E-Journal of Humanities, Arts and Social Sciences (EHASS)
ISSN – Online 2720-7722 | Print 2821-8949
Volume 5 Issue 4 April 2024 pp 393 -401
Available online at: https://noyam.org/journals/ehass/
DOI: https://doi.org/10.38159/ehass.2024543

Experiences of Using a Real Compound Microscope and a Virtual Compound Microscope in Understanding Plant Tissues by First-year Life Science Students at a Tertiary Institution in South Africa

Vuyokazi Momoti [1], Sakyiwaa Boateng [1] & Thamsanqa Sihele[1]
[1] Faculty of Education, Walter Sisulu University, Mthatha, Eastern Cape, South Africa.

ABSTRACT
During the COVID-19 outbreak, the majority of tertiary institutions preferred virtual laboratories to face-to-face laboratories which posed a challenge to many students. The objective of the study was to examine students' experiences at a higher institution using both a physical and virtual microscope. This qualitative study involved ten randomly chosen first-year Life Science students. They had to prepare and view onion cells under a real microscope, while the second assignment required them to observe onion cell preparation in a virtual laboratory. Students completed a questionnaire containing open-ended questions. The results were analyzed using themes, and the study found that pupils prefer physical microscopes to virtual microscopes. This is because students interact with the equipment in the laboratory, which encourages intellectual interests, knowledge sharing, and the development of social connections. Students can manipulate actual objects, manually focus microscopes, and interact in real time with microscopic worlds. This hands-on expertise is critical for instructing students and researchers on laboratory practices. Real microscopes are versatile pieces of equipment that can be utilized for a wide range of applications, from basic instruction to advanced research. Although virtual microscopes have advanced in terms of image quality, real microscopes provide better resolution and clarity. The study will make a substantial addition to university laboratory pedagogies and expose students to scientific investigations, given the majority of students come from rural schools with limited laboratory equipment such as microscopes.

Keywords: Physical Microscope, Virtual Microscope, Experiences, Intellectual Interest, Social Interactions

Correspondence
Vuyokazi Momoti
Email:
vmomoti@wsu.ac.za

Publication History
Received: 27th December, 2023
Accepted: 13th February, 2024
Published online:
5th April, 2024

INTRODUCTION
The tertiary institution where this study was conducted is located in a rural province in South Africa, where the majority of students have never used a laboratory let alone a microscope. The researchers identified the need to add to the existing literature of students using both real microscopes and virtual microscopes to get a better understanding of plant tissues. According to Kara, utilizing a microscope in the classroom enables pupils to establish and develop critical competencies such as educational, cognitive, informational, communicative, and general cultural.[1] Kadirberdievnam defines microscopes are described as "windows into the world of microorganisms."[2]

[1] Kara Yilmaz, "Determining the Effects of Microscope Simulation on Achievement, Ability, Reports, and Opinions about Microscope in General Biology Laboratory Course," 2018.
[2] Bekmetova Shoxida Kadirberdievna, "Increase the Effectiveness of Education in Biology Classes Using a Digital Microscope," *JournalNX* 6, no. 11 (2020): 85–92.

Microscopes show a screen image of the micro-world and allow you to examine microorganisms, and micro-level compounds, and investigate the complicated bodily system at the cell level. A virtual microscope, according to Herodotou et. al., is a web-based technology incorporated into a virtual learning environment that allows numerous students to have simultaneous online access to images (samples).[3] Digital technologies enable fascinating new opportunities for academic learners to interact meaningfully, and they can assist students in taking ownership of their learning, synthesizing information, and cultivating a greater engagement with the subject matter.[4] The research aims to understand the perceptions of Life Science undergraduate students about using a physical compound microscope versus a virtual microscope to study plant tissues. The findings of the research are presented in the subsequent sections.

LITERATURE REVIEW

Kara highlights that laboratories are specially designed environments to develop, produce, and test the intended materials for a specific purpose.[5] Microscopes, for example, are unavoidable in biology laboratories and are now utilized in a wide range of professional fields to supply or enhance certain capabilities, particularly in biological, medical, geological, and forensic science. Because of the microscope's use and relevance in science and engineering, science students must be introduced to microscopes and learn how to utilize them. Ambusaidi et al., argue that laboratories are an important part of teaching science and achieving its objectives.[6] Furthermore, laboratories are controlled conditions in which scientific experiments are carried out. Research has shown that there are many advantages such as students' deep understanding of science concepts and correcting their misconceptions when labs are used in teaching science. The use of digital educational resources allows one to radically change the organization of students' learning processes, forming their systemic thinking, rationally organizing the cognitive activity of schoolchildren during the educational process, and using computers to individualize the educational process. In addition, laboratories help to study phenomena and processes in the micro and macro-world, within complex technical and biological systems, and to use computers to individualize the educational process and turn to fundamentally new cognitive means.[7]

According to Ambusaidi et al., virtual laboratories facilitate the formation of conceptual models such as immersion, which allows students to experience phenomena for themselves rather than through the eyes of teachers or textbooks; interaction, which allows students to transition from passive observers to active thinkers; and engagement, in which students control the computer to reach their targets in sophisticated ways.[8] Kara argues that educational technologies allow users to progress at their own pace, learn through audio-visual and visually supported learning objects, learn through multimedia, and carry out expensive or dangerous activities in digital laboratories by removing danger from the activity.[9] Furthermore, the use of technology in science classes provides numerous opportunities for educational development, such as the ability for students to collaborate with their classmates on meaningful activities; effective technology can also enhance and enrich learning in interactive environments, which encourages creativity through e-learning applications in various modes such as visualization, simulation, and modelling.

Virtual laboratories, according to Herodotou, Aristeidou, Scanlon, and Kelley, allow students to do experiments at their own time and pace using simulations, and they have been found to improve learning and understanding in disciplines such as physics and chemistry.[10] Rayment, et.al. argue that crucial practical skills development is essential for bioscience courses in higher education.[11] Learning theories, such as Novak's model of meaningful learning, support the premise that practical work would allow students to integrate their experiences to produce a more meaningful learning experience.

---

[3] C. Herodotou et al., "Virtual Microscopes and Online Learning: Exploring the Perceptions of 12 Teachers about Pedagogy," *Open Learning: The Journal of Open, Distance and e-Learning*, August 13, 2022, 1–25, https://doi.org/10.1080/02680513.2022.2112661.
[4] Maria C Caruso, "Virtual Microscopy and Other Technologies for Teaching Histology during Covid-19," *Anatomical Sciences Education* 14, no. 1 (2021): 19.
[5] Yilmaz, "Determining the Effects of Microscope Simulation on Achievement, Ability, Reports, and Opinions about Microscope in General Biology Laboratory Course."
[6] Abdullah Ambusaidi et al., "The Impact of Virtual Lab Learning Experiences on 9th Grade Students' Achievement and Their Attitudes towards Science and Learning by Virtual Lab," *Journal of Turkish Science Education* 15, no.2 (2018): 13–29.
[7] Kadirberdievna, "Increase the Effectiveness of Education in Biology Classes Using a Digital Microscope."
[8] Ambusaidi et al., "The Impact of Virtual Lab Learning Experiences on 9th Grade Students' Achievement and Their Attitudes towards Science and Learning by Virtual Lab."
[9] Yilmaz, "Determining the Effects of Microscope Simulation on Achievement, Ability, Reports, and Opinions about Microscope in General Biology Laboratory Course."
[10] Herodotou et al., "Virtual Microscopes and Online Learning: Exploring the Perceptions of 12 Teachers about Pedagogy."
[11] Sarah Rayment et al., "Investigating Student Engagement and Making Science Real during a Pandemic: Bioskills at Home, a Case Study," *Education Sciences* 12, no. 2 (2022): 106.

Virtual labs range from simple 2D video games to interactive 3D simulations that offer a more engaging learning environment (Reeves and Crippen, 2021).[12] Some provide pupils with specific instructions and technical guidelines to help them execute challenging jobs while others are more open-ended. When compared to traditional labs, virtual labs have numerous advantages, including lower costs, easier access, time savings, environmental safety, and adaptability. However, one disadvantage of virtual laboratories is that, unlike traditional labs, they may not necessarily provide the same learning environment or possibilities for student interaction. According to Eidesen et al., employing instructional videos in conjunction with pre-quizzes for lab preparation improves both efficiency and learning outcomes.[13] Michels et al., argue that when students use virtual microscopes, they are more engaged, empowered to drive meeting discussions, and confidently communicate findings from independent practice work.[14] The use of a shared video viewer in an interactive, student-driven learning environment results in engaging discussions, strong microscopy abilities, and student confidence. Furthermore, students engage in direct visual penetrative training, allowing the instructor to observe unique student intuition. Laboratory experiments, according to Delgado et al., allow students to engage in the scientific method.[15]

METHODOLOGY

The study used a qualitative research method with 10 first-year students studying Life Sciences at a South African university. An open-ended form and a worksheet were supplied. To protect the participants' identity, they were coded as Participant A through Participant J. The worksheet included two exercises: Exercise 1 (Physical) microscope and Exercise 2 (Virtual microscope).

Exercise 1 Physical microscope (Figure 1)

1. Place a drop of water on a slide.
2. Peel away a layer of onion slice and peel off a very thin strip of onion membrane from the inside layer.
3. Place the membrane on the water droplet on the slide. The membrane should lay flat on the Slide.
4. Add a drop of iodine to the slide and cover with the cover slip.
5. Observe and draw your specimen under 40X.

Figure 1. The compound microscope

Exercise 2: Virtual microscope

Watch the video clip - **https://youtu.be/6gIneqf6pYU**

[12] Shalaunda M Reeves and Kent J Crippen, "Virtual Laboratories in Undergraduate Science and Engineering Courses: A Systematic Review, 2009–2019," *Journal of Science Education and Technology* 30 (2021): 16–30.
[13] Pernille Bronken Eidesen, Anne E Bjune, and Simone I Lang, "'Show Me How to Use a Microscope'–The Development and Evaluation of Certification as Direct Assessment of Practical Lab Skills," *Ecology and Evolution* 13, no. 10 (2023): e10592.
[14] Kristin K Michels, Zachary D Michels, and Sara C Hotchkiss, "Advantages of Live Microscope Video for Laboratory and Teaching Applications," *Natural Sciences Education* 45, no. 1 (2016): 1–5.
[15] Tracie Delgado, Shun-Je Bhark, and Joshua Donahue, "Pandemic Teaching: Creating and Teaching Cell Biology Labs Online during COVID-19," *Biochemistry and Molecular Biology Education* 49, no. 1 (2021): 32–37.

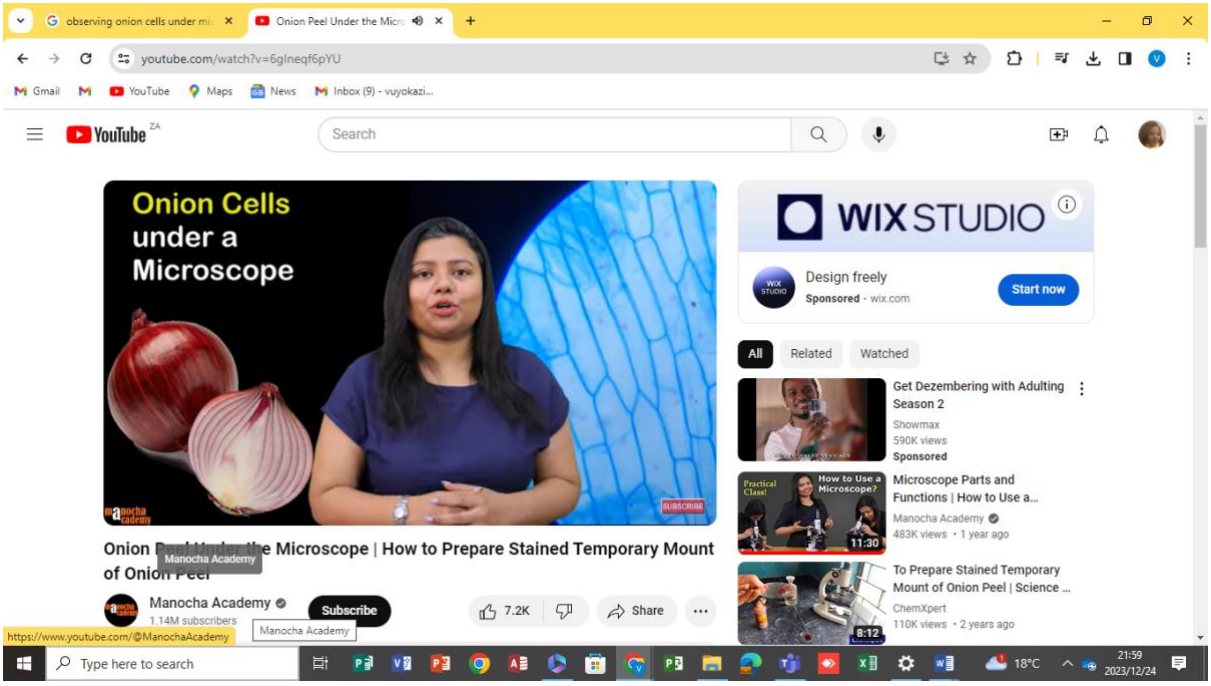

Figure 2. Video clip of the virtual microscope

1. **Draw the onion cells under each magnification used in the video.**

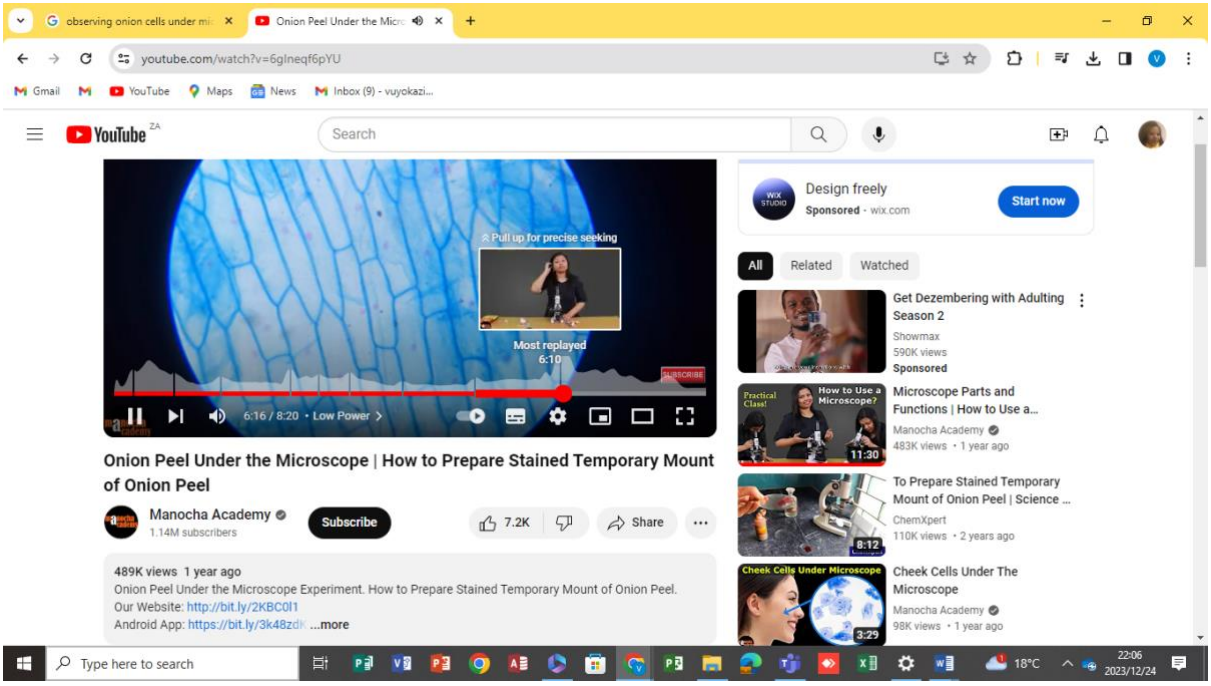

Figure. 3 Onion cells under the microscope

FINDINGS

Table 1. Participant A

Themes	Physical microscope	Virtual microscope

Scientific skill acquired	Placing the cover slip on the slide without forming bubbles	Listening and observation
Challenges	No challenges	No
Preferences	Physical microscope	
Duration taken to prepare &focus the slide	30 minutes	10 minutes

Table 2. Participant B

Themes	**Physical microscope**	**Virtual microscope**
Scientific skills acquired	Handling of a microscope	Concentration skill
	Manipulating the objective lens	Observation skill Listening skill
Challenges	Yes-struggled to get a clear slide due to bubbles	No
Preferences	Physical microscope	
Duration taken to prepare and focus the slide	20 minutes	10 minutes

Table 3. Participant C

Themes	**Physical microscope**	**Virtual microscope**
Scientific skills acquired	To switch the microscope on only when in use	Differentiation of the objective lenses and absorbing all that is said in the video
Challenges	Yes, I struggled to view the cells	no
Preferences	Real microscope	
Duration taken to prepare and focus the slide	25 minutes	16 minutes

Table 4. Participant D

Themes	**Physical microscope**	**Virtual microscope**
Scientific skills acquired	Retention of information	Observing and recalling
Challenges	My eyes were hurting, the microscope had one eyepiece, I struggled to get a drop with a dropper and my slide was messy	No,
Preferences	Virtual	
Duration taken to prepare and focus the slide	45 minutes	8 minutes

Table 5. Participant E

Themes	**Physical microscope**	**Virtual microscope**

Scientific skills acquired	Operating skill	
	Placing the cover slip on the slide without forming bubbles	Observing How to place a glass slide on the stage of a microscope at an angle
Challenges	Struggled to get the epidermal tissues from the onion	no
Preferences	Real microscope	
Duration taken to prepare and focus the slide	20	10-15 minutes

Table 6. Participant F

Themes	**Physical microscope**	**Virtual microscope**
Scientific skills acquired	Focusing onion cells using different objective lenses	I adjusted the focusing knobs until all cells were crystal clear
Challenges	Lack of practice, we are always using virtual laboratories	No
Preferences	Real microscope	
Duration taken to prepare and focus the slide	20	10

Table 7. Participant G

Themes	**Physical microscope**	**Virtual microscope**
Scientific skills acquired	Focusing, manoeuvring both the coarse knob and fine adjustment knobs	Ability to focus well and cells were very clear
Challenges	No	No
Preferences	Real microscope	
Duration taken to prepare and focus the slide	20mins	9

Table 8. Participant H

Themes	**Physical microscope**	**Virtual microscope**
Scientific skills acquired	Observation skill, paying attention	Listening, drawing
Challenges	Placing the slide correctly on the stage, there were no stage clips in my microscope	No challenges
Preferences	Real microscope	
Duration taken to prepare and focus the slide	20	8

Table 9. Participant I

Themes	**Physical microscope**	**Virtual microscope**

Scientific skills acquired	Operating the microscope	To be organized, to have all the tools needed to save time
Challenges	I did not read the instructions, had too many bubbles on the slide	No
Preferences	Real microscope	
Duration taken to prepare and focus the slide	27 minutes	10 minutes

Table 10. Participant J

Themes	**Physical microscope**	**Virtual microscope**
Scientific skills acquired	Handling of a microscope	Concentration skill
	Manipulating the objective lens	Observation skill Listening skill
Challenges	Yes-struggled to get a clear slide due to bubbles	No
Preferences	Physical microscope	
Duration taken to prepare and focus the slide	22minutes	10 minutes

DISCUSSION

Scientific skills acquired in using the physical (real) microscope

Based on the responses of all participants, it is revealed that the students gained technical skills in operating the microscope. Handling a microscope, placing the cover slip on the slide without producing bubbles, adjusting the objective lenses, and focusing the prepared slide are all part of this. The expected slide of onion cells is shown in Figure 3. Manipulative skills are important for students to be able to complete science activities effectively, according to Fadzil and Saat, and a good technique in handling and manipulating scientific apparatus is important because it can reduce, minimize, and control misinterpretations and may minimize the errors in scientific experiments.[16] Microscope skills are a skill that should be handled by laboratory students who operate with a microscope, and improving the skills of observation using a microscope requires continual training through a variety of practical activities.[17]

Scientific skills acquired in using the virtual microscope

According to the findings, the majority of pupils improved their listening, concentration, and observation skills. Participant I stated that he/she learned to be organized before performing work on a virtual microscope by having all of the necessary instruments, such as a pen, pencil, and eraser. Virtual microscopes can be a useful supplementary educational tool that helps to connect theory with practice by providing students with visualization of practical procedures and instrument techniques.

Challenges experienced by students when using the real microscope and virtual microscope

Ninety percent (99%) of the students had encountered difficulties, such as incorrectly inserting the coverslip into the slide. Participant E struggled to extract the onion's epidermal tissues. Because they were constantly assigned virtual laboratory assignments, participant F exhibited a lack of familiarity with the real microscope. Participant D stated that his/her eyes hurt and that the slide was sloppy. Only one kid out of ten had no problems using the real microscope.

Students encountered no difficulties while viewing the film using the virtual microscope. Several research works have indicated that interactive animations and computerized learning can help improve conceptual knowledge of

[16] Hidayah Mohd Fadzil and Rohaida Mohd Saat, "Exploring Students' Acquisition of Manipulative Skills during Science Practical Work," *Eurasia Journal of Mathematics, Science and Technology Education* 13, no. 8 (2017): 4591–4607.

[17] Nata Maulida Fajarini, Endah Peniati, and Muhammad Abdullah, "The Effect of Microscope Skills On The Observation Results Of Plant Tissue Preparations by Students Of SMAN 4 Tegal," *Journal of Biology Education* 9, no. 3 (2020): 234–44.

various scientific ideas.[18] To overcome these challenges, students benefit from hands-on training, clear instructions, and guidance from instructors or experienced peers. Practicing the preparation process multiple times allows students to develop the skills needed for successful onion slide preparation and microscopic observation.

Preferred microscope

According to the findings, 90% of pupils prefer to use real microscopes while 10% prefer virtual microscopes. According to Ambusaidi et al., in traditional laboratories, students employ hands-on to activate experiential ideas and engage with scientific phenomena in real-world settings.[19] Real microscopes provide a three-dimensional view, allowing users to perceive depth and spatial relationships in the specimens. This depth perception is essential for accurate interpretation of structures and can be challenging to replicate in virtual environments. While virtual microscopes have improved in providing high-quality images, real microscopes often offer superior resolution and clarity.

CONCLUSION

The study sought to investigate students' experiences at a tertiary institution with a physical microscope and a virtual microscope The findings revealed that pupils prefer physical microscopes to virtual microscopes. Physical lab experiments teach students more important laboratory processing skills than virtual lab experiments. According to research, students value the importance of the physical laboratory since it helps them understand biology ideas. Nonetheless, numerous studies have demonstrated that both laboratories are effective. The purpose of employing a real microscope is to encourage learners' interactions with other students, the instructor, and the equipment. While virtual microscopes have their advantages, particularly in terms of accessibility and sharing digital images, real microscopes continue to be essential tools in scientific research, education, and various industries due to their tangible and versatile nature, as well as their ability to provide a genuine, hands-on experience. The researcher concludes that the choice between real and virtual microscopes often depends on the specific needs and goals of the user.

BIBLIOGRAPHY

Ambusaidi, Abdullah, Ali Al Musawi, Sulaiman Al-Balushi, and Khadija Al-Balushi. “The Impact of Virtual Lab Learning Experiences on 9th Grade Students’ Achievement and Their Attitudes towards Science and Learning by Virtual Lab.” *Journal of Turkish Science Education* 15, no. 2 (2018): 13–29.

Caruso, Maria C. “Virtual Microscopy and Other Technologies for Teaching Histology during Covid-19.” *Anatomical Sciences Education* 14, no. 1 (2021): 19.

Delgado, Tracie, Shun-Je Bhark, and Joshua Donahue. “Pandemic Teaching: Creating and Teaching Cell Biology Labs Online during COVID-19.” *Biochemistry and Molecular Biology Education* 49, no. 1 (2021): 32–37.

Eidesen, Pernille Bronken, Anne E Bjune, and Simone I Lang. “‘Show Me How to Use a Microscope’–The Development and Evaluation of Certification as Direct Assessment of Practical Lab Skills.” *Ecology and Evolution* 13, no. 10 (2023): e10592.

Fadzil, Hidayah Mohd, and Rohaida Mohd Saat. “Exploring Students’ Acquisition of Manipulative Skills during Science Practical Work.” *Eurasia Journal of Mathematics, Science and Technology Education* 13, no. 8 (2017): 4591–4607.

Fajarini, Nata Maulida, Endah Peniati, and Muhammad Abdullah. “The Effect of Microscope Skills On The Observation Results Of Plant Tissue Preparations by Students Of SMAN 4 Tegal.” *Journal of Biology Education* 9, no. 3 (2020): 234–44.

Herodotou, C., M. Aristeidou, E. Scanlon, and S. Kelley. “Virtual Microscopes and Online Learning: Exploring the Perceptions of 12 Teachers about Pedagogy.” *Open Learning: The Journal of Open, Distance and e-Learning*, August 13, 2022, 1–25. https://doi.org/10.1080/02680513.2022.2112661.

Kadirberdievna, Bekmetova Shoxida. “Increase the Effectiveness of Education in Biology Classes Using a Digital Microscope.” *JournalNX* 6, no. 11 (2020): 85–92.

Michels, Kristin K, Zachary D Michels, and Sara C Hotchkiss. “Advantages of Live Microscope Video for Laboratory and Teaching Applications.” *Natural Sciences Education* 45, no. 1 (2016): 1–5.

Rayment, Sarah, Karin Garrie, Ishwinder Kaur, Gareth McVicker, Emma Storey, Jody Winter, Luigi A De Girolamo, Callum Rimmer, David Negus, and Carl Nelson. “Investigating Student Engagement and Making Science Real during a Pandemic: Bioskills at Home, a Case Study.” *Education Sciences* 12,no.2 (2022):106.

Reeves, Shalaunda M, and Kent J Crippen. “Virtual Laboratories in Undergraduate Science and Engineering Courses: A Systematic Review, 2009–2019.” *Journal of Science Education and Technology*30(2021):16–30.

[18] Ambusaidi et al., “The Impact of Virtual Lab Learning Experiences on 9th Grade Students’….”
[19] Ambusaidi et al., “The Impact of Virtual Lab Learning Experiences on 9th Grade Students’….”

Yilmaz, Kara. "Determining the Effects of Microscope Simulation on Achievement, Ability, Reports, and Opinions about Microscope in General Biology Laboratory Course," 2018.

ABOUT AUTHORS

Ms. V. Momoti is a Laboratory Instructor in Botany and Zoology and a Researcher at the Faculty of Education - Walter Sisulu University, South Africa.

Dr. S. Boateng is a Senior Lecturer specializing in Physical Sciences Teaching and a Researcher at the Faculty of Education - Walter Sisulu University, South Africa.

Mr. T. Sihele is a Lecturer specializing in Life Sciences Teaching and a Researcher at the Faculty of Education - Walter Sisulu University, South Africa.