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Using Arts-Based Methodologies: Facilitating First-Year Pre-Service Teachers' Collaborative Teaching of Cell Biology

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Abstract

Even with well-prepared lectures, some of my students still struggled to understand some of the concepts of cell biology. I therefore wondered if an exploration of teaching methods involving the arts would help them to engage with the subject content in ways that made it more accessible, and help them to understand the concepts better. Building on earlier approaches of using collaborative learning, I requested students to discuss, plan, and present to each other on cell biology concepts using arts-based teaching methods. In groups of 4–6 members, they could use any strategy such as dance, drama, music, poetry, and drawing to teach the concepts. The students collaboratively prepared content for a concept of their choice and presented it using their chosen and developed teaching strategy. Some of the strategies that students seemed to enjoy using included rapping the concepts, songs, dance, role play, and poetry. A few students resorted to individual PowerPoint presentations. The hope was that the enjoyment would translate into students' familiarisation with and understanding of the concepts better than through traditional teaching. Although the approach demonstrated that students could teach these concepts in versatile and fun ways, it did not assess their understanding of the concepts presented.

Keywords: arts-based methodologies, STEAM, STEM, teaching strategies, lecturer-designed task, micro-teaching, epistemological access, reflective narrative, flipped classroom

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Introduction

Can students learn concepts of cell biology better through arts-based activities such as song, dance, drawings, and poetry? How can an educator facilitate students to engage with everyday arts activities such as song and dance to learn concepts in life sciences? Life sciences is one of the science, technology, engineering, and mathematics (STEM) disciplines that are also grouped as science, technology, engineering, arts, and mathematics (STEAM) subjects (Aguilera & Ortiz-Revilla, 2021; Xanthoudaki, 2017).

The disciplines that constitute STEM are similar in their knowledge discourse and structure and are deemed to have connections between them. Bernstein (1999, p.159) described them as having "a coherent, explicit, and systematically principled structure, hierarchically organized, as in the sciences." These similarities and connections (Uştu et al., 2021) gave them the potential for an interdisciplinary approach to teaching the subjects. The STEM approach to education thus promises curricula as a meta-discipline where interdisciplinary bridges bring together what the traditional curricula have taken as separate disciplines (Uştu et al., 2021). Experiences of real life are complex, multifaceted, and constantly evolving in context. Disciplinary teaching and intended learning view science knowledge as static and fixed and as such, easy to understand because it is governed by laws and principles (Henriksen, 2014). Disciplinary knowledge in STEM subjects is also specialised and hierarchical (Maton, 2013), which makes their interaction with other forms of knowing discrete from each other and from human experiences and particularly, seemingly distant from the lived experiences of the students who are expected to learn, understand, and make use of the knowledge.

Interdisciplinary approaches can help educators to create learning opportunities through pedagogical approaches that mimic real life situations, which are often complex and ill-defined. Interdisciplinarity has been shown to foster creativity in students (Kubat & Guray, 2018). An interdisciplinary approach to teaching STEM subjects also provides students with increased motivation because authentic learning opportunities are meaningful and have a clear purpose to which students can relate. To engage in interdisciplinarity, students must first understand the concepts and then will they be able to relate to them. This study did not delve into interdisciplinarity but explored how students relate to the content through different lenses.

The poor performance of learners in general, in STEM subjects is due to the perception that they are difficult to teach and to learn (Winberg et al., 2019). They are difficult to learn because the knowledge is distant from learners' lives. STEM subjects are also perceived to be difficult to learn because the curricular and teaching approaches used often decontextualise the students from the knowledge and ultimately, alienate students from the intended knowledge (McKenna & Boughey, 2016). Students do not find any relationship with the knowledge because of its nature, how it is presented to them, and expectations relating to assessment. This alienation is associated with how the students are cultured into the university. The university culture is rigid and cannot accommodate students' prior knowledge and experiences of life and of learning. McKenna and Boughey (2016) argued for academic literacies, including scientific literacies, to homogenise university literacies with student culture—rather than depending on university literacies alone in classroom settings. This was echoed by Muller (2014) who asserted that the culture of teaching affected the achievement of students and hence, their success rate. This alienation results in lower enrolment and ensuing performance, particularly of women at tertiary level (Anaya et al., 2022), including teacher training.

Ultimately, those few students who do enrol for STEM subjects do not all complete their respective courses. Students need to be enculturated into the university so that their learning interactions are not divorced from their lives; the culture of teaching and learning must not exclude but recognise them so that they can also recognise themselves in the knowledge gained in STEM classrooms. The perception that STEM subjects are difficult also partly emanates from the poor epistemological access, which is ascribed to classroom-based factors including pedagogical approaches that alienate learners from the subjects and affect their self-efficacy and their beliefs about their abilities (Middleton et al., 2019). Bozalek et al. (2011, p. 2) noted:

> *Normative theories of student learning suggest that the lecturer needs to expose students to knowledge in the field and students will, on their own, be able to piece together how it works. In this autonomous model, students intuitively discover and understand the mechanics of the taught field, and are thus able, given that they apply themselves diligently enough, to both understand and even, at higher levels, produce knowledge in the field. When students find this difficult or even impossible to do then the fault must lie with the student; students may be cognitively unable or just too underprepared to grasp the concepts in the field.*

In this ubiquitous model of teaching in university settings, students are expected to be autonomous individuals who function by making sense of knowledge, and are able to cope with the demands of a course if exposed to its knowledge. This expected outcome is not always the case and the model is the cause of poor performance. According to Muller (2014), epistemological access has its roots in "what it means to teach" (p. 255). The implication is that teaching needs to be guided by the purpose to enable students to understand the knowledge intended for them in STEM subjects. Maniram and Maistry (2018) defined epistemological access as how students negotiate and access disciplinary knowledge, including the ways of knowing that influence their knowledge within a discipline.

This position challenges lecturers who have the pedagogic responsibility to be responsive to students' learning contexts, and to achieve epistemological assess for their students—particularly in STEM subjects. Muller (2014, p. 264) posited that a balanced and contextually nuanced mix of three aspects of epistemological access is appropriate for developing understanding of knowledge and meaning making, namely:

- Knowledge of theoretical propositions and theoretical systems, which focuses on theoretical, conceptual. and dispositional knowledge.
- Knowledge of things themselves, which implies knowledge of physical things and phenomena that constitute the things.
- A practice, its associated rules, norms, and customary moves. This aspect propounds that knowledge can be understood as practice and can be expanded through practice in a community, as suggested by Vygotsky (1978) and developed by Wenger et al. (2002).

Epistemological access is intertwined with the notion of *learning as connection*. Shumba and Kampamba (2012) suggested that the learning of science happens at the nexus of concept and context. This implies the student's social-cultural, socioecological, personal, familial, and other real-life situations and experiences in the community are relevant for meaningful learning. This is particularly important in STEM subjects, which seem distant from the lived lives of students. The lecturer should design teaching that will enable students to draw from the various tools in their lives to make meaning of the knowledge.

This study sought to draw from students' experiences of the arts to enable them to show their understanding of cell biology concepts. In so doing, the teaching was hoped to be humanistic and help with the *commoning* (making common) of the knowledge (Freire, 1970; UNESCO, 2015). Carter et al. (2021) thought the STEAM approach has potential to challenge existing identities of students, teachers, and researchers on how they view the nature and dominance of their home disciplines, their knowledge base, and nurtured abilities to handle the knowledge of these disciplines. STEAM therefore has potential to open and enable different spaces, skills, and competencies without converting artists into scientists or scientists into artists. It should only end at the point of enabling students to appreciate the interconnected (rather than the disciplinary) nature of knowledge.

Teacher educators therefore are tasked with preparing pre-service teachers to teach STEM subjects in a manner that makes them interesting and fun for learners such that there is an improvement in their performance and consequent increased uptake of STEM specialisations. Arts-based methodologies entail the use of arts subjects and methodologies for teaching (Carter et al., 2021). Thus, this article explores the use of arts-based and participatory methodologies in the teaching of life sciences, a STEM subject. This perspective has the potential to generate capabilities and competences that enable new, deeper, meaningful, as well as humanistic learning experiences—thus, a STEAM approach. Therefore, rather than exploring only the teaching of STEM, the investigated approach explores the pedagogical link between STEM and some forms of arts. The main research question for this study was: "How can a lecturer facilitate arts-based collaborative student interactions for STEM teaching in a life sciences classroom?"

The following sub-questions guided the study:

- How do pre-service teachers present the concepts using the chosen strategies?
- What are the emerging insights on the students' use of arts-based methodologies to present the chosen organelles?

This study was conducted in a first-year life sciences pre-service teacher context.

Literature Review

The key concern for this study was the employment of an alternative teaching method that would help students to collaboratively make sense of the concepts of cell biology in meaningful and engaging ways using arts of choice in microteaching activities. Mandikonza (2022) has demonstrated that pre-service teachers appreciated working collaboratively to develop an understanding of the cell biology concepts. Further to this, working collaboratively to understand the arts through using the arts is likely to enhance students' creativity and facilitate them to unlock their intelligences (Carter et al., 2021; Talib et al., 2019; Zhbanova, 2019). An assumption is that while engaging the arts for teaching science, students would also understand the arts better. Engaging the arts can be a creative process as students use them for their intended purposes. Zhbanova (2019) contended that the creative process emerges from observation, finding patterns, creating mental images, and making conclusions, all of which make learning more meaningful. In this case, it was hoped that facilitating students to engage with science concepts by using the arts would be a creative process but more important, would improve their ability to relate the arts to science concepts.

Stohlmann et al. (2012) suggested that among other practices for teaching math and science at high school, cooperative learning was important with the educator as facilitator. To achieve this, the teacher should build on students' prior knowledge to enable knowledge to be advanced through social discourse. Knowledge building should be understood as a social process in context, that is, it involves social interactions. This assertion agrees with sociocultural approaches to teaching and learning as propounded by Vygotsky (1978) who argued that the learning process should engage the individual in meaningful social learning processes. Carter et al. (2021) identified STEAM as a social practice that is increasing ecological awareness because learning is in context. Therefore, students' ability to construct new knowledge of science using what they already know, and what relates to their experiences, is paramount for learning. This means the ability of students to contextualise knowledge is important for knowledge development. Zhu (2020) foregrounded student-centred active learning as the key outcome of an integrated STEAM approach to teaching. That means students are engaged throughout the learning sessions. Student-centred active learning was also proposed by Taber (2018), who argued for mediation of social learning processes within students' zone of proximal development (ZPD).

Zhu (2020) further identified interactive lectures, blended learning, and individualised instruction as key elements for STEAM teaching and learning. Interactive lectures include question-and-answer activities that engage both educator and students in developing concepts. According to Zhu (2020), blended learning involves online and face-to-face interactions. The flipped classroom is a key component of this approach. The flipped classroom is when students are given a task to do away from the classroom, and then bring their task response to the classroom. The lesson can be conducted online or face-to-face. Lesson content is developed through facilitation of the students' responses (Church et al., 2021).

Henriksen (2014) described how a teacher requested students to create visual images of a concept (visual art used to teach a concept or idea). The teacher in question asked students to design an advertisement to sell a cellular organelle. Students drew on advertisement, artistry, and the intended cell biology knowledge to come up with the visual presentation. This teacher also asked students to write songs about cell concepts and sing them in class. This is similar to the approach I used, but I left it open for students to choose any strategy they wanted to use to teach any selected concept.

Research Methodology

This article presents a reflective narrative of my attempt at enhancing epistemological access by engaging first-year students on concepts on the topic of cell biology through the explorative use of arts-based teaching and participatory methodologies at a South African university. All first-year sciences students take the Natural Sciences 1 course. Cell Biology is the first topic in the Life Sciences component of Natural Sciences 1, and forms the basis of Life Sciences in the four-year teacher education programme.

First, I taught the general structure of the cell, and presented the general structure of both plant and animal cells as seen through the light microscope on PowerPoint. This showed the outline of the cell and a few organelles including the cell membrane, the nucleus, and the cytoplasm. This was to familiarise the students with the high school diagrams and introduce them to the images of plant and animal cells that they would observe with the light microscope during their practical sessions in the laboratories. I further used PowerPoint to introduce the ultrastructure of the cell as seen under the electron microscope. I used diagrams presented on PowerPoint to show details of the contents of the nucleus and of the cytoplasm. Further to the PowerPoint presentations, I played YouTube video clips that showed the general ultrastructures of the plant and animal cells, respectively. I used the nucleus and the cell membrane to introduce students to how the structure of organelles is related to their function in the cell, and I taught about these few organelles. In this study, as a teaching method, pre-service teachers were tasked to work in small groups of between four and six members to design a 10–15-minute micro lesson using any method of their choice among song, rap, poetry, role play, drawing, and PowerPoint to teach the structure and function of an organelle of their choice and to present this to their colleagues in class.

Corrégé and Michinov (2021) found that a group size of four members was effective for students because they provided adequate conditions for discussion and collaboration leading to *learning gain*—a term that implies learning. Blatchford and Russell (2020) thought small groups of four to six allowed for student interactions and provided opportunities for the teacher to assist individual students. Enu et al. (2015) pointed out that although cooperative learning was enhanced in small group settings, group size itself was not important—it is the strategies used to engage groups that are important in driving learning of concepts. My decision for four to six students was conscious and deliberate; the information on each of the organelles was very brief and did not need more presenters. And, small groups were ideal because collaborating members of a group tend to present together, and the time available would give each one a chance to present and receive comments from the lecturer on their part. The prompt for the students' task was:

> *Work in groups of 4–6 members to use any of the strategies such as dance, drama, music, poetry, and drawings to teach the structure and function of cellular organelles of your choice. The lesson presentation will be for 10–15 minutes.*

This article reports on that task by means of vignettes of students' work and lecturer reflections to establish the efficacy of the exploration. The quality of students' presentations is used here as a proxy for success of the method. Quality was determined by the appropriateness of the method or strategy used, the correctness of the content, the learning support materials used to present, and how innovating and captivating the strategy was for the audience. A qualitative, interpretive, and reflective narrative case study was used. Qualitative research focuses on understanding real-life problems, including concepts, opinions, emotions, or experiences, and relationships of research participants without using numbers (Mohajan, 2018). In this instance, I present the case of my experiences with students using arts-based methodologies to present on cell biology concepts. I studied these experiences by establishing if the approach used to give students a task to present on organelles was appropriate for teaching about the cell structure and function. Students' groups presented online during online sessions. Research participants were the Natural Sciences 1 student teachers and me. The data generated from online lessons were recorded on the Canvas Ulwazi institutional platform. The data therefore were in the form of audio-visual recordings. Because an interpretive approach permits subjective and multiple perspectives, the researcher can explore human experiences in their socio-ecological contexts. Thus, I could study my own experiences of facilitating the use of arts-based methodologies to teach topics in cell biology. These were presented as vignettes in this report.

An interpretivist paradigm was appropriate for this study because it provided for the researcher to study social reality, which is viewed as not singular or objective but is rather shaped by human experiences and social contexts (Tracy, 2013). Therefore, it is appropriate to subjectively study the phenomenon of using of arts-based methodologies in social contexts and classroom teaching processes. Knowledge is developed through communication and practice is mediated by the researcher (Tracy, 2013). The case study was appropriate for this study because it allowed for the study of the contemporary phenomenon, the use of arts-based methodologies, in participants' natural setting. The natural setting was the interactions in a teacher education classroom (Johansson, 2005). Data for the study were in the form of PowerPoint presentations, lecturer's notes, and students' notes and the artefacts they produced for and during presentations.

Narrative enquiry was appropriate because it is a form of qualitative research where accounts are the raw data (Chambers, 2003; Wolgemuth & Agosto, 2019). Narrative studies discern meaning by analysing stories about individuals and the societies in which they live. They also present interactions within the societies by studying how these stories are constructed. Therefore, narrative enquiry is suitable for a qualitative interpretivist study because it allows for the development of subjective and contextualised knowledge (Butina, 2015; Creswell, 2007; Wolgemuth & Agosto, 2019). A biographical account of the processes and struggles involved in the practice of teaching cell biology allowed me to interrogate nuanced experiences of the phenomenon. This interrogation of practice is in line with Clandinin and Connelly (2000), who posited that narrative enquiry can be conducted within formal institutions, including classrooms in schools. The narrations themselves, being an analytical artefact, are accompanied by a process of reflection. This reflective process elicits reflection-in-action (the reflections on practice development that took place during lessons) as well as reflection-on-action—investigating the unfolding of the teaching practice and its effect on conceptual development, as well as the affective dimension of the phenomenon after the lesson (Chambers, 2003).

At the beginning of the year, students were invited to participate in research processes aimed at improving my teaching practice. Students were invited to complete consent forms and were informed of the voluntary participation clause, which provided that should they change their mind at any time during the year, they were free to withdraw or to withhold their participation in any of the studies. Data were analysed inductively, and the analysis was guided by the key concepts in the literature and the research questions. It was notable to examine the accounts presented in the vignettes and establish what they meant for the research questions.

Results

The class had 270 students. These pre-service teachers worked in self-organised groups of between four and six participants. It was not possible to establish the exact number of student groups that shared an organelle because only a few of them presented due to time constraints, and they tended to repeat the organelles. Only two or three groups could present on the same organelle. Groups that shared an organelle were asked to provide input by adding information the presenters had missed. Table 1 shows the distribution of groups per organelle presented.

Table 1

Distribution of Groups per Organelle Presented

Group Size	No. of Groups	Organelle	Strategy Chosen
5	3	Nucleus	PowerPoint, pictures, and video
20	1	Cell/plasma membrane	Role-play/drama, song, and video
6	3	Rough endoplasmic reticulum	Poetry, PowerPoint, and video
6	2	Golgi body	Poetry
4	2	Lysosomes	Song
6	2	Mitochondria	PowerPoint and video
5	2	Ribosomes	Song
5	2	Plant cell wall	PowerPoint image
6	2	Chloroplast	PowerPoint image and video

For the PowerPoint presentations shown in Table 1, one member of the group acted as organiser and conductor of the presentation and guided the others. They introduced the members and the layout of the presentation. The other members presented a few lines of the script notes of the organelle, in turn.

Group members therefore chose sections of the scripts that they would present, however, they all worked on the same script. That implies that in their preparation, students would have familiarised themselves with their respective scripts. This allowed for smooth transition from one presenter to the next and if there was a diagram, they all referred to the same one. My thinking is that students collaboratively helped each other to understand the organelle prior to presentation. Although an observer could not conclusively say that the students had learnt and understood structure and function of the organelle, there is evidence that there were social processes when students interacted on the organelle.

When presenting in song, members of the group participated simultaneously, with participants taking different roles. Some members hummed the tune as others presented the notes as lyrics of the song. This choice of presentation was different from the previous one where students took turns to present from one script—here, they contributed together by providing lyrics and the sound.

Because there were fewer organelles than groups, two or three groups sometimes prepared to present on one organelle. Over and above the organelles, students could also cover the topic of the general structure of the cell itself, which I had covered in class. Six groups chose to use song and poetry, 10 groups used PowerPoint presentations, and one group used role-play (drama). Due to time constraints, not all groups could present and so those that shared an organelle had one group presenting and the others added comments on what was missing, and whether and how the strategy used was effective for teaching the organelle.

Only songs, role-play, and PowerPoint are highlighted in this research report to illustrate the creativity that pre-service teachers have, and can show, if the lecturer gives them a chance to explore collaborative teaching using unconventional strategies.

Songs

One of the songs that six pre-service teachers composed was on the cell membrane, and is presented in Excerpt 1.

Excerpt 1

Lyrics for a Song on the Cell Membrane

> ***The Plasma membrane***
> *-the plasma membrane is the membrane enclosing the cell*
> *-another name for the plasma membrane is the cell membrane*
> *-it is found in all cells and it separates the interior of the cell from the exterior environment*
> *The plasma membrane has got proteins which stick outside of it that allow for cells to interact with one another.*
> *-These membrane proteins have got different functions, one them being the Junctions which serve as a connection between two cells joined together.*
> *-There are Gap junctions and also Tight functions*
> *-Their function is to help cells communicate with one another and be able to receive and also transfer different materials between each other.*
> *-Another function served by membrane proteins is Enzymes function*
> *-The enzymatic activity is to localise metabolic pathways fixed to membranes,*

membrane embedded enzymes catalyse chemical reactions occurring within the cell.
Transport protein takes important substances from one side of the membrane to the other side,
Important substances like ions(sodium and potassium)sugars(glucose), messenger molecules and many more.
We have two different types of transport protein
1. activated diffusion
2. Active transport

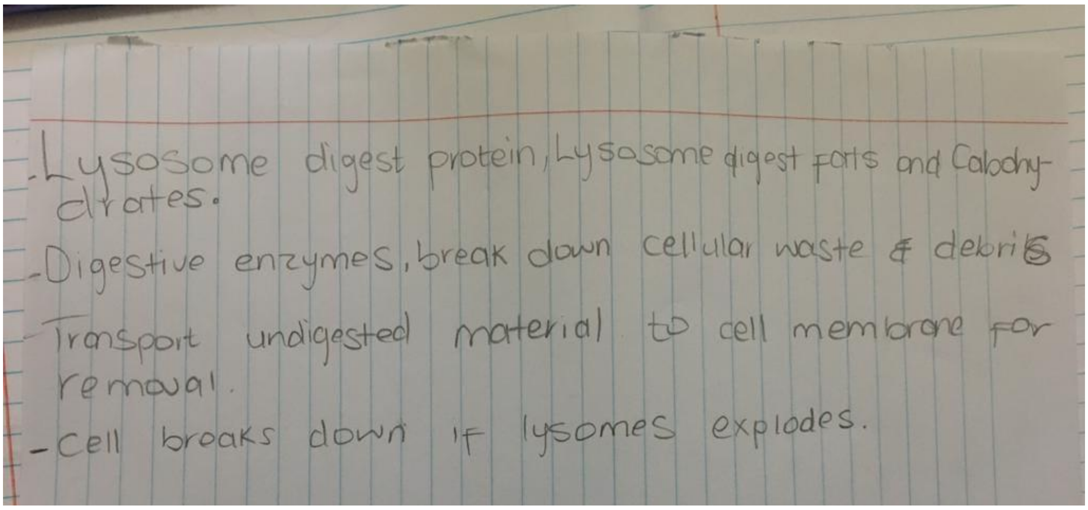
Four group members each narrated a few lines in turn, while the others hummed a tune and performed a slow swing dance. While they sang, I took note of what was missing and what needed to be corrected. After the presentation, I asked the other students to comment on how appropriate the strategy chosen was, how it was implemented, and the correctness and depth of the content. The melody was very beautiful; it was a mix of a capella and rap. The group received resounding applause from the rest of the class.

I proceeded to illustrate where the cell membrane is located, and how it relates to the structure and functions of the cell. Because the students had sung the song, they did not have an illustration of where exactly the cell membrane was. Therefore, I consolidated their presentation by referring to an image of the generalised structure of the cell to show the location of the cell membrane. I then presented the fluid mosaic model of the cell membrane to show the different components, including the bilipid layer, the intrinsic and extrinsic proteins, glycolipids, glycoproteins, cholesterol, and phosphorins to illustrate some of the concepts on the architecture of the cell membrane that were alluded to in the song.

Another group of six presented an a capella song with the following lyrics about the lysosome (Excerpt 2).

Excerpt 2

Lyrics for the Song on Lysosomes


-Lysosome digest protein, Lysosome digest fats and Carbohy-
drates.
-Digestive enzymes, break down cellular waste & debris
-Transport undigested material to cell membrane for
removal.
-Cell breaks down if lysomes explodes.

One member sang the lyrics soulfully while the others hummed a background sound. They combined this song with a PowerPoint image of the structure of the lysosome, which they showed to the class during their song. Their visual presentation shifted from the singers to the PowerPoint presentation that showed the structure of the lysosome. They combined the singing with a slow swing dance as they hummed. The presentation was therefore multimodal—the song, its lyrics, and the image. Given the time available for each group presentation and the brevity of their notes, this group repeated their song thrice. Of note, was that although the dance was not related to the organelle in question, it made the presentation interesting to watch and listen to. The content presented on structure and function of the lysosome was correct, and the method chosen was appropriate for the teaching. I consolidated this by showing a YouTube video of the lysosome. I also noted that the students had not distinguished between primary and secondary lysosomes and therefore used the presentation as a background on which to build content on primary and secondary lysosomes. And I linked these to phagocytosis, phagocytic vesicles, pinocytosis, and pinocytotic vesicles to result in secondary lysosomes. It was also important for me to distinguish lysosomes from other single membrane bound organelles, the peroxisomes. The presentation therefore demonstrated the knowledge that could develop through collaboration and zones of proximal development (Vygotsky, 1978). I acted as a more knowledgeable other to expand students' knowledge to show relationships between lysosomes and other organelles.

Role-Play

One group designed a role-play for the fluid mosaic model of the cell membrane and transmembrane transport. They organised themselves into a bigger group of 20 members by combining four groups. Some members faced each other in a line and held hands to represent the phospholipids. Some with labels on their shirts stood between them to represent transmembrane proteins, and others with different labels on their shirts represented extra membrane proteins and yet others with labels on their shirts represented the particles that were to move across the membrane (including water, alcohol, lipid molecules, and cholesterol). The particles were labelled as polar and non-polar particles. One participant was a narrator and at each stage, she narrated the structure and behaviour of the membrane and the particles.

Although the fluidity of the membrane was not illustrated, the correct content of the basic structure of the membrane was demonstrated through the role-play. Students were able to illustrate the bilipid layer and transmembrane proteins. This presentation was supported by a PowerPoint picture and a video animation after the role-play. The activity took almost 30 minutes, which was thrice the length of the designated period. The labels on students' shirts and the combination of role-play, PowerPoint, and closing animation consolidated a very informative activity.

The rest of the class applauded the presenters in acknowledgement of the quality of their work. I then asked the class if this method of teaching was appropriate, and whether the content was correct. Students had appreciated the method, and examples of their comments include:

> *This was awesome, the group managed to show the structure of the cell membrane.*
>
> *The way they thought about representing the transmembrane proteins made the membrane structure visual and this helped me to understand movement across the membrane. For example, the high concentration of particles on the outside and them moving through the pores showed diffusion. The group failed to convince me about active transport.*

This student appreciated one illustration of passive transport and how it is related to the porous nature of the membrane, however, the demonstration of the notion of active transport was not well received by the student.

To consolidate the presentation, I used my prior PowerPoint presentation of the ultrastructure of the cell to show where the cell membrane is in plant and animal cells and how it relates to other organelles and to the functions of the cell. The other organelles that relate to the cell membrane include the cell wall and cell-to-cell junctions. I further presented the fluid mosaic model, and how it was discovered through freeze-fracture and the use of a scanning electron microscope. This led to distinction of the different functions of two main electron microscopes, the transmission electron microscope, and the scanning electron microscope. The role-play had served as background for building other concepts relating to the cell membrane.

PowerPoint Presentations

As in Mandikonza (2022), a few individuals decided not to collaborate with others. They instead decided to make individual lecture-based PowerPoint presentations. They argued that they could benefit from working in groups and preferred individual work. They presented fairly comprehensive PowerPoint-based lectures with pictures and notes. These students indicated that in high school, they were taught to be independent and found that they understood and completed tasks better when working alone:

> *At high school, we mostly worked independently and we kind of competed against each other. We were encouraged to work in groups, but the final result was yours alone. We therefore had to work minimally with others and then work very hard alone. I personally only looked for others when I needed specific help when the teacher was not there. You help someone, and they beat you in class.*

Therefore, high school practices influence students' socio-cultural abilities. As an educator, I have ideas about how students learn best but I think that it is important to allow them to work in the ways they think best for them to succeed. Nonetheless, the educator should continue to encourage students to collaborate in the activities that they engage in during lessons. I left these students to work alone but encouraged them to collaborate through informal assessment activities such as 5–10-minute discussions during my lessons.

Those students were also not patient with the back-and-forth that takes place when working in groups. They offered comments such as:

> *Group work is very slow and boring. Students argue, at times over simple things and that takes so much time. Working in groups delays because time is spent on deciding how to do the group activity rather than doing the activity itself. By the time you agree on anything, you will have forgotten why you got together after all.*

These students thought the deliberation that happens in group tasks slowed their work. They also thought the deliberations distracted them from the actual task. All group activities involve setting the rules of engagement first before embarking on the actual task, which is what these students felt they did not have time for.

Student Responses to Using Arts in Group Work

Some students thought teaching through the arts did not give the science content the seriousness that it demands. They noted:

> *Students spend a lot of time to think about the strategy to use and they spent a lot of time rehearsing their presentation. That time could have been used to study the organelles. The effort was spread on both the content and the strategy instead of the content alone.*

Thus, they saw the importance of content, but they did not see how the strategy facilitated epistemological access—by working collaboratively and learning from each other or by organising the notes used during presentations. This contrasts with most students who thought learning biological concepts through non-formal teaching and learning strategies was fun, and made learning of the concepts easier and lighter.

Many pre-service teachers expressed that they enjoyed preparing for and presenting the collaborative microteaching lessons and besides getting a better understanding of the concepts, they also got to know each other. Comments included:

> *Our group was made up members from our residence. We know each other from the classroom but had not talked a lot to each other before this task. Once we formed the group, we agreed that one of us make the notes. We came together and she taught us about the organelle. When we understood it, we discussed on the method of presenting. We shared some tunes from songs that we each like. We agreed on one and then we added the notes to the tune.*

Therefore, students ended up adapting songs that they already enjoyed and sang to for the task. Further, they said:

> *It was fun because we got to know each other's names, the songs that others liked, and we also we taught each other. We mostly used our smart phones to get the information and the images of the organelle.*

Vygotsky (1978) asserted that learning is social, and in the third generation of cultural activity theory, Engeström (1987) suggested that mediation of learning an object (content in this study), entailed participants working in a community. My students used tools including psychological tools, such as the task, as well as their knowledge of songs. Students interacted on developing understanding of the concepts. The group task was a mediation tool for learning the intended concepts. It also emerged that students' responses were a form of informal assessment that the teacher educator could use to assess the affective and cognitive outcomes of the teaching process. These pre-service teachers appreciated the teaching method, and the teacher educator for the teaching approach, which was new to them.

Discussion

My study interest was how student teachers responding to a lecturer-generated task, and working collaboratively, would present information on chosen organelles and their choice of strategy. Students decided inter alia, on the use of song, drama, and PowerPoint pictures. The task they responded to acted as a stimulus and mediating tool (Engeström, 1987; Vygotsky, 1978). I facilitated students to engage their creativity through the mediation tool. The students showed that when motivated, they can come up with innovating and interesting teaching methods. But, in using these methods, a lecturer has to illustrate the nature of content to be taught by giving a good background before giving the task.

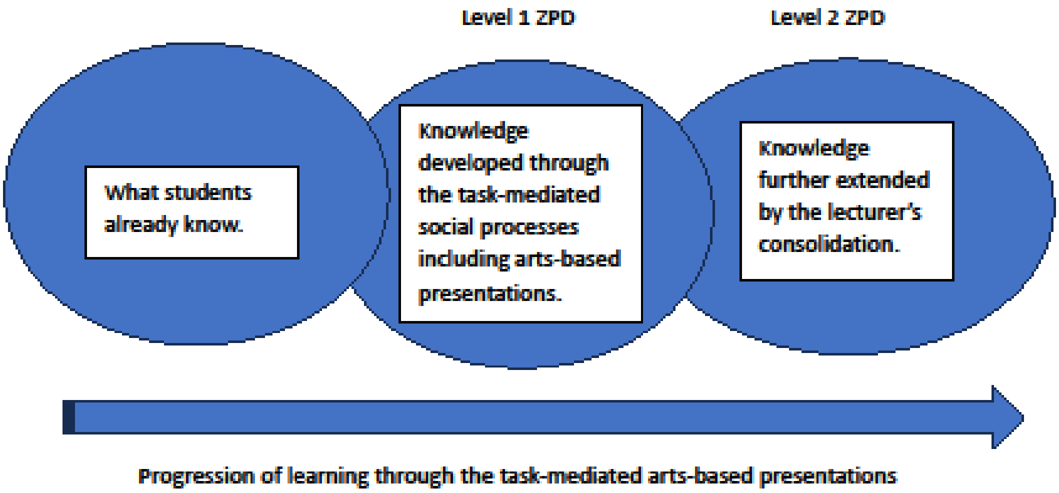
Further, Talib et al. (2019), Zhbanova (2019), and Carter et al. (2021) asserted that students who engage in arts-based methodologies demonstrate creativity. This methodological space allowed students to explore their inner selves and to find links between their everyday lives and the disciplinary content. Although the links shown in the activities do not point to their understanding of content, they illustrate how they could relate the teaching of cell biology content to music and visual arts such as role-play (Henriksen, 2014).

The flipped classroom approach was central to this whole activity. Through this classroom strategy, pre-service teachers were able to engage with the concepts and choose the one they wanted to collaborate on. Some pre-service teachers engaged with concepts that were easy for them and that would give them flexibility to design the way to teach it. Others chose an organelle they thought was difficult for them to understand so that in the process of conducting the task, they might understand it better. These students therefore used the opportunity to study it in-depth and assist each other to understand it. Thus, sociocultural learning processes helped the pre-service teachers to expand their zone of proximal development (Engeström, 1987; Vygotsky, 1978). In working together, some pre-service teachers were the "more knowledgeable" who helped others to understand the intended concepts before sharing them with the class. Every group had an active leader who organised the students to collaboratively engage with the task. The task was therefore a scaffolding tool for the flipped classroom, including pre-service teachers' interaction among themselves, with the intended knowledge, and for how they interacted during in-classroom activities. Taber (2018) who emphasised Vygotsky's work, proposed that the teachers who wish to scaffold their students' learning in their ZPD need to design appropriate learning activities and support materials. Students were challenged to explore presentation of concepts with the hope that they would understand them better using the arts, which are part of the tools in their ZPD.

Taber (2018) also suggested that during scaffolding, the teacher's role must wane. This was evident with a lecturer who introduced the topic of structure and function of cells including cellular organelles, and then designed a task for students to pick up from where he left off. Further, the lecturer only came in to consolidate the presentations, giving more autonomy to the students. This approach of facilitating students to engage in flipped classroom tasks allows the teacher to intervene as a second level mediation process where he scaffolds students from what they presented, to another level in learning the concepts. The students therefore undergo two levels of the ZPD as shown in Figure 1.

Figure 1

Stepwise Expansion of the ZPD in Class



The first level is where the students collaboratively engage in arts-based strategies to develop understanding and to present to their colleagues. The second level is where the lecturer intervenes to consolidate the students' presentations and use concepts presented as the starting point for other related concepts. In the first socio-cultural process, students learn from each other and in the second, students learn mainly from the lecturer. Using arts-based teaching strategies to present concepts on cellular organelles created a platform for students to engage with concepts and for the lecturer to use these as a starting point to mediate his own teaching and expand the students' ZPD more meaningfully.

Conclusion

It is possible to facilitate students to work collaboratively to present to each other on cell biology concepts provided the students are given a task to guide them. The task is a mediation tool that mediates students' interactions among themselves and their interactions with knowledge. This was illustrated by those students who expressed that they were able to learn the concepts through the interactions.

The flipped classroom was shown to be a successful mediating approach for arts-based STEAM collaborative learning processes. The lecturer-generated task facilitated pre-service teachers to interact and deliberate with each other and with biology concepts in interesting and less formal ways, pointing to their ability to familiarise these would-be strange and difficult concepts that tended to be outside their lived lives. That the pre-service teachers managed to link the pedagogy of concepts to aspects of their lives that they enjoy, is evidence of the success of facilitating epistemological access and the knowledge commoning intent of the teaching strategy. Therefore, if lecturers provide pre-service teachers with the platform, they can innovate the teaching of concepts in ways that link the arts and science through pedagogy while developing understanding of the same concepts. Ultimately, social learning activities tend to provide conditions for collaborative learning and creativity pursuits for attaining quality STEAM education as per Sustainable Development Goal 4. The integration of collaborative arts-based strategies makes the lesson STEAM-focused because students explore the meaning of sciences concepts through socio-cultural processes—and they learn other attributes including social interactions and collaboration.

For this teaching strategy to be successful, the lecturer needs to generate an appropriate task for students to work on collaboratively away from the classroom. There must be adequate time for students to make their presentations, therefore, time management is crucial. The activity could also be assessed, which would stimulate greater engagement. Even though these lessons are primarily for student presentations, the lecturer must be prepared to mediate those.

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