis on the development of critical thinking, creativity, and communication, which are essential skills needed in the integration of knowledge across disciplines (Bazler & Van Sickle, 2017). It also focuses on the individualisation of learning, which enables learners to explore their strengths and utilise these strengths in the development and consolidation of the studied content, thereby consolidating positive attitudes (Bazler & Van Sickle, 2017) towards science.

According to Ramagnoli (2017), the application of the arts in science teaching may also help learners to look beyond scientific concepts as merely equations, proofs, memorised operations, and prime numbers to see the people whose experiences affect science and mathematics. For instance, the scientific concept of force and motion (STEM) can be taught using human movements, i.e., dance (STEAM). This deepens and embodies the learning and helps learners consolidate their understanding of the theory, concepts, and skills (Lindquist et al., 2017).

Cook et al. (2017) also emphasise the importance of the integration of the arts in science lessons, since they have the potential to engage learners more deeply. The STEAM educational approach, therefore, is learner-centred rather than focusing on the subject area (Tsurusaki et al., 2017). The shift from STEM to STEAM, therefore, is not only expressed in the addition of the 'A' to STEM but also in the recognition that aesthetics, beauty, and emotion (affect) play important roles in problem-solving (Marmon, 2019). This highlights the importance of the arts as a solution to complex STEM concepts and problems, and also as a foundation for perpetuating innovation in the future (Mehta et al., 2019).

STEAM education represents the future of innovation and creativity. Csikszentmihalyi (1997) defines creativity as an act or idea that changes an existing domain or that transforms an existing domain into a new one, and a creative learner as a person whose thoughts or actions change a field or establish a new area. Art and science share many overlaps in terms of both standard practices and habits of mind, which can be harnessed in transdisciplinary thinking to enhance creativity (Tsurusaki et al., 2017). STEAM education as an approach, therefore, employs the arts, which embodies creativity, to connect disciplines that were previously perceived as disparate and provide learners with the necessary skills, problem-solving and positive attitudes needed to excel in the field of science (Marmon, 2019).

From the literature review on the importance of the incorporation of the arts (STEAM) in the teaching and learning of science, it can be deduced that it will provide learners with the above-mentioned advantages to enhance their creativity and positive attitudes towards the subject. I shall now use a specific example to illuminate the ideas in this section.

THE APPLICATION OF PUPPETRY ART IN EDUCATION

The use of drama (art) in the teaching of science helps learners view science as a human-social experience, which might enhance their understanding of the world rooted in scientific and humanistic traditions. This draws them closer to and increases their positive attitude towards science. The power of drama in combining the elements of art, music and sport can also help learners develop creativity as well as an affective and aesthetic awareness (Najami et al., 2019). As Braund et al. (2013) point out, as with other sociocultural and socio-linguistic traditions, the arts can lead to active teaching and learning in science. According to research, learners learn best through active participation and interaction with the teacher and other learners in the learning process (Chi & Wylie, 2014). Active participation means that the learners are cognitively and meaningfully engaged with the learning content (Pino-Pasternak & Volet, 2018). Since the arts are used to express feelings and ideas (Turkka et al., 2017), it is not surprising that methods drawn from the arts have been suggested when dealing with controversial issues in science education. This is because the arts enable multiple ways of expression and exploration of the science content (Turkka et al., 2017). Arts education is primarily focused on creativity, an essential component of innovation (Marmon, 2019), which promotes problem-solving and makes learning natural science fun and attractive. Research has shown that instructional methods embedded in arts education have yielded more motivated and engaged learners who can increase their learning (Mishra & Henriksen, 2013; Marmon, 2019).

Puppetry art is one of the numerous forms of art that can be incorporated into the teaching and learning of science. It provides a platform for the presentation of natural science lessons that lead to effective and meaningful construction and application of knowledge (Marmon, 2019). Puppets can be described as visual and symbolic representations that can communicate ideas sophisticatedly and act as a communication medium (Kruger, 2007). Puppets are powerful and stimulating tools in educational entertainment and have been used extensively in educational entertainment in South Africa for many years (Kruger, 2008). Puppets, theatrical creatures that exist and are autonomous art forms, allow learners to derive philosophical principles from performances and seek meaning in materiality (Cohen, 2017).

Puppetry art in education falls under the category of applied art (Kruger, 2008), which can be used as a tool for the promotion of the personal, social, and emotional development of learners in the science classroom (Simon et al., 2008). The use of puppets in the science classroom to present arguments can help learners to engage in dialogue and consider alternative perspectives on scientific ideas in a non-threatening situation (Simon et al., 2008).

According to Simon et al. (2008), using puppetry art as a teaching tool will help teachers to actively engage learners in the science classroom. As stated by the scholars puppetry art may be used to engage with the content of natural sciences to make the abstract content more meaningful and easier for the learners to internalise and apply (De Beer, 2015). The application of puppetry art as a teaching tool introduces a different style of interpersonal relationships which may be very productive for learning science. Engagement with science content through puppetry art might make science more enjoyable and enhance learners' attitudes and accomplishments in the subject. This is because the use of puppetry art in whole-class teaching can provide a stimulus for discussions that may involve learners in reasoning, arguments, open questions, and justification of ideas as part of the process of solving a problem (Simon et al., 2008).

Puppet characters can have "problems" for the learners to solve (Simon et al., 2008). The learners might treat the puppets as though they were real characters in the classroom and respond positively to problems posed by the puppets. According to Sasway and Kelly (2020), learner-centred strategies may improve the academic climate, attitudes towards science, and learners' confidence and self-worth, making science learning more engaging.

The use of puppets as teaching tools could also allow the teachers to take on new roles in the classroom. While using puppets, teachers could model behaviour and learning conversations without appearing to intervene as authority figures. This may enhance teachers' confidence, positive beliefs, and self-efficacy in science teaching (Simon et al., 2008). The use of puppetry art as an educational tool in the science classroom, therefore, has the potential to make a positive impact on the attitudes of the learners (Simon et al., 2008) because it aids scaffolding, which is crucial for the guided construction of knowledge. This may enable learners in peer group interactions to have alternative opportunities for cognitive development due to their exposure to reasoning that is superior to their own (Simon et al., 2008). This is evidenced by the Team Hyena Puppet (THP) project. THP is an interdisciplinary project that uses art (puppets and dance) to teach science. The team utilises dance to represent the cell cycle and puppets in the teaching of biology. This has transformed a previously dry section of a biology course into a memorable and meaningful event for the learners, and their performance in examinations has improved tremendously (Trommer-Beardslee et al., 2019).

Puppets may evoke thoughts, associations, feelings, and intentions during their interaction with learners, and after a lesson in the form of recollections (Ahlcrona, 2012). This can be attributed to their influence on the attitudes of the learners through external properties such as appearance, movement, speech, and action (Ahlcrona, 2012). Puppets, therefore, use the power of "affect" in shaping learners' positive attitudes, because "affect" is a sensation or a flow of energy which can be transformed into action, thought, or interaction (Sloan, 2018). This action, thought, or exchange has a powerful influence on learners' affective domain, thereby influencing their attitudes (Sloan, 2018).

Levy (2002) further elaborates on the benefits of using puppetry art as a pedagogy for science teachers. These benefits include having a personality that is appealing to their learners and fellow teachers, and being more confident, which positively impacts their teaching style. Furthermore, teaching with puppetry art gives teachers a safe avenue through which they can enjoy the fun and spontaneous aspect of teaching. He concludes by adding that such teachers would probably not suffer from professional burnout as soon as others would.

The use of puppetry art as a teaching tool also enables the teacher to view the lesson from the learners' perspective, incorporating their ideas and feelings into the lesson presentation so that the learners can relate to the puppet (Levy, 2002). According to Levy (2002), Simon et al. (2008) and Ahlcrona (2012), the use of puppetry art as a teaching tool promotes the development of positive attitudes in learners towards their studies because the puppets influence the learners' imaginary world and improve their creativity (Güçlü & Çay, 2017).

Natural sciences are a fusion of the major branches of science, the study of which will equip learners with the necessary process skills and values to provide a strong foundation for further study in science (Yeboah et al., 2019). Knowledge of natural science, therefore, is generated when learners interact with the content and teachers utilise appropriate instructional scaffolds to make learning a journey of discovery filled with adventure, curiosity, and wonder (Yeboah et al*.,* 2019). To make natural science learning a journey of discovery, the use of puppetry art as a teaching tool becomes a viable option. According to Ahlcrona (2012), the puppet, by virtue of its hidden property of appearing to be living in the interactions in the science classroom, has the capacity to evoke affective complexes and generate emotions in the learners.

In order to comprehend the power of affect in influencing attitudes, Sloan (2014) describes the affective experience as a feeling of relaxed alertness. He calls it a positive and pleasurable sensation associated with spontaneous creativity. Affect has often been considered an integral part of art (Turkka et al., 2017) and has been described as an "indiscriminate convergence of multiple potentials at any moment into becoming a being, which activates connectivity" (Sloan, 2018, p. 586). This might explain why the use of puppetry art in the teaching and learning of natural science might spur creativity (Güçlü & Çay, 2017; Sloan, 2018) and influence positive learner attitudes. This will have the capacity to enable learners to grasp and assimilate the content much more easily (Yeboah et al., 2019).

According to Levy (2002), the use of puppetry art as a teaching tool could have several benefits for learners. This includes helping to establish a safe atmosphere for follow-up discussions about learners' feelings on issues that matter to them. It might also help to increase humour in the classroom, which can turn the teaching of scientific concepts into long-lasting positive memories. He further emphasises the power of the puppets in reaching out and touching the hearts of the learners, firing up their imagination, and creating the "other personality" that brings excitement and drama to the science lesson.

The dual nature of the puppet in communicating ideas, i.e., visual and symbolic (Kruger, 2007), has the capacity to positively influence learners' attitudes towards natural sciences and improve their achievements as well. In a project carried out by Belohlawek et al. (2010), it was determined that using puppets to engage the learners in a lesson developed their thinking about concepts in science in an inquiring and exploratory approach. This was evidenced by the learners' high levels of consistency, engagement, and motivation. They employed more reasoning, gave more explanations, and justified their ideas better in the science lesson (Simon et al., 2008).

According to Simon et al. (2008), the use of puppetry art in teaching science enhances both the engagement and interest of the learners and the teachers' beliefs and practices. The use of puppets as a teaching tool in natural sciences may help learners develop emotional values. This may enable them to perform communication acts based on knowledge-related and emotional motives, which overstep the boundaries between the actual and imagined worlds (Ahlcrona, 2012). Güçlü and Çay (2017) reinforce this statement by adducing that puppets are important in education because they are familiar figures which may affect the imaginary world of the learners and improve their creativity.

According to Kruger (2008), incorporating puppetry art into the teacher's teaching strategy may be a powerful and stimulating tool in the classroom. Ahlcrona (2012) describes the power of puppets when applied in the context of teaching and learning of science as being able to evoke and arouse learners' emotions, thoughts, and associations, which positively impacts their attitudes. It can also help them form recollections, which consolidates their learning (Ahlcrona, 2012).

In a study carried out by Najami et al. (2019), in which puppetry art was used to teach chemistry to tenth-grade middle-school learners, they found that the use of puppetry art in teaching had a positive effect on the learning of various chemistry topics. The learners were found to have better scores than those taught without puppets. Moreover, the learners had a more positive attitude towards learning chemistry. The scholars, therefore, proposed that the inclusion of puppets as a teaching tool in the chemistry curriculum might help learners gain a better understanding of concepts that may be difficult to comprehend when using traditional teaching methods.

CONCLUSION AND RECOMMENDATIONS

The use of puppetry art in education offers a range of opportunities to develop STEM learners. This includes decision-making, exploring experiences, interacting with others, self-discovery, specific skills, and handling materials. It also makes learning memorable and stimulates learner engagement. This can be attributed to the power of the puppets as versatile tools for communication and learning (Ahlcrona, 2012). Puppetry art may be incorporated into the teaching of sciences to stimulate learners' positive attitudes and improve their performance since the puppets' characters are detached from the teacher's persona. They, therefore, add a unique teaching dimension that is flexible and controllable (Pearce & Hardiman, 2012). The use of puppetry art as an alternative teaching aid may improve teachers' and learners' self-efficacy, and make the teaching and learning of sciences more interesting (McGregor & Knoll, 2015) and meaningful.

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