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Essay

Online Adaptation to "Gotcha! Which fly trap is the best? An introduction to experimental data collection and analysis"

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Abstract

We present here a simple and engaging experiment capitalizing on the universal need to rid our homes of fruit flies to teach experimental design and analysis. In an earlier paper, we described an experiment in which students learn the scientific process by attempting to answer the question, "what is the best way to catch fruit flies?" The experiment was designed to be easily adaptable to the resources available to the instructor. With the recent increase in schools opting for the online delivery of courses, we are updating the paper with suggestions on how students can complete the fly trap experiment from home. Traps are made with common items and baited with materials found in most kitchens and placed near open windows for up to five days during temperate seasons. Students are encouraged to creatively modify trap designs and baits based on their resources. Students then count and record the number of flies captured in each trap/bait combination and share their data across the class to create a large data set to analyse and explore for trends. Online video conferencing platforms, such as Zoom, can be used before and after the experiment to facilitate group discussion and maintain student engagement. Datasets can also be pooled across classes and we have included a sample dataset created through a Twitter callout for participants. The experiment is easily adaptable to allow students to have a valuable hands-on experience with experimental design, data collection, data analysis, and effective peer communication without leaving their own home.

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Supporting Materials: Supporting Files S1. Fly Trap – Example Dataset and S2. Fly Trap – Sample Analysis for Anecdata Dataset.

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INTRODUCTION

The fruit fly, *Drosophila melanogaster*, is a common household nuisance that is also extensively used in research laboratories as a model species to explore a suite of biological phenomena, often from a genetic perspective (1). We designed an experiment, in an earlier lesson, which posed a question that unites homeowners and fly geneticists, "What is the best way to catch fruit flies?" (2,3). In the experiment, students used various fly trap and bait combinations in order to answer this question. The experiment introduced students to experimental design, data collection, and data analysis. With the recent COVID-19-driven increase in schools moving to online learning, we are updating the in-class experiment with suggestions on how to complete this experiment without physically being in a classroom. Our fly trap experiment was designed to be adaptable based on the resources available to students and instructors. The adaptability of the experiment gives students the opportunity to have hands-on experience solving a problem through the lens of a scientist while taking a class online. The adaptations that can be made to the experiment allow students to achieve similar learning objectives as in the original paper without any direct physical interaction with one another. For example, various online conferencing platforms can be used to facilitate student discussions with their peers and promote student engagement with the lesson plan. Study participants can also be recruited online and we include a sample dataset, and access to the online data repository through Anecdata (https://www.anecdata.org/projects/view/794) we generated through a call-out on Twitter for people to participate and trap flies using a simple 2x2 trap/bait design.

ADAPTATIONS FOR CATCHING FLIES

Our in-class fly trap experiment is easily adapted to be conducted at home; the traps and baits are common household items and designed to be swapped and exchanged. The recommended baits include fruit, vinegar, beer, wine, and kombucha. These are all common household items, some or all

of which students likely have and students should be encouraged to explore other options and be creative in the baits that they choose. Fruit flies feed, mate, and lay eggs on rotting fruit, so, ultimately, the bait should either be a piece of fruit or should have a component that mimics rotting fruit. For example, vinegar and wine are common baits used to catch fruit flies and are thought to be effective because they are acidic and release volatile compounds similar to those released by rotting fruit (4).

Traps generally consist of a container, with or without a cover. The three trap designs in the classroom exercise were 8oz plastic cups covered with plastic cling wrap or a paper funnel, or left open. Students can use any cup or small jar that is available to them, or a plastic bottle can be cut to create a cup. We use canning "jelly jars" in our lab. The material for the cover is also adaptable, e.g., a plastic bag and rubber band could be substituted for the cling wrap.

In this experiment, flies will be attracted from outside to be captured in the traps. Our original exercise included the option of releasing flies into a room or container, but fruit flies are found in the wild in essentially all temperate areas inhabited by humans and artificially seeded flies are, therefore, not strictly necessary. Rather than releasing flies into a room or container, the traps will be placed near an open window for up to five days. Windows should be open, but window screens can be in place. While we are reasonably sure that flies do not violate any known laws of physics, they do seem to be able to, mysteriously, get around screens. The number of captured flies will then be recorded. In temperate areas, flies can be caught from late spring through the fall (5). The captured flies may be quite active within the traps, making it difficult for students to count the number of captured flies. If a student is struggling to count the flies, we recommend that they take a picture of the trap and then count the number of flies caught in each trap. Traps can also be placed in a refrigerator or freezer to slow the flies and make counting easier and can be frozen to kill all flies before disposing of the counted traps in the waste.

Some students may be unable to leave a window open for the 5-day period. Students without the option of leaving the trap near an open window may choose to run the experiment for a shorter time period, or can leave the traps outside in an area that can be shielded from the elements to the best of the student's ability. Ultimately, while it is better to run the experiment for up to five days to catch enough flies for a reasonable sample size, adaptations can be made to fit most students living conditions. While the experiment was designed to be completed using common household items, instructors should note that in some extreme situations, students may be unable to complete the experiment due to their living conditions. In the case that a student's living situation does not allow them to complete the experiment in any way, the student could plan out a hypothetical experiment and then use another student's data for analysis. The online dataset on Anecdata that we have created should allow all students to analyze data, even if they cannot collect data of their own. We have also included a data set from our fly trap experiment for instructors to use as an example with their students (S1. Fly Trap – Example Dataset).

ALTERED ASSESSMENT FOR ONLINE LEARNING

The fly trap experiment is an opportunity for students to gain a better understanding of experimental design, and the experimental design they propose can be assessed by the instructors. The students can provide a rationale for the baits that they choose to use, the number of replicates they choose to have, etc. Students are able to complete this experiment at home using common household items, but some students may lack certain resources. For example, if a student chooses 3 different bait types, they may not have enough cups to have the suggested four replicates, resulting in a smaller sample size and less replication. As part of the student's assessment following the experiment, they can analyze their own experimental design. Students can discuss the possible effects of smaller sample sizes, what they would have done if they had any resource at their disposal, and what they think was successful as part of their experimental design.

The data analysis can be done as stated in the original paper (See "Teaching Discussion-Five-Days After Release". Students can explore their data in different ways and prepare different visual representations to best explain their results using readily available spread sheet and graphics software (e.g., Microsoft Excel or Google Sheets). They can then further explain why they chose a particular type of graph to represent their data. Students can use the data to examine the difference between using a large data set versus a smaller data set. Typically, a larger data set should allow better resolution of any differences between the treatments. Working with a larger data set can also give students the opportunity to practice using more complex methods of data analysis, data management, and data presentation. Students can also identify trends in their own data and compare these to the trends in the larger data set as a whole, which can potentially highlight how working with a larger data set can impact the result of an experiment.

Instructors should note that the marking of assignments through distance learning can be more time consuming than in-class assessments, and the planning of this experiment should reflect the potential increase in time required to assess the students' work. Students can be assessed using short discussion prompts that will test their knowledge of experimental design, trends in the data, and the results of their data. For example, students can be asked to briefly explain the reasoning behind their choice in bait, any trends in their data, and if the result of the experiment was expected. The figures the students generate can also be assessed.

MAINTAINING STUDENT ENGAGEMENT THROUGHOUT DISTANCE LEARNING

The experiment can be completed by students on their own, or as a group. Most students can relate to the question we are asking because fruit flies are commonly found in households. In our experience, students are generally engaged with the lesson because they are seeing the real-world application of their experimental work. Also, it is just sort of engaging in a fun way; we are literally trapping flies for science. If students work alone they may not be able to generate a large data set, but they will still be able to analyze their own data and they can use the online data set. Additionally, the hands-on nature of this experiment will be specifically helpful to students who require, or simply benefit from, hands-on work to facilitate their learning.

The experiment can also be done through distance learning in a way that facilitates group discussions to encourage student engagement. The class can meet to discuss the experiment at various points using video conferencing platforms such as Zoom

or Microsoft Teams. Encouraging group discussion throughout the experiment can give students the opportunity to gain skills in effective peer communication. Before the experiment, the class can brainstorm and discuss different bait types that could be used by students. For larger classes, features on video conferencing platforms, such as the "breakout room" function on Zoom, sub-meetings within the larger meeting, can allow students to meet in small groups to create an interactive learning environment and discuss the experimental design. Working in small groups allows students to collaborate and share their ideas, and encourages the students to have discussions with one another. Distance learning could create scheduling issues within groups. An alternative to video conferencing between students would be for the students to film short videos of themselves explaining their experimental design. Students could then be assigned to review other students experimental design. Teachers can also use online meetings before the experiment if the students require a demonstration of trap construction.

A spreadsheet that all students have access to, e.g., on Google Sheets, can be created for students to upload and view each other's data. For larger classes, students can be split into smaller groups to share their data if the instructor decides that the data set from the entire class is too overwhelming for students to work with. Students can analyze their peers' data and compare it to their own. We did a call out on Twitter to recruite participants in a scaled-down 2X2 design of the fly trap experiment, with the idea of advertising the experiment broadly to encourage participation. Within the first two days of the tweeting the call-out, we generated hundreds of likes and retweets, but only a handful of actual responses with data. While the Twitter call-out shows how social media is a great tool for communication and collaboration, a lesson we learned through this experience was that, while social media can generate responses, it is much more difficult to motivate people to actively participate. Instructors could use this as a way to start a discussion with their class on effective ways to target an audience. Another lesson we learned from our Twitter call-out is that there are several free, online citizen science platforms that can be used by anyone to generate live data sets. We have created a project entitled "Which fruit fly trap is best?" that can be found on Anecdata. The Anecdata project is a scaled-down version of the fly trap project that uses two bait types and two trap types. We simplified the experiment to a 2x2 design as a way to facilitate greater participation. Students and instructors can access this dataset and add their own observations if they would like to use the same baits and traps used in the scaled-down experiment. In order to access the data, students and instructors can create a free account with Anecdata and visit the project page (https://www.anecdata.org/projects/view/794) and join the project. Students can use their school email to create their account. To add an observation to the project, students can click "Add Observation" where they will then be directed to a page to input their data. Students can see the entire dataset of the project by going to the project page and selecting "Observations and Data" then "Table View". The table view allows users to see all results, and has an option to download the results for analysis offline. The data can be downloaded by anyone, regardless of if they have added an observation to the dataset or not. This data set can also act as a sample dataset for an instructor to use as a reference for their class. We have included a sample spreadsheet that can be used to analyze the dataset on Anecdata (S2. Fly Trap – Sample Analysis for Anecdata Dataset). By sharing and comparing their data, students can see if their results match other students' results who used similar bait/trap types. If a student was physically unable to complete the experiment, the shared document will allow for the student to work with a data set. An additional section can be added to the spreadsheet in the original paper (S1. Fly Trap – Excel Template for Results) in which students can add their location. Students can then compare their data with that from other locations and determine, for example, if different baits, traps, or combinations perform differently in urban versus rural areas. Online learning presents an opportunity for students all over the world to connect and run this experiment at the same time in different parts of the world and share data. Overall, students are encouraged to be creative and exploring in the questions they ask.

Students can also have a virtual meeting after the experiment, and share their interpretations of any apparent trends in their data and compare their data to other student's results. Students can create slide presentations as a way to share their data in a meaningful way with other students. If scheduling meeting times within groups is challenging for a class, the slides can be simply be shared with the group members and reviewed by each student individually. Audio can be embedded within the slides if the instructor would prefer their students explain their results in more detail than a slide allows, or the "Note" section below slides can be used.

Overall, this experiment can be modified to suit student and instructor needs by changing the bait/trap types or the data analysis depending on the resources available to the instructor and students. Although distance learning has its own challenges, this easily adaptable experiment can fit the needs of the instructor and class. While synchronous learning can allow for more group discussion, students can still gain meaningful experience in designing and executing an experiment, and analyzing data, while working on their own.

SUPPORTING MATERIALS

- S1. Fly Trap – Example Dataset
- S2. Fly Trap – Sample Analysis for Anecdata Dataset

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Table 1. Online fly trap experiment teaching timeline and description of steps

Activity	Description	Estimated Time	Notes
Pre-Experiment Activities			
Instructor Video	1. The instructor demonstrates the proper amount of liquid/solid bait to insert into an open trap. 2. The instructor demonstrates how to properly secure plastic wrap and poke holes in the second trap using elastics and a pencil. 3. The instructor demonstrates how to cut a paper funnel and attach it to the trap. 4. The instructor will inform students that when they begin to count their flies after 5 days, they can take a picture of the trap, or freeze the traps for 5 minutes to slow the flies, making counting easier.	10-15 minutes	The instructor may choose to do this as a live lesson on Zoom, or can pre-record a video showing the trap construction.
Group Discussion	1. As a class, or in small groups, students will suggest possible baits for the experiment. 2. Students will discuss any modifications they would need to make to the design based on the resources they have available to them.	5-10 minutes	• This discussion period allows students to begin to plan what they will use for the traps and the bait. • In cases where live group discussion is not an option, a shared document can be created in which students can share their bait/trap ideas with one another.
Question Period	Students may require a short question period with the instructor to clarify any changes they will need to make to the experiment based on the resources available to the students.	10 minutes	Students may get hung up on the idea that they do not have the exact cups the instructor used in their video, or the exact bait types. Ultimately, any container with or without a covering will work for this experiment.
At-Home Experiment			
Preparation of Traps	Students will prepare the traps with various baits.	30-45 minutes	
Set Up Traps	Students will place traps near an open window for up to 5 days.	5 days	Students can also place traps in an area outside of their home that is relatively shielded from the elements, or can leave the traps out for less than 5 days.
Five Days After Release			
Count Flies	1. Students will count the number of flies captured by each trap. 2. Once counted, the data is recorded in a digital spreadsheet by the students.		• The captured flies may be active in the traps, making it difficult to count the flies. Students can take a picture of the traps, or the students can place the traps in the freezer for 10 minutes to immobilize the flies, making them easier to count. • Instructors may also have their students upload their data to the live data set found on Anecdata
Disposal of Traps	1. Students will freeze traps for 30 minutes to euthanize the flies. 2. Students will dispose of the traps in a trash, or by flushing the contents of the traps.		
Group Discussion	1. Students will meet as a class or in small groups and discuss the trends in their data and the class data set. 2. Students can discuss ways of effectively discussing their results to different target audiences, as well as ways to recruit participation in experiments like this fly-trap experiment.		Students can be asked to have a short slideshow to show their figures that they prepared from their data.