



Portable inexpensive microscopes for Science, Technology, Engineering, Art, and Mathematics (STEAM) Outreach

Sabrina Segar^{1,2} and Jennifer O. Liang²

¹University of Minnesota Duluth, Department of Biology, 1035 Kirby Drive, Duluth, MN, 55812, USA

²University of Minnesota Duluth, Department of Education, 1205 University Upper Campus Dr., Duluth, MN, 55812, USA

Abstract

The microscopic world has potential to engage a wide variety of people with the beauty of science. Recent technological advancements have resulted in the development of portable, cost-effective microscopes and imaging devices. This project compared four microscope options for use in community outreach. K-12 student participants attending a variety of community outreach events completed a Likert-type survey rating four microscopes (Phone Clip Microscope, Endoscope with Screen, Dissecting Microscope, and Compound Microscope with Screen) on Image Clarity and User Friendliness for viewing live planaria. We hypothesized that microscopes with built-in digital screens instead of eyepieces would receive the highest rating. This hypothesis was supported, as the Compound Microscope with Screen had a significantly higher rating than the other microscopes. Notably, participant age had little effect on responses. Observations suggest that screens were more accessible than eyepieces, especially for younger students. Furthermore, screens improved collaboration, as several participants could observe specimens together.

Keywords: Microscopy, Community Outreach, Affordable, User-Friendly, Planaria, K-12 Students

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Correspondence to: Sabrina Segar, sabrina.segar@gmail.com and Jennifer Liang, joliang@d.umn.edu

INTRODUCTION

The microscopic realm holds significant potential to engage diverse audiences by combining science and art, the main objectives of the Science, Technology, Engineering, Art, and Mathematics (STEAM) movement. Currently, microscope use has been largely limited to laboratory and classroom settings. However, a new generation of microscopes can solve many of the logistical challenges of bringing microscopy to larger audiences, specifically to community events in which professional scientists interact with members of their community. These new microscopes vary from microscope lenses that clip over cell phone cameras to battery-run, portable, compound microscopes with built in screens. These new microscopes range in price from \$7-\$250 USD and offer an array of capabilities. In addition to being inexpensive and portable, several of these new microscopes display their images on screens rather than through microscope eyepieces. The use of screens offers several advantages, including enabling multiple people to view samples together, increasing collaboration, making microscopy accessible to younger children who cannot use traditional eyepieces, and allowing easy capture of images and videos.

The goal of this project was to find the best microscope for outreach events by comparing four microscopes ranging in size and cost in real-life outreach events with participants ranging from kindergarten to high school students. Participants rated each microscope for clarity of image and ease of use. They also provided their age and level of experience with microscopy. Our hypothesis was that the compound microscope with the screen would be rated the most highly for clarity of image and ease of use because of its large and high-resolution viewing screen. The results supported our hypothesis. The compound microscope was rated the most highly by all age groups. We anticipate that the results of this study, as well as example images from each microscope option, will be a useful resource for others who want to bring microscopy to their community and ultimately help encourage everyone to think of themselves as scientists.

METHODS, MATERIALS, AND DATA COLLECTION

Materials

Four microscopes were used in this project, listed here with the term we used in the paper and the full name taken from their Amazon page: (1) "Phone Clip Microscope" is the "Carson MicroMini 20x LED Lighted Pocket Microscope with Built-in LED and UV Flashlight and Universal Smartphone Digiscoping Adapter Clip", (2) "Endoscope with Screen" is the "Elikliv Coin Microscope, 4.3" LCD Digital Microscope 1000x, Coin Magnifier with 8 Adjustable LED Lights, PC View Compatible with Windows/Mac, EDM4B, Black", (3) "Dissecting Scope" is the "AmScope SE306R-P-LED Forward-Mounted Binocular Stereo Microscope, WF10x Eyepieces, 20X and 40X Magnification, 2X and 4X Objectives, Upper and Lower LED Lighting, Reversible Black/White Stage Plate, Pillar Stand, 120V or Battery-Powered", and (4) "Compound Microscope with Screen" is the "TOMLOV DM301 Max Microscope for Kids Students Adults with X-Y Stage, Digital Microscope Camera with 7" Screen, USB & HDMI Output, Wireless Biological Lab Scope for School Home Education with Slides". Additional bright field images were taken in the research laboratory using the Compound Microscope with Screen and a Nikon Eclipse 801 Epifluorescent Microscope connected to a color Spot Imaging Diagnostic Instruments Insight Microscope Camera.

"Brown Planaria, Living" (Item 132954), Wisconsin Fast Plants® Standard *Brassica rapa* Seeds (Item 158804), Quad Wicks for growing the plants, (Item 158978), and plant Fertilizer, 14-14-14 (Item 158970) were obtained from Carolina Biological Supply Company. The planaria were maintained at room temperature without feeding and with regular changes of water from our aquatic zebrafish facility (conductivity 1000 μ S, pH \sim 7.4). The Wisconsin Fast Plants® were grown in a homemade system. Live zebrafish embryos were obtained by natural spawning of adult fish. Fish were maintained and their developmental stage was determined using standard methods (Kimmel et al. 1995; Westerfield 2007). Zebrafish embryos were mounted in depression slides using either methylcellulose or agar with no cover slip (Westerfield 2007). All procedures using zebrafish were approved by the University of Minnesota Institutional Animal Care and Use Committee.

Additional materials included glass flat and depression slides (Amscope BS-50P and BS-C12), plastic transfer pipets (RPI 147516), 250 ml plastic containers with lids for transporting planaria (Fisher 02-891D), and a micro-SD card reader to transfer images from the Endoscope with Screen and Compound Microscope with Screen onto a computer. In addition, participants were given microscope-themed stickers to take home.

Surveys and participants

Two survey structures were created for gathering participant feedback. The first, aimed at middle and high school (older) students, used words for the ratings and included pictures all four microscopes to ensure the ratings matched the microscope. Participants typically filled out the survey on their phones as they moved through the microscope stations. The second, aimed at elementary school (younger) students, used pictures for the ratings (emojis and images of planaria) and was split into four surveys, one for each microscope. Participants filled out the surveys on tablets located at each station. The two types of surveys contained the same questions, which included agreeing to participate in the survey, questions about age and level of microscope experience, and Likert-style questions (Sullivan and Artino 2013), with which participants rated the clarity of image and ease of use of each microscope. The surveys were made using Google Forms and were shared with older students using a QR code and filled out using their cell phones. Younger students used Chrome books placed at each station. This project was deemed “Not Human Research” by the University of Minnesota Institutional Review Board.

Outreach events

Data were gathered at four outreach events during the spring semester of 2025: the Women in STEM event at FIRST Robotics FRC Regionals (Duluth, MN), Congdon Elementary School STEM Night (Duluth, MN), University of Minnesota Duluth Astronomy Day (Duluth, MN), and Fairmont Jr. Sr. Highschool (Fairmont, MN). Participants primarily ranged in age from 5-18. A few people aged 25 years and higher also participated and are presumed to be parents or guardians attending with their children. Two events had primarily middle and high school students, whereas the other two were primarily elementary school students. At all events, four stations were available, each containing one of the microscopes to be evaluated and live planaria that were mounted in water on a depression slide covered with a regular slide.

Analysis

Data for Clarity and User Friendliness were analyzed together and separated by age group (5–10, 11–13, 14–18, 19–24, and 25+ years). Averages and standard deviations (STD) were calculated using Microsoft Excel and analyzed using Fisher’s Exact Tests using the Real Statistics Excel add-in (Zaiontz 2023). The p-values used to determine if there were significant differences between groups were adjusted using a Bonferroni correction.

RESULTS

The goal of this project was to find a portable microscope(s) that could be used in community outreach events and ultimately be part of a kit available for community outreach at the University of Minnesota Duluth. A microscope suitable for such a kit needed to fall at an affordable price point, be accessible to a wide range of participants, and produce high-quality images. The project aimed to decrease bias by using real life participants in ongoing K-12 outreach events that included students of different ages and abilities.

Microscopes and planaria

Four microscopes were chosen for this study (Figure 1). All were purchased from Amazon and were chosen to span a wide range of prices and capabilities. For instance, three (Phone Clip Microscope, Endoscope with Screen, and Compound Microscope with Screen) used digital screens, while the Dissecting Microscope used eye pieces. The magnification capabilities ranged from 20X for the Phone Clip Microscope to 1600X for the Dissecting Microscope. The Phone Clip Microscope and Endoscope with Screen provided a light source from above the sample, while the Dissecting Microscope and Compound Microscope with Screen provided light from above or below the sample. Live planaria were used because they are inexpensive, easy to maintain, small enough to require microscopy to observe the details of their morphology, and resilient due to their ability to regenerate.

Survey

The survey to rate the microscopes had two versions. One, for middle school and high school students, included all the microscopes, and the other, aimed at elementary school students, had a survey for each microscope (Figure 2). At least 120 participants completed a survey. Most reported occasional microscope use (67%), while a minority had never used a microscope (28%) or were proficient (5%). Broad participation occurred across all age groups falling in the K-12 range, with some participation from people over 25 years of age (Table 1).

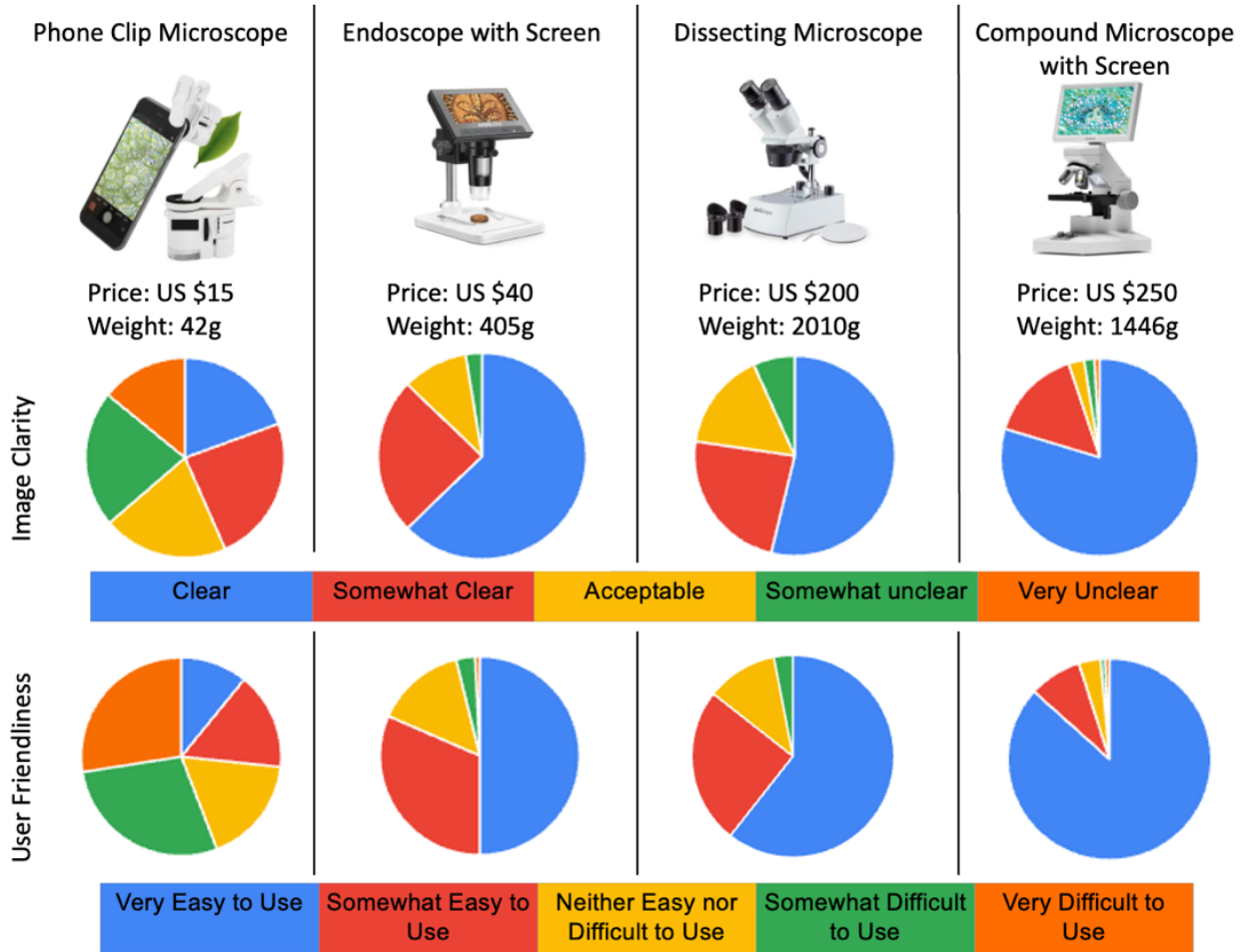


Figure 1. Ratings of the four types of microscopes by participants at outreach events. Graphs show participant ratings in the “Image Clarity” and “User Friendliness” categories. Prices listed align with the start of this project in early 2025 as ordered through the University of Minnesota Amazon Business Prime account. Weights are listed to show ease of transport.

Table 1: Completed surveys by age group

Age range (years)	Surveys (#)	Surveys (% of total)
5-10	36	22
11-13	40	24
14-18	88	53
18-24	0	0
25+	2	1

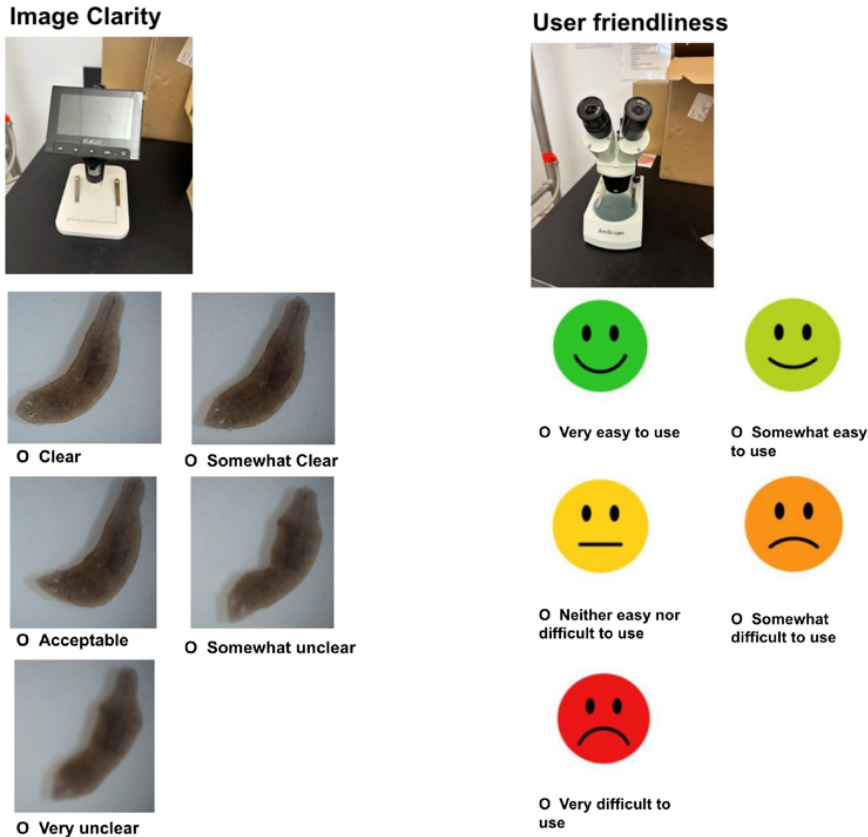


Figure 2: Representations of survey questions used for elementary school aged students. The image on the left represents one of the questions from the survey used to rate Image Clarity for the Endoscope with Screen. The image on the right represents one of the questions from the survey used to rate User Friendliness for the Dissecting Microscope.

Analysis

Overall, all four microscopes were able to take images of live planaria (Figure 3). However, differences were observed in the quality of images (Clarity rating) and their ease of use (User Friendliness rating) when used in an outreach environment (Figures 1 and 3, Table 2, Supplemental Material 1). When all responses were considered together, the Compound Microscope with Screen had the highest rating in both categories. The Endoscope with Screen and Dissecting Microscope were rated in the middle, and the Phone Clip Microscope was rated the lowest. This grouping was supported by statistical analysis. The ratings of each microscope were significantly different from the other microscopes, except for the Endoscope with Screen and Dissecting Microscope which were not significantly different from each other in either the Clarity or the User Friendliness ratings (Supplemental Material 1)

Compound Microscope with Screen

The Compound Microscope with Screen had the highest percentage of participants that gave it the highest rating for User Friendliness and Clarity (Figure 1). Conversations during outreach events suggested the large screen (7-inch diameter) was an important factor in the ratings, as it made it easy to focus on the moving sample. The large screen also made it easy for multiple people to view the sample at the same time.

This microscope also had several features that made it easy to bring to outreach events. It weighed only 1446 grams (~3 lbs.) and came in a carrying case that made it possible to transport without damage. However, some limitations were observed. For instance, only a small part of the planaria could be viewed at a time, even with the

lowest power (4X) objective. In addition, the small field of view combined with the light-avoidance of the planaria made it difficult to keep the planaria in the viewing area. This microscope could illuminate the sample from above or below, making it useful for opaque samples such as the planaria.

Because the Compound Microscope with Screen had the highest ratings, we carried out additional tests in our research laboratory (Figures 4 and 5). First, we tested the three objectives (4X, 10X, and 20X) by imaging anthers of Wisconsin fast plant® flowers and live, 8-somite stage (13 hours post fertilization) zebrafish embryos from our research laboratory. High quality images of the anthers were produced using illumination from above and the 4X and 10X objectives. However, a focused image of the pollen using the 20X objective could not be obtained (Figure 4). The images of the zebrafish embryos were all high quality, and specifically the somites, round balls of mesodermal tissue, were distinct enough to count (Figure 4). The field of view of the 4X objective was large enough to capture the whole length of a 2-day old zebrafish larva (data not shown).

In the next test, we compared the Compound Microscope with Screen to our research imaging system, a Nikon Eclipse 801 Epifluorescent Microscope connected to a SPOT Insight color digital camera. This system is no longer sold but would cost about US \$9,000 used. For this comparison, live zebrafish embryos at approximately prim-16 stage (31 hours post fertilization) were mounted in agar with the dorsal side of the head facing the objective. Images produced using the 4X objective on the Compound Microscope with Screen were of similar quality to those produced using the 10X objective on the Nikon microscope (Figure 5). For instance, a normal midbrain-hindbrain boundary was apparent in wild-type embryos, and altered morphology could be distinguished in *squint* and *n-cadherin* mutants, which both have neural tube defects analogous to the human birth defect anencephaly (Lele et al. 2002; Aquilina-Beck et al. 2007; Gonsar et al. 2016).

Table 2: Clarity and User Friendliness ratings for the four microscopes rating by outreach activity participants

Microscope	Ratings (Average Score + STD) ¹	
	Clarity	User Friendliness
Phone Clip Microscope	2.54 + 1.33	3.07 + 1.37
Endoscope with Screen	4.25 + 0.88	4.49 + 0.77
Dissecting Microscope	4.43 + 0.81	4.25 + 0.92
Compound Microscope with Screen	4.80 + 0.60	4.69 + 0.65

¹ There were at least one hundred responses for Clarity and User Friendliness for each microscope. For these calculations the five rating choices were assigned numerical values with the most positive rating set at 5 and the most negative at 1.

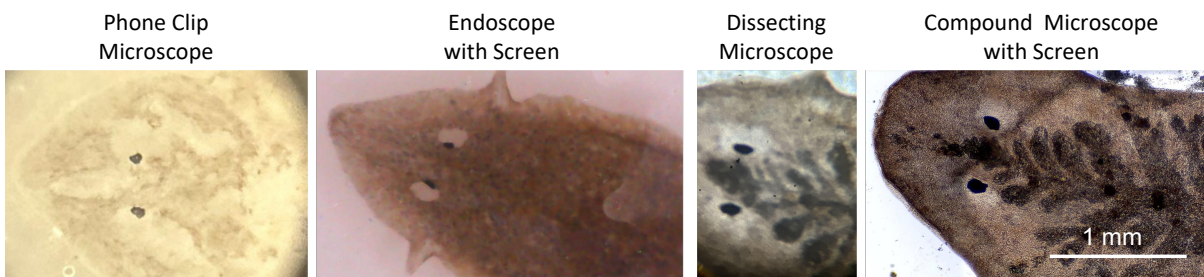


Figure 3: Images of live planaria taken with each microscope. Images are dorsal views of the head with the anterior to the left. The images for the Phone Clip Microscope and the Dissecting Microscope were taken with a cell phone camera. Images were digitally adjusted so that they were all at the same scale. The image taken with the Endoscope with Screen was cropped so that it showed a similar part of the animal as the other images.

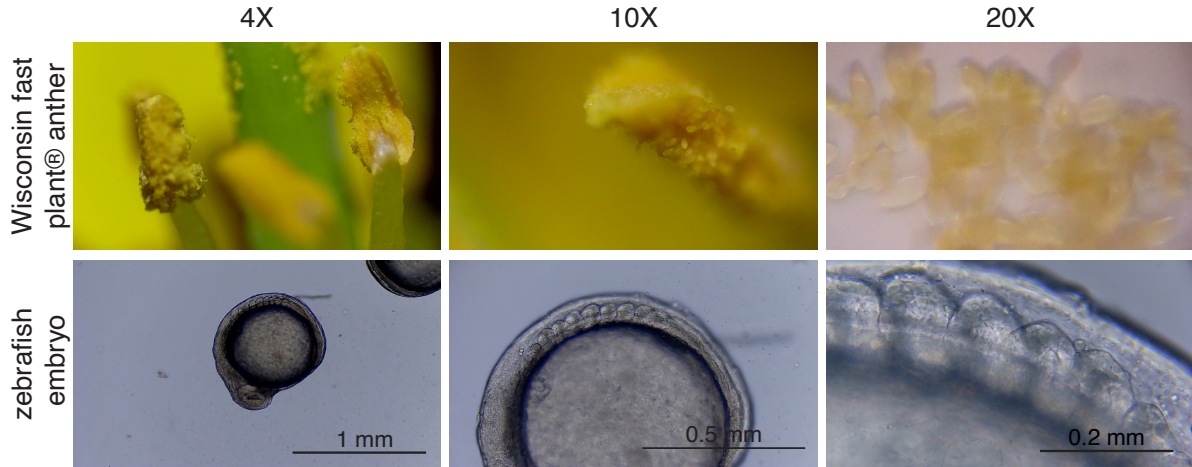


Figure 4: The 4X and 10X objectives produce high quality images of both opaque and translucent samples. Images of the anthers are lateral views with the top of the flower at the top of the image. As the flower did not fit under the 20X objective, dry pollen grains were imaged using a cover-slipped depression slide. Live zebrafish embryos are displayed in lateral view with the head to the bottom left.

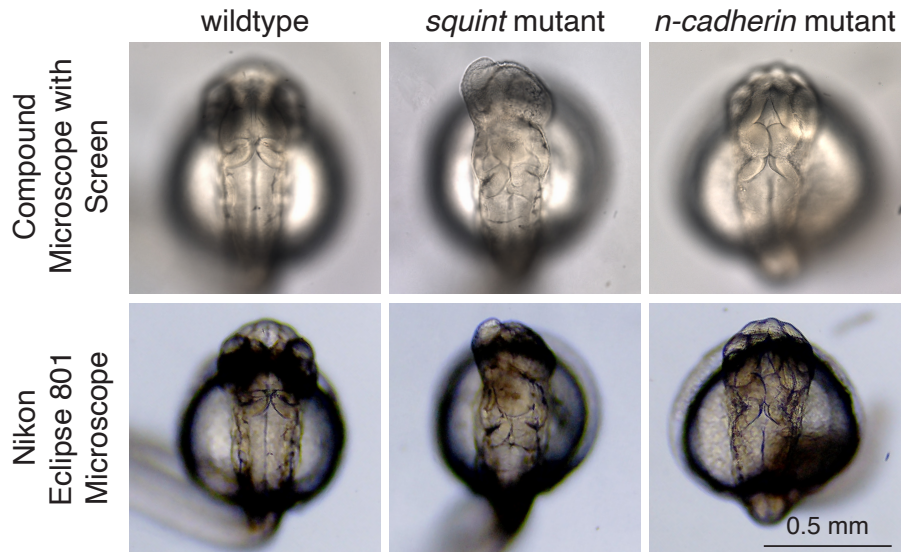


Figure 5: Comparison of the quality of images taken with the Compound Microscope with Screen to a research imaging station. Images are dorsal views, anterior to the top, of the heads of live zebrafish embryos at approximately prim-16 stage (31 hours post fertilization).

Dissecting Microscope and Endoscope with Screen

The Dissecting Microscope and Endoscope with Screen were similar in their level of magnification, with maximums of 1600X and 1000X, respectively. They both had wide viewing angles, making it easy to see the whole planaria. The Dissecting Microscope was the closest to a conventional microscope used in a research laboratory or undergraduate course. Participants had fun looking through the eye pieces, and the microscope was very sturdy and stable. However, since the planaria were mounted in water, that glass stage often got wet, which made it hard to move slides around. The Dissecting Microscope was the heaviest used in this study. The glass part of the stage was also not fixed in place, so it had to be taken out and wrapped carefully to prevent breakage during transport. Out of the microscopes used in this project, only the Dissecting Microscope had the option of illuminating a sample from above and below at the same time.

The Endoscope had a smaller screen (4.3-inch diameter) than the Compound Microscope, potentially contributing to its lower ratings. Endoscopes with larger screens are now available, and we anticipate these would be rated more highly. The Endoscope was not sturdy. To stabilize it enough to take pictures, we had to supplement the structure with rubber bands. Making large changes in the magnification required adjusting the height of the endoscope and refocusing, which typically took several minutes, even for an experienced user. The Endoscope was limited to illuminating samples from above, which worked for our opaque planaria, but this made it less flexible than the Dissecting Microscope. However, it was light and easy to transport.

Phone Clip Microscope

The Phone Clip Microscope was the lowest rated in both categories. While this microscope might be a good choice in very specific situations, it was not a good choice for observing live planaria. While very inexpensive, this microscope had the lowest level of magnification (20X) and required use of a smart phone, which made it difficult to use in an outreach setting, especially with young participants. The Phone Clip Microscope had a very small focal distance; the casing of the microscope had to touch or be very close to the sample to get a focused image. This was challenging when the sample was a live animal in water. In addition, smart phones with multiple lenses, a common configuration, would often switch to using a different lens during focusing.

DISCUSSION

The objective of this project was to find a microscope that would work well for outreach events, especially those aimed at K-12 students. Three microscopes in this study, the Compound Microscope with Screen, Endoscope with Screen, and Dissecting Microscope were all rated highly by participants in real outreach events. These three microscopes were portable, affordable, high-quality, and easy-to-use. The microscopes with built-in screens were the best matched for the outreach events in this study, which had hundreds of participants moving through dozens of activities. Participants could acquire clear images in seconds and share their thoughts and observations with one another and with the activity leaders. The Compound Microscope with Screen produced images comparable to research imaging systems. The Endoscope with Screen and Dissecting Microscope would be good choices if the goal is to see the entirety of samples that are larger than 1 mm or that move rapidly. The Dissecting Microscope was the only microscope tested that can be used for manipulating a sample under magnification.

Projects like this one have the potential to provide greater access to scientific exploration and give a wide range of students the opportunity to experience the joy of discovery (Supplemental Material 2). The use of microscopes opens opportunities to bridge the divide between members of research laboratories and their communities, especially as many organisms used in biological research are quite small. Furthermore, the use of screens instead of eye pieces can increase accessibility. In our study, the greatest impact of using the microscopes with screens was to give young children, who might be too small to use both eye pieces, a successful and engaging experience. Finally, this project made the beauty of biological systems accessible to participants and thus emphasized the creative, artistic side of science. This approach has the potential to broaden people's idea of who can be a scientist while demonstrating that science can be approached through art.

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About the Authors

Sabrina Segar is a recent graduate of the University of Minnesota Duluth where she graduated with a B.A. in Biology and a B.A.Sc. in Secondary Education -Teaching Life Sciences. She is continuing her education through the pursuit of a master's degree and plans to teach someday. This project was a great combination of her passions, her love for education and bringing science to everyone.

Jennifer Liang is a Professor of Biology at the University of Minnesota Duluth. Her research laboratory uses zebrafish to study the early steps in the development of the central nervous system. Her goal is to help everyone think of themselves as a scientist and experience the joy of discovery.

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Supplemental Material 1: Data and statistical analysis

Supplemental Table 1: Total responses for Clarity ratings

	Ratings (total number)				
	Clear	Somewhat Clear	Acceptable	Somewhat Unclear	Very Unclear
Phone Clip Microscope	13	19	21	34	33
Endoscope with Screen	65	41	19	4	1
Dissecting Microscope	80	33	15	4	0
Compound Microscope with Screen	124	12	5	1	1

Supplemental Table 2: P-values for each pairwise comparison of Clarity ratings¹

	Endoscope with Screen	Dissecting Microscope	Compound Microscope with Screen
Phone Clip Microscope	8×10^{-23}	6×10^{-27}	1×10^{-41}
Endoscope with Screen		4×10^{-1}	5×10^{-10}
Dissecting Microscope			5×10^{-6}

¹P-value indicating a significant difference was set at 0.008 (0.05/6) using a Bonferroni correction.

Supplemental Table 3: Total responses for User Friendliness ratings

	Ratings (total number)				
	Very Easy to use	Somewhat easy to use	Neither easy nor difficult to use	Somewhat difficult to use	Very difficult to use
Phone Clip Microscope	22	27	23	25	16
Endoscope with Screen	74	29	12	3	0
Dissecting Microscope	64	28	19	8	0
Compound Microscope with Screen	94	18	3	2	1

Supplemental Table 4: P-values for each pairwise comparison of Clarity ratings¹

	Endoscope with Screen	Dissecting Microscope	Compound Microscope with Screen
Phone Clip Microscope	6×10^{-215}	3×10^{-10}	2×10^{-22}
Endoscope with Screen		3×10^{-1}	1×10^{-2}
Dissecting Microscope			2×10^{-5}

¹P-value indicating a significant difference was set at 0.008 (0.05/6) using a Bonferroni correction.

Supplemental Table 5: Clarity ratings by age and microscope

Microscope	Age range	Ratings (total number) ¹				
		Clear	Somewhat Clear	Acceptable	Unclear	Very unclear
Phone Clip Microscope	Age 5-10	0	0	1	0	1
	Age 11-13	5	6	7	8	9
	Age 14-18	8	13	13	26	21
Endoscope with Screen	Age 5-10	3	6	3	0	0
	Age 11-13	18	12	4	2	0
	Age 14-18	44	23	13	1	1
Dissecting Microscope	Age 5-10	5	5	2	0	0
	Age 11-13	26	8	3	2	0
	Age 14-18	48	21	10	2	0
Compound Microscope with Screen	Age 5-10	15	1	3	0	0
	Age 11-13	33	1	1	0	0
	Age 14-18	74	11	1	0	1

¹P-value indicating a significant difference was set at 0.01 (0.05/3) using a Bonferroni correction. There were no significant differences in the ratings among age groups.

Supplemental Table 6: Use Friendliness ratings by age and microscope

Microscope	Age range	Ratings (total number) ¹				
		Clear	Somewhat Clear	Acceptable	Unclear	Very unclear
Phone Clip Microscope ²	Age 5-10	0	0	0	0	2
	Age 11-13	6	10	7	3	7
	Age 14-18	16	17	16	21	9
Endoscope with Screen	Age 5-10	8	3	1	0	0
	Age 11-13	25	9	1	1	0
	Age 14-18	51	20	10	2	0
Dissecting Microscope	Age 5-10	10	13	2	3	0
	Age 11-13	23	11	6	1	0
	Age 14-18	35	12	12	3	0
Compound Microscope with Screen ³	Age 5-10	20	16	1	0	0
	Age 11-13	34	4	2	0	0
	Age 14-18	54	9	1	0	1

¹P-value indicating a significant difference was set at 0.01 (0.05/3) using a Bonferroni correction.

²There were significant differences between the ratings for ages 5-10 and those for ages 14-18 (0.002).

³There were significant differences between the ratings for ages 5-10 and those for ages 11-13 (0.002) and 14-18 (0.002).

Supplemental Material 2

Guide for students developing a microscope-based outreach project

Objectives

- Use outreach events as a mode to convey science to others and collect data for your project
- Learn how to organize and analyze data
- Explain and interpret the results and conclusions

Methods and Data Collection

Part A: Planning

In carrying out a research project, you will have the opportunity to ask questions, create methods, and conduct experiments to gather data. You will then be able to analyze this data and interpret the findings to answer your research question. In preparation for a research project, you should be aware of the timeline and the resources available to you. You, your mentor, and other collaborators should work together through the planning aspect of the project. What is your primary question? How can you gather data that is applicable to your question? What methods of data collection are necessary and reliable?

For instance, you could focus on discovering which microscope would be the best for outreach events. You could narrow the focus of your study to image clarity and user friendliness. Methods of data collection to match your focus are also needed, such as Likert-type scales to allow outreach participants to quickly and easily provide ratings based on their experience at our activity.

Part B: Institutional Approval

The most challenging part of a project can be obtaining institutional approvals. These all need to be obtained before you start your project. If your research involves humans, such as gathering data from the people participating in an outreach event, your project plan needs to be reviewed by the Institutional Review Board (IRB). You can first submit a human determination form first to see if a full IRB protocol is necessary. If the project is not ruled exempt from IRB oversight, you will need to write and get approval for a full IRB protocol on your project. If you are using vertebrate animals, you will need to get any procedures using the animals approved by the Institutional Animal Use and Care Committee (IACUC) and everyone working with the animals will have to be on the protocol, which includes completing IACUC-required training. Finally, everyone working with chemicals should complete the relevant chemical safety training and all chemicals should be reviewed for safety.

Part C: Choosing the specimen

Taking live specimens to outreach requires extra materials and time. It is best to choose organisms that the project leaders are very familiar with. The organisms should be portable, able to withstand a lot of handling, and easy to keep alive. For example, live planaria are a good match for a microscope-based project as their size (~ 5 mm long) is appropriate for a wide range of magnifications. Live planaria can be easily wet mounted on a slide by either the people leading the activity or the participants themselves. To do this, a plastic transfer pipet, planaria, and a drop of water are placed into the depression of a glass depression slide. A cover slip is then placed on top to keep the planaria and water in the depression. The planaria should be kept on the slide for about ten minutes because the light from a microscope increases planaria activity and can dry out the slide.

Planaria are also very easy to transport and use. The planaria should be transported in a covered container with extra water. Approximately 10 planaria in 200 ml of water is a good ratio. On arrival to the outreach event, the cover or the transport container should be removed so the water remains oxygenated. This transportation container should be used as a recovery tank for the planaria that have been used on slides. To move them to the recovery tank, the cover slip should be removed and a transfer pipet full of water used to wash the planaria into the recovery container.

Part D: Implementing the Outreach Activity

It is important to have a plan for finding appropriate outreach events where you can host a station. If possible, build on connections with local schools, university outreach events, and FIRST Robotics, a non-profit focused on STEM education. Have a plan for how your activity is going to flow but be flexible so that you can change the plan if needed. When participants arrive, give them a brief overview of the project and what they will be doing. In addition to explaining the goal of the project, ensure you provide enough background information and share a few fun facts. Keep your introduction to five minutes or less so the emphasis is on the hands-on experience. Ensure that someone who can both ask the participant questions and answer their questions is always nearby. If you are gathering data from participants, make sure that they can easily and quickly do this before leaving your activity. Finally, consider having a souvenir your participants can take home at the end of your event, such as STEM-themed stickers (Figure).

Part E: Data Analysis

Make sure to have a system for collecting and backing up all the data collected during the outreach events. It is also important to sort the data and organize it according to the analysis you are planning to do. Another challenge is finding the correct statistical test, especially if the sample sizes are not the same across categories and if you have many sets of data to compare. There are many free online calculators and free software that can be used, many of which also include guides for finding the right test. For instance, Interactive Statistical Calculation Pages provides online calculators for many statistical tests and Real Statistics for Excel provides a free plug that brings many additional statistical methods into Excel (Zaiontz 2023)(Interactive Statistics).

Figure: Example of a STEM-themed sticker that was given to participants in an outreach-based microscope project.



CITED REFERENCES

Interactive Statistics. [accessed 2025 Aug 26]. <https://statpages.info/>

Zaiontz C. 2023. Real Statistics Using Excel; [accessed 2023 Aug 9]. <https://real-statistics.com/>