FEATURE ARTICLE

The Use of Puppetry and Drama in the Biology Classroom

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Abstract

Teachers often wonder how best to teach the myriad of social and ethical issues that are encompassed in the biology curriculum. One can just think of issues such as genetic engineering, evolution (and the continuous evolution-creationism debate), research ethics (the haunting book The immortal life of Henrietta Lacks *comes to mind), human population studies, health care and nutrition, sexuality and gender, drugs, environmental pollution, to name but a few. In this article we highlight the advantages of puppetry in the biology classroom, as an engaging pedagogy that could assist conceptual change in students. We explore the dual epistemological border-crossing that takes place in the classroom when puppetry is used: (a) the integration of societal and ethical issues within the biology curriculum, and (b) the infusion of art and drama within the natural sciences. We reflect on our own classroom action research on puppetry, and share our main findings. We also provide practical guidelines for using puppetry as pedagogy within a problem-based and cooperative learning setting.*

Key Words: *puppetry; epistemological border-crossing; social and ethical issues in biology; arts in the natural sciences; teaching for the affective domain.*

○ Introduction

We Need to Stop Addressing the Affective Domain as a Game of Bingo

The biology teacher is faced with the challenging task of also teaching for the affective domain. Krathwohl (1964) defines the affective domain as encompassing values, attitudes, and learner motivation, and developed a taxonomy for the affective domain that ranges from simple awareness on one end to internalizing values on the other. In a demanding 21st-century, we not only need to emphasize important skills such as critical thinking and problem solving, but we also need to focus on affective qualities such as values, respect, tolerance, ethical behavior, and academic honesty. Rotherham and Willingham (2010) state that 21st-century skills favor student-centred methods such as problem-based and project-based learning. These authors show that, unfortunately, many teachers rarely use these methods, and that it's often "a matter of chance rather than the deliberate design of our school system . . . we cannot afford a system in which receiving a high-quality education is akin to a game of bingo" (Rotherham & Willingham, 2010, p. 17).

We would like to use this metaphor—a game of bingo—and we claim that affective education is an even bigger problem than problem- and project-based skills, and that many teachers simply assume that affective development will automatically follow the attainment of the cognitive outcomes. Teaching for the affective domain should receive more attention in both pre-service and in-service teacher education. Buma and De Beer (2014) use the analogy of an iceberg, with the cognitive outcomes the visible part of the iceberg that can be seen above the surface of the water, and the affective outcomes are the invisible part under the water. The affective domain, which Buma and De Beer (2014, p. 540) call the "missing link" in science education, is very important for cognitive development. Recent research in neuroscience shows us that learning experiences with an emotional stamp (the affective domain) become committed to memory (Dubinsky et al., 2013). Yet research shows us that teachers shy away from teaching for the affective domain. Several reasons are listed in literature for the marginalization of affective outcomes: the ambiguity of the affective domain, and the lack of teachers' pedagogical content knowledge in this regard (Neumann & Friedman, 2010), teachers' views on the nature of science (Cronje, 2015), and the difficulties in measuring affective learning outcomes (Birbeck & Andre, 2009).

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Puppetry (and drama) as a pedagogy is an excellent way of addressing the affective domain in the biology classroom (Dahlstrom, 2014; Brits et al., 2016). However, teachers are generally hesitant to

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use such pedagogies, among others, due to their views of the nature of science (Brits et al., 2016). Cronje (2015) has shown that many South African teachers have a view of science that predominantly accentuates tenets such as its empirical, inferential, and tentative nature, while often overlooking tenets such as its creative nature that accentuate human creativity and imagination as pillars of the natural sciences. A growing number of voices nowadays no longer see the natural sciences and the arts as two distinct fields, and STEM (Science, Technology, Engineering, and Mathematics) is slowly making way for STEAM education (plus Arts) (Fulton & Simpson-Steele, 2016).

In this paper we look at the advantages of a dual epistemological border-crossing (Cronje, 2015): first, the border-crossing between science and our daily lives (highlighting science-and-society approaches), and second, the crossing of borders between two different bodies of knowledge, namely scientific knowledge and the arts. Fulton and Simpson-Steele (2016) see an alignment in the processes of science and art in that both require discovery, observation, experimentation, description, interpretation, analysis, and evaluation. These researchers are of the opinion that STEAM could lead to more meaningful experiences than a single subject or content area can render (Gurnon et al., 2013). Tselfes and Paroussi (2008) show that theater and the arts bring an important dimension into science education, namely how scientific ideas are produced and embedded in the historical and social context of the age that created them. This is also in line with the thinking of Gibbons (2000), who, with his construct of "mode 2 knowledge production" refers to interdisciplinary, contextual science. Tselfes and Paroussi (2008) refer again to the "cross-thematic" curriculum, and that scientific and artistic cultures are compatible.

In this article the authors explore the use of puppetry as a pedagogy in the biology classroom. Puppetry is not just an effective medium to use in early childhood education, it also holds much promise in teaching senior students. We argue that this epistemological border-crossing holds much promise in the biology classroom. We share our own experiences of using puppetry as a pedagogy in our own classrooms.

Learning as *Homo ludens*: The Advantages of Puppetry in the Biology Classroom

Natural sciences is rational by nature. An often-neglected aspect is that science also relies heavily on creativity and imagination (Brits et al., 2016). In this article the roles of puppetry and drama as pedagogies are explored, in which the learners enter the biology classroom as *Homo ludens*, the playing human (Huizinga, 1955). The power of storytelling lies in its "narrative effect," whereby it creates interest and enhances understanding of the concepts being taught (Brits et al., 2016). Flannery (1989) also highlights the role of personal vignettes and storytelling in the biology classroom, and its value in addressing affective outcomes. Wagner (1980, p. 13) speaks of the doyenne of drama in education, Dorothy Heathcote, who said to "always look for the precise dramatic pressure that will lead to a breakthrough, to a point where the students have to look at a problem in a new way." This highlights the role of the affective domain in conceptual change. Researchers often look at students' conceptual change from a reductionist cognitive view only. Pintrich, Marx, and Boyle (1993) state that such a view on conceptual change from a "cold" cognitive lens is not advisable, and that a "warm" lens—one that takes into consideration that human emotions, worldviews, and belief systems influence how conceptual change occurs—should be adopted. We argue that, through puppetry, human emotions will also be part of the learning, and that this could assist conceptual change.

The pedagogical advantage of drama (or puppetry) is that it creates environments that will appeal to the affective domain. Keogh et al. (2008) showed that teachers who used puppetry found that it created the opportunity to present authentic problems rooted in students' everyday experience, enabling them to readily identify with the problem of the puppet character. Odegaard (2003) also shows that drama can contribute to learning about the nature of science as well as the interaction between science and society.

Soord (2008, p. iv) highlights a number of advantages of using puppetry: "Puppets are extraordinary. While they acquire a life of their own, they remain inanimate and can seem less intimidating when addressing sensitive issues. They break boundaries between people, both physically and emotionally. They allow us to take on numerous identities and act as a shield for us to hide behind. They can give people the confidence to say and do things they wouldn't usually say or do if they were visible." Soord has shown that puppetry is an excellent way of dealing with controversial or sensitive issues, and that students are more likely to communicate their own viewpoints or concerns during a puppet show than during a traditional classroom situation.

Our Own Classroom Action Research on Puppetry

Classroom action research (CAR) represents a midpoint between teacher reflection at the one end and traditional educational research at the other (Mettetal, 2002). Our research focuses on puppetry as a pedagogy in the classroom in three different contexts: (a) with children (e.g., at science fairs), (b) with student teachers, and (c) with teachers during in-service professional development activities. The overall research question that guided this CAR was: What are the advantages of puppetry in the science classroom? Our findings are that teachers acknowledge that puppetry addresses the affective domain. One participant in our study reveals that puppets could be used to address controversial topics within the Life Sciences curriculum: "It is an excellent way of addressing emotions and also explaining controversial differences." One teacher stated, "It helps to make learning interesting. Learners are curious, and they enjoy puppetry as a medium." Teachers also flag the importance of involving all students in the puppet show: "It works best if learners are involved throughout. They should write their own scripts, and make their own puppets." Teachers also commented on how learners could express their own views during puppetry, without fear of judgement of others: "Puppetry creates a safe space for students to share their thoughts." Puppetry could create a conducive teaching and learning environment that could facilitate the discussion of sensitive issues such as HIV/AIDS. Puppetry assisted student teachers to engage in a pedagogy that is not considered "mainstream" in science education, and this facilitated physical, emotional, and cognitive engagement. It also showed the science student teachers that every teacher should have a personal teaching style, and that there is not a "one-size-fits-all."

○ Methods

Involving Students in Puppetry in the Biology Classroom

When using puppetry as a pedagogy in the classroom, the students should be involved. You are advised to let the students work in small groups, and utilize a cooperative learning and problem-based approach. Each group of students should select one of the topics discussed below (or any other topic that you deem fit). We would like to refer you to basic guidelines for cooperative learning, which are summarized in an article in *The American Biology Teacher* by De Beer and Petersen (2017), including, among others, positive interdependence (students should engage in cooperative learning with the view that they can succeed only if other students do, too), individual accountability (each student should take responsibility for his or her role in the learning activity), and developing social skills (students should develop leadership abilities, decision-making skills, communication skills, and conflict management skills). We suggest that the students work in groups of four. Johnson and Johnson (1999) argue that groups larger than four will not optimize learning. It is also important that each student should assume a particular role, for example:

Student 1 could finalize the puppetry script and assume the role as the editor of the script. However, it is important that all four students contribute to the research and writing of the script. In Table 1 we provide some guidelines for writing a puppet script. Of utmost importance is that the script should focus on a problem, for which solutions are sought.

Student 2 could take the responsibility for obtaining the puppets that will be used. The puppets can be bought or hand-made by the students. Several websites provide guidance on making puppets (see Table 2). Sock puppets are easy to produce, and are just as effective as more expensive puppets. Puppets, of course, could be entities other than humans, such as an endangered animal or a mitochondrion. Masks could also be used, in which case puppets are replaced by people who assume new identities.

Student 3 and 4 could be the main puppeteers, although there could be more than two puppets involved in dialogue. In Figure 1, three South African student teachers are engaged in a puppet show, in which two learners (Lerato and Jaco) learn about the tenets of science and indigenous knowledge from Samuel, the scientist.

When the students stage their puppet shows, it is important to involve the audience. The script should include questions asked by the puppets of audience members. An example of a puppet script (on indigenous knowledge regarding medicinal plants), used in our research, is provided in Figure 2.

Aims

- To know examples of indigenous plants that are used as sources of food, medicine, and cosmetics.
- To provide context for the ethnobotanical surveys that learners will engage in (see De Beer & Van Wyk, 2011).
- To identify ethical points for discussion or class debate.

The scripts should aim to give direction and structure, but should be flexible enough to accommodate the number of participants. As seen in Figure 1, we adapted the script to involve three puppeteers.

Table 1. Guidelines for writing and presenting a puppet script.

The following guidelines can be given to the students when writing their puppet scripts:
• Start with 3 Wss: What, Who, and Where? What is the play (lesson) all about? Who are the main characters? Where is the activity happening?
• Do thorough desktop research. The dialogue should be factually correct, and should seek answers to a potential problem.
• Plan to involve the audience (biology class) by posing a challenging problem or questions that demand critical thinking.
• Respect other opinions. Criticize ideas, not people.

Table 2. Resources to guide students in making puppets.

Currell, D. (1996). *An introduction to puppets and puppet-making*. Seattle: Amazon Books.
Kennedy, J. (2006). *Puppet planet: The most amazing puppet-making book in the universer*. Cincinnati, OH: North Light Books.
Ross, L. (2012). *Hand puppets: How to make and use them*. Seattle: Amazon Books.
wikiHow, "How to make a sock puppet," http://www.wikihow.com/Make-a-Sock-Puppet
wikiHow, "How to make puppets," http://www.wikihow.com/Make-Puppets
Pinterest, "Puppet making," https://za.pinterest.com/explore/puppet-making/?lp=true
Instructables, "How to build a quality puppet," http://www.instructables.com/id/How-to-Build-a-Quality-Puppet/

Figure 1. Puppeteers at work. Here they perform puppetry for a group of students at a workshop in Durban, South Africa. The student teacher on the left has the persona of Sam, the scientist, and the other two student teachers have the personas of two students learning about indigenous knowledge, Lerato and Jaco. (We amended the script provided in Figure 2 to include a third person.)

	Conversation	Comments
Lerato	Sam… you do not look well. Is everything OK?	Lerato looks concerned.
Sam, the scientist	Morning Lerato. I do not feel well at all. I have a terrible flu. My head is sore, and I have a fever.	Sam is obviously ill. Lerato uses her hand to determine (on his forehead) whether he has a fever.
Lerato	Don't you think you should see a doctor? Friends what do you think? (Students answer). Should Sam go and see a doctor?	Get participation from the audience
Sam	No Lerato, I think I should make use of the medicine from Nature's pharmacy. It…..	Sam is interrupted by Lerato's enthusiastic question
Lerato	Nature's pharmacy? What is that, Sam?	Repetition of the word *Nature's pharmacy* to emphasize the medicinal properties of plants; the scientific merit of medicinal plants could be debated in the classroom.
Sam	Well, many plants have useful properties. Some of these plants are medicines. It can help us to feel better when we are sick.	
Lerato	Mmm (Lerato thinking) ….but is it safe to use these medicines from plants, Sam?	Lerato looks concerned. A class debate could follow on the ethical issue of drug regulation and usage.
Sam	Lerato and friends, people have experimented with plants over many, many years. This knowledge has been passed on from one generation to the next. We call it indigenous knowledge. So to answer your question, yes, it is safe, Lerato.	
Lerato	That is awesome, Sam! So are there plants in nature's pharmacy that will help for your flu?	
Sam	Indeed, Lerato. One of the big medicines is *wormwood*. It's scientific name is *Artemisia afra*.	Expanding scientific literacy.
Lerato	Wormwood has a smell……and……just look at its feathery leaves…..	
Sam	That is correct, Lerato. The leaves of this aromatic plant is boiled in water—we call this a *decoction*—and then a little bit of honey or sugar is added….	*Decoction* explanation of scientific literacy
Lerato	Why do we need to add honey or sugar, Sam? Does the plant not taste nice?	Repetition, keeps line of story.
Sam	No, it has a very bitter taste, and the honey or sugar gives it a better taste. Wormwood is mostly used to treat coughs, colds and influenza, but people also use it to treat fever and colic. Let me put some Wormwood leaves in the pot…	Have a pot as prop, and, if possible, some *Artemisia afra* leaves.
Lerato	Do you know of anyone your community who also uses wormwood as medicine for flu? Or perhaps other medicinal plants?	Lerato directs the question at the students to engage them in a class discussion. An ethical consideration that could be discussed in the classroom could be the protection of intellectual property rights, and patenting.
Sam	Students, I have an idea! Maybe you should ask your grandmother and grandfather, or elderly people in the community, if they use medicinal plants.	Let students engage in an informal ethnobotanical survey. Ethics that should be discussed are the responsibilities and roles during community engagement, and conservation.

Figure 2. Example of a puppet script: Useful plants (excerpt).

○ Addressing Sensitive Issues in the Biology classroom

The following are a number of scenarios that students could be given, and that could form the basis of their puppet scripts. We cannot provide scripts on all these aspects in an article of limited length, so we will provide in the paragraphs below a few things that students should consider when writing the scripts (and doing their research).

Evolution: The Big Debate

Hynd (2003) alludes to the fact that true conceptual change implies the acceptance of the construct of study. Some students with creationist views struggle to accept evolution as a construct, and very often the teacher does not create a platform in class for students to discuss this. Students often have a poor understanding of the mechanism of evolution (Kyriacou et al., 2015), and a dialogue between two puppets (a layman and a biologist) could be an effective platform for students in the audience to voice their opinions. Such dialogue could be an effective way to address the cognitive biases of essentialism and teleological reasoning, which are very resistant to change (Kyriacou et al., 2015). Let the students consider the following:

- Let one puppet voice creationist viewpoints, and the other puppet—a biologist—should respond to those ideas.
- The scientist puppet could discuss evidence for evolution, such as palaeontology and molecular evidence.

Research Ethics in Science & Medicine

In the bestseller *The immortal life of Henrietta Lacks* by Rebecca Skloot, interesting scenarios are provided that could be a very good foundation for a puppet script that focuses on ethics in science (and medical) research. Apart from the tragic story of Lacks herself, and the embedded racism that characterized the era of racial segregation, there are several examples of unethical research that could form the basis of a puppet script. One example is the Tuskegee syphilis study on how syphilis killed a person, from infection to death (Skloot, 2011, p. 50). The Tuskegee Institute recruited hundreds of African American men with syphilis, and watched them die a slow, painful, and preventable death, without treatment. Penicillin had already been discovered, and these men could have been cured. Sadly the general public did not learn about the Tuskegee study until the 1970s, when hundreds of men had already lost their lives. Several interesting possibilities for a puppet script exist: a medical researcher who has to appear in front of an Ethics Committee, or a family member of a deceased patient going to court to fight this injustice. Through mock trails various arguments for and against a specific case can be presented in the presence of a jury. By including a jury, more students can voice their opinions. Another example of a possible puppet script could be the Mississippi Appendectomies (Skloot, 2011, p. 50), unneeded hysterectomies performed on poor black women to stop them from reproducing and to give young doctors a chance to practice the procedure.

The following considerations could guide the students when doing research and writing the scripts:

- A court of law could be an interesting place for the puppet script to unfold. Dialogue should be written for the defense (e.g., a scientist accused of unethical conduct), the prosecution (e.g., how the conduct constituted an infringement of human rights), and then a third person (puppet) being the voice of the jury (of which all students in the classroom should be part). This will ensure that all students are prompted to share their opinions.
- Another setting could be an Ethics Review Board, which is considering the application of a group of scientists wanting

to do particular research. The development of guidelines to be used by the Ethics Review Board will necessitate thorough research by the students, creating the opportunity for additional debate in the presentations.

Health Issues and Genetic Engineering in the Biology Classroom

A myriad of health issues can be discussed by using puppetry. One example is the stigma that often still surrounds people who are HIV positive, for instance, that they are promiscuous. The AREPP (African Research and Educational Puppetry Programme) (Evian et al., 1995) launched a "Puppets against AIDS" initiative in the 1990s. The targeted audience were people aged 17–55, which demonstrates that puppetry is not only a pedagogy for young children. Genetic engineering and cloning is another possibility of a theme worth exploring.

Considerations for the students could include:

- Two puppets could be in dialogue about genetically modified food, and whether it is safe to eat.
- Another script could look at cloning, and the ethics and biological difficulties in cloning humans and/or the use of cloning in medical treatment. This could prompt students to do desktop research on the difficulties experienced in cloning people and the use of cloned tissues in the treatment of diseases. Two proteins essential to cell division, known as spindle proteins, are located very close to the chromosomes in primate eggs. Removal of the egg's nucleus to make room for a donor nucleus also removes the spindle proteins, interfering with cell division (National Human Genome Research Institute, 2017).

Gender & Sexuality

Issues of gender and sexuality are also sensitive issues that could be explored in the classroom through the medium of puppetry. A puppet can mention sensitive issues without being embarrassed by it and in the process demolish ignorance, fear, and imaginary social borders. A "gay puppet" could give a face to the suffering and discrimination that many gay or transgender people still face in many parts of the world.

Bailey et al. (2016) discuss factors such as childhood gender nonconformity and the contribution of atypical prenatal androgen exposure to sexual orientation. By engaging with such research while writing a puppet script, students will develop a much more nuanced understanding of the complexity of this issue. (Also noteworthy in the Bailey et al. is the reference to nonhuman animals in which homosexuality occur, e.g., Japanese macaques [*Macaca fuscata*], mountain gorillas [*Gorilla beringei*], and the Bottlenose dolphin [*Tursiops* sp.].)

Indigenous Knowledge in the Biology Classroom

Indigenous knowledge is an oral tradition, and story-telling is an important facet of it (Michie, 2000; Jones & Hunter, 2003). Puppetry, which requires good story lines and participation of an audience, is therefore a pedagogy that holds much promise in teaching indigenous knowledge systems. Cronje, De Beer, and Ankiewicz (2015) present several tenets of the nature of science that are shared by indigenous knowledge as epistemology, including human creativity and subjectivity. The example of a puppet script in Figure 2 provides an example of how such indigenous knowledge could be addressed in the biology classroom.

Dealing with Social Justice Issues in the Biology Classroom

The example below, of an imaginary dialogue between a student (or young researcher or journalist) and the political activist Rosa Parks (1913–2005), provides an example of how biology content could be merged with a social justice agenda in a puppet script. This script serves as an example but was not used as part of our intervention. SP is the student puppet, and RP is the Rosa Parks puppet.

SP: Mrs. Parks, thank you very much for participating in this interview where we will look back at civil rights in the 1950s in the United States, and where we stand today. You are a legend and inspiration to many people of all races and classes from all over the world.

Mrs. Parks, The Human Genome Project has revealed that there are probably about 20,500 human genes (National Human Genome Research Institute, 2016). Although both internal and external factors play a role in skin color, current research suggest that variants in around twenty known genes determine human skin color. These genes forms thus about 0.097 percent of the total human genome, yet race plays an overwhelming role in society and strongly dictates the direction in which race-related social problems are solved. From your experience and your iconic involvement in the Montgomery Bus Boycott of 1955, do you think that it is rational that race does play such a decisive role in society?

RP: We are still living in a highly unequal and unjust society in which the wrong doings of the past (read: consequences of the segregation laws) are clearly visible in our communities. African Americans forms about 13 percent of the U.S. population. U.S. Census Data indicate that the poverty rate amongst blacks (24.1%) are much higher than any other ethnic group (Hispanics, 21.4%; Whites, 9%; and Asians, 11.4%) in the country. So why am I telling you this? I believe that most of these socioeconomic challenges can only be eradicated with specific interventions based on factors that must take race into account. Although controversial, many white people live in denial about the fact that, decades after segregation, it still puts them in a more privileged position in society, for example, from a socioeconomic perspective. From their privileged stance they are in a better position to create a better future for themselves. The opposite is often true for disenfranchised people. Although violence within poverty-stricken communities is often higher than in other wealthier communities, violence cannot be linked to race. So in short, my answer to your question is: I believe that race is not necessarily overrated if we need to find answers to socioeconomic problems, but that we need to be very cautious about blaming everything (such as some violence, which can be regarded as pure criminality) on race. But surely, race is not a biological construct, but a social construct.

SP: How did it feel back then, during the civil rights movement, not to have the same civil rights as white Americans?

RP: It made me feel inhuman, worthless and powerless, and it was tough to act against the systematic segregation laws and the police forces. In many instances these feelings were overwhelming and had devastating effects on families—such as leaving

school early, alcoholism, abuse, and many other social ills. Many of these are still visible in many poverty-stricken communities. However there were also positive consequences like people standing together and forming the civil rights movement; both me and my husband were involved in such actions.

SP: Did the civil rights movement prepare you for your actions that particular day when you refused to offer your bus seat to a white person?

RP: Yes and no. Yes, because the activists involved in civil rights movement hoped (and planned) that there would be an incident like that. They felt that the time was right for the black community of Montgomery to stand up for their human rights and dignity. No, because I did not plan on doing it (and was not asked by the movement to do it) on that particular day. At that moment, I only felt tired of being trampled on and stood up for my rights. I did not think of the consequences that my actions would hold for the civil rights movement or the negative effects that it would have on my personal life.

SP: In retrospect, did that incident made you feel that you conquered the world?

RP: No, because I did not do it alone. Many men and women long before me played a role in preparing the United States for social transformation. The emancipation of African Americans was the sacrifice and work of many known and unknown people who did their part to change the conditions, so that all people can live today in a free and open society.

SP: Do you think that all people today will agree with you about the free and open society? Is it not true that we are now dealing with other forms of discrimination? In this regard the treatment of the LGBT community and immigrants come to mind. What will your massage be to these marginalized people?

RP: I would like to encourage disenfranchised groups to stand up for their rights.

○ Conclusion

Puppetry as a pedagogy holds much promise in the biology classroom to address affective learning outcomes. It can cross various ethical scientific boundaries and provoke discussions that lead to the development of scientific communication skills.

It could also enhances the self-directed learning of the students, as they are encouraged to engage in desktop research and writing scripts. Puppetry takes as its point of departure the role of science in our everyday lives, and thus a science-technology-society perspective. This could lead to students viewing science (biology) as relevant to our daily lives. Gibbons (2000) speaks of "mode 2 knowledge production," and with this construct he emphasizes science that is contextualized and relevant to students. By writing these puppet scripts, students engage in such "mode 2 knowledge production," which requires epistemological border crossing and creative thinking. By utilizing engaging pedagogies such as puppetry, we can effectively teach for the affective domain and do not leave it for chance. Several permutations are possible, such as using masks, where real people (with the mask also providing a new identity) replace the puppet.

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