Be an Astronaut!

Metadata

General Info

Title

Be an Astronaut!

Short description

Being an astronaut means first and foremost: managing a lot of stress and making sense of the data you get! But who's to decide? This is where all the astronaut training tests and experiments come in. You'll learn how to make professional decisions in challenging circumstances! And along the way, you'll learn how to collect, evaluate, analyze, and communicate data.

Keywords

Cognitive load, experimental design, psychological effects scientific data literacy, reporting research, summarizing data, presenting data

Educational Context

Context

Student centered problem-based learning, interdisciplinary activities, collaboration

Age

Primary and secondary level, the appropriate age level depends on the particular task (from the set of astronaut training tasks) and can be chosen flexibly.

Prerequisites

None.

Lv. Of difficulty

Varies with task at hand.

Duration

3 hrs max

Educational Objective

Create an educational framework with the goal to challenge our students and start the process of inquiry-based learning. The applicability of this approach extends to many subjects in the STEAM arena.

Cognitive Objectives

The focus lies on problem-based learning.

Affective

Promoting group work.

Psychomotor

Depends on task at hand.

Subject Domain

A whole range of topics can be subsumed under the heading "Train like an astronaut". The concept is therefore not limited to STEAM lessons, but extends to fields as diverse as psychology and the human sciences.

Big Ideas of Science

Scientific problems often pose a great challenge to human ingenuity. Getting unnecessary complications out of the way is at the heart of scientific inquiry. Working together on a problem, acquiring the necessary background knowledge, critically examining the answers obtained, and presenting the results in an appealing manner are the cornerstones of scientific work.

Subject Domain

There is an obvious connection to physics, but any other STEAM topic can be implemented just as well within this framework. Any data-based science can be incorporated into this concept.

Orienting & Asking Questions

Some people collect autographs. Some people collect numbers. Let's say we also collected a bunch of numbers. How can we get an overview here?

Here's some real data: 102 male and female astronauts applied to participate in a mission - see our AMADEE20 mission web link: https://oewf.org/en/class-of-2019/

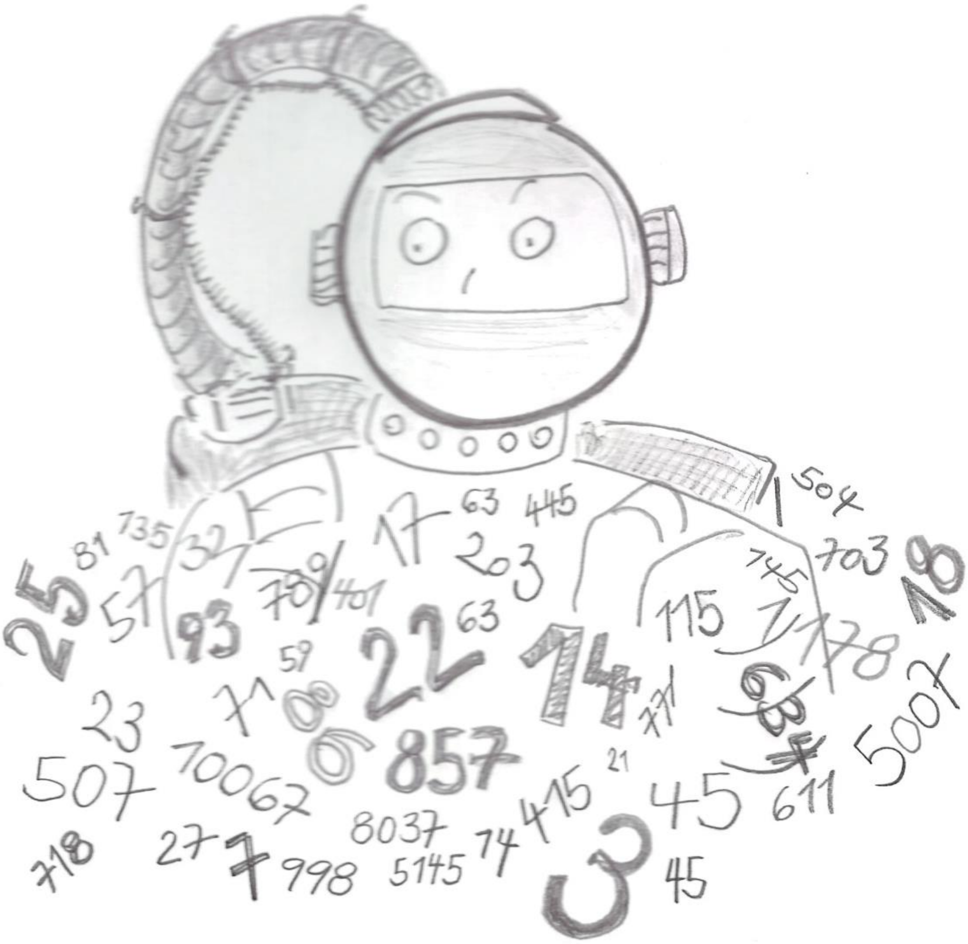
In the selection process, each applicant had to do push-ups. We simply counted the number of push-ups.

These are the results of the experiment:

Men:
23, 32, 43, 30, 35, 36, 41, 48, 62, 28, 31, 40, 29, 44, 47, 25, 27, 28, 31, 35, 41, 21, 27, 26, 40, 30, 25, 20, 35, 27, 31, 30, 27, 20, 35, 30, 25, 30, 20, 25, 26, 28, 33, 35, 37, 40, 25, 30, 45, 27, 30, 33

Women:
20, 23, 33, 17, 20, 21, 35, 12, 18, 23, 22, 31, 28, 27, 40, 37, 18, 15, 11, 16, 19, 20, 18, 34, 36, 21, 15, 17, 25, 20, 15, 12, 20, 16, 13, 15, 21, 20, 26, 24, 15, 14, 17, 12, 15, 20, 14, 16, 15, 20

With this pile of numbers, it's easy to lose track. What could you do to keep an overview here?



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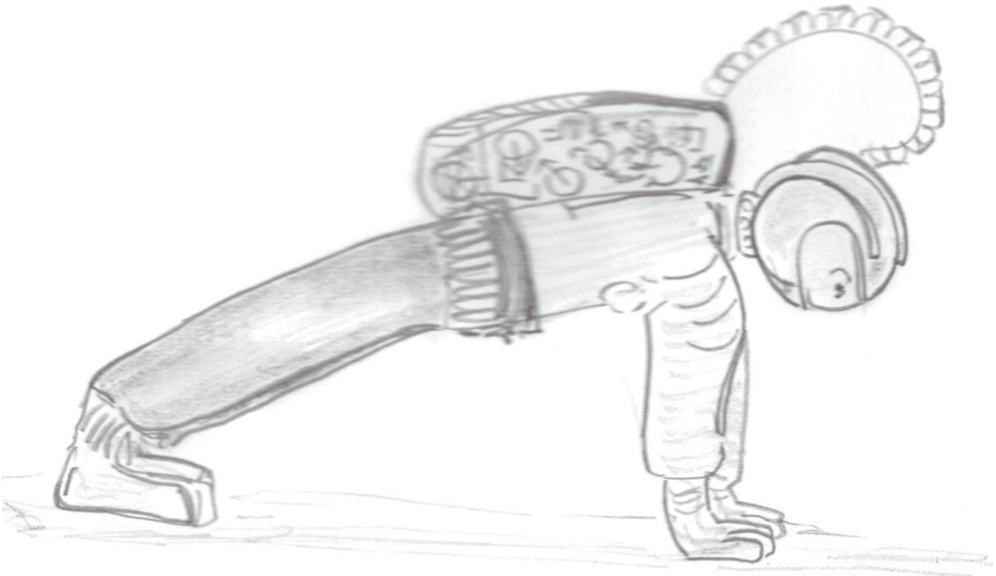
Hypothesis Generation and Design

Somehow the suspicion suggests itself that men and women cope differently with the tasks set. Is that true at all? And does it depend on the task set? We also measured how women and men cope in stressful situations. Can we see a difference here? In the case of push-ups, you might get the impression that men do better here. Can we support this hypothesis?

How do we need to design our experiment so that the comparison is fair in the first place? Can you imagine a setting so that the comparison would certainly be unfair?

If you do a scientific experiment yourself soon, don't forget to make your hypothesis!

What are your guesses about the outcomes and how would you like to prove your suppositions?



Planning and Investigation

Now plan your own investigation.

We also check the reaction times of the astronaut candidates. You can do that too. Work with a partner to do this.

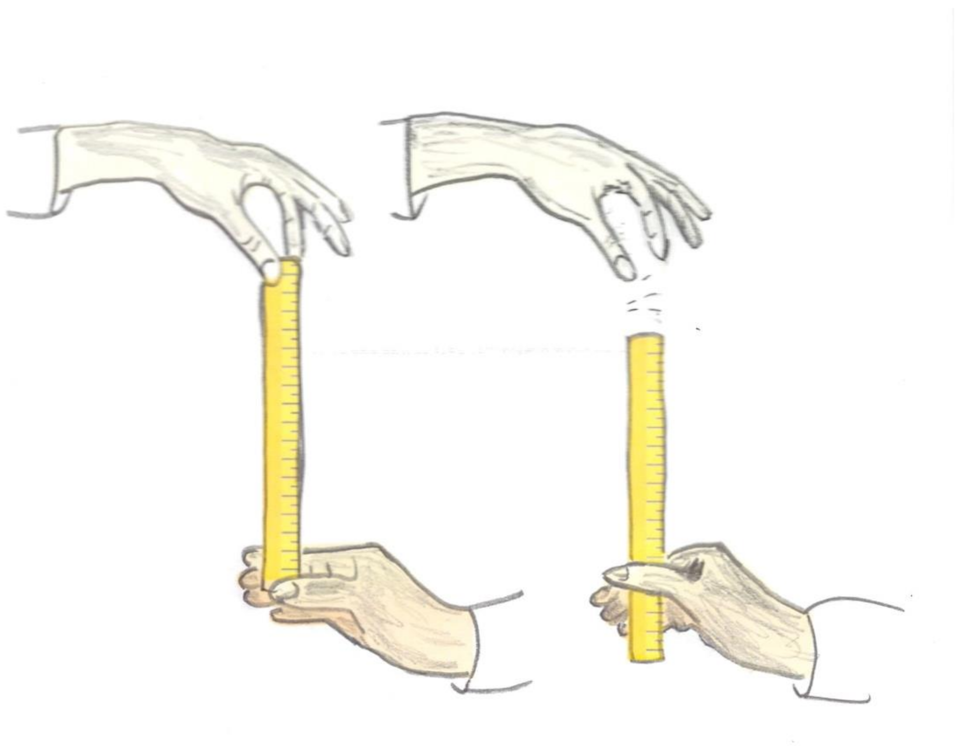
The aim of this experiment is to determine whether a factor such as background noise affects reaction times.

This is how Anna and Georg conducted the experiment:

1) Anna stretches out her arm and forms a gap with her index finger and thumb. As a first test run, Georg drops the ruler lengthwise through this gap.
2) Now the first run of the experiment can begin. To do this, Georg marks a zero line on the ruler. Georg now holds the ruler so that the zero line lies exactly in the gap that Anna forms with her fingers.
3) Without any warning, Georg suddenly drops the ruler at a certain moment.
4) Is Anna fast enough to catch the ruler by closing only her thumb and index finger quickly? Anna must only move her thumb and index finger in this experiment - not her whole arm!
5) Could Anna catch the ruler? Possibly - but certainly above the zero line that Georg drew in before.
6) How many centimeters above the zero line could Anna stop the ruler from free falling? Write down the value.

A single value does not say too much about Anna's reaction time. Repeat the experiment 20 times and write down all values. Now you also have a bunch of numbers that we can evaluate to learn about the reaction time under different conditions.

Will Georg's response time be better or worse? How do we find out if background noise affects the reaction time of Anna or Georg?



Analysis & Interpretation

You have to do the evaluation with the reaction times yourself. Here we only show you how we evaluated the data from the push-up experiment. So let's take a look at our recordings with the data again:

Men:
23, 32, 43, 30, 35, 36, 41, 48, 62, 28, 31, 40, 29, 44, 47, 25, 27, 28, 31, 35, 41, 21, 27, 26, 40, 30, 25, 20, 35, 27, 31, 30, 27, 20, 35, 30, 25, 30, 20, 25, 26, 28, 33, 35, 37, 40, 25, 30, 45, 27, 30, 33

Women:
20, 23, 33, 17, 20, 21, 35, 12, 18, 23, 22, 31, 28, 27, 40, 37, 18, 15, 11, 16, 19, 20, 18, 34, 36, 21, 15, 17, 25, 20, 15, 12, 20, 16, 13, 15, 21, 20, 26, 24, 15, 14, 17, 12, 15, 20, 14, 16, 15, 20

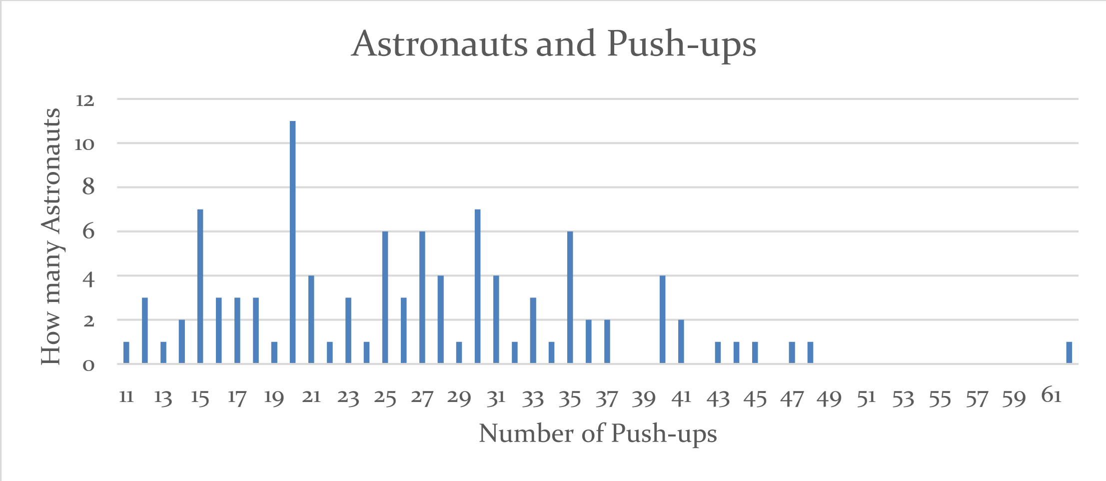
First, we look at the data from all 102 applicants. We look for the smallest and the largest value in our data pile.

The smallest value in the data set is: 11

The largest value in the data set is: 62

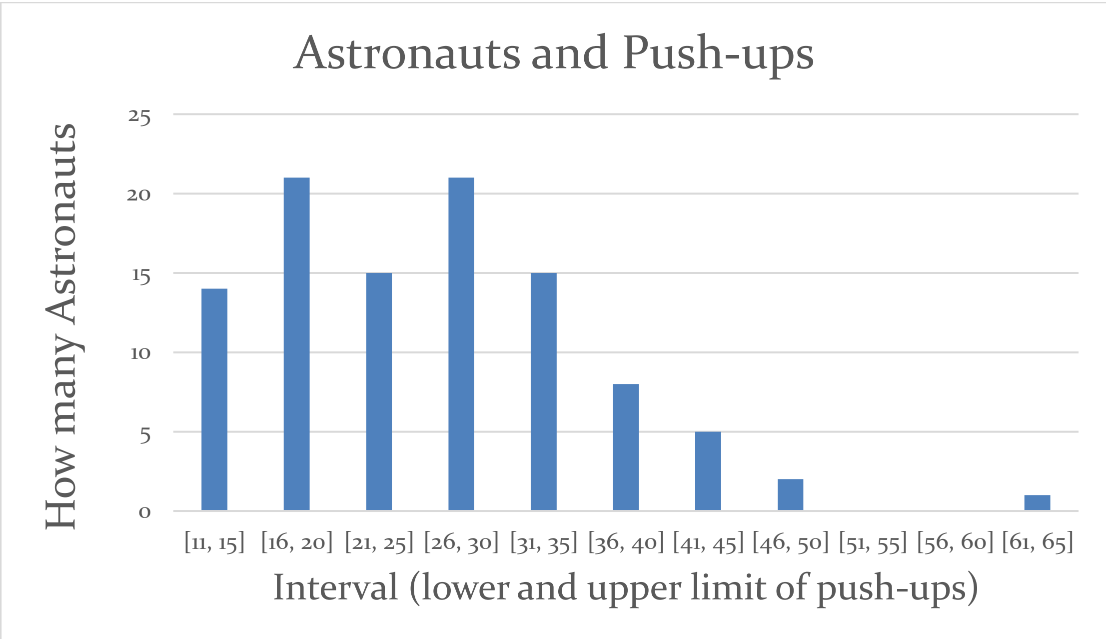
The values in between occur with varying frequency. For example, there are 7 astronauts who did exactly 15 pushups. And 4 astronauts who did exactly 21 pushups.

We can make a chart for all possible values of the performed push-ups and get a good overview. What stands out here?



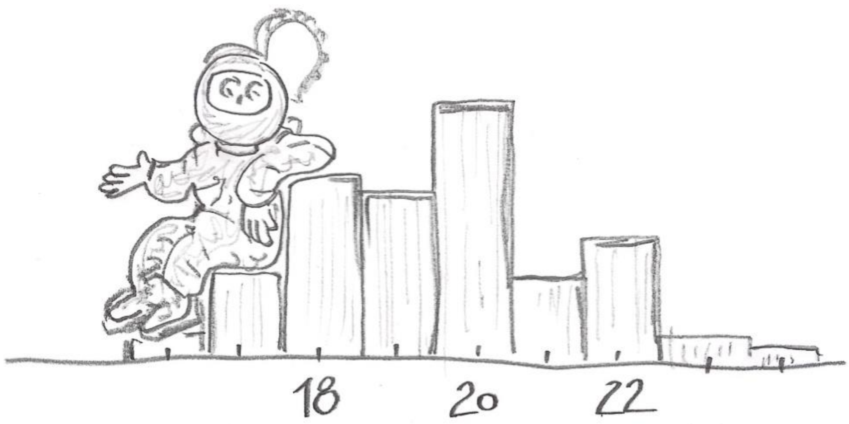
Sometimes it can also be convenient to summarize the data a little.

For example, we count how many applicants could do at least 11 but no more than 15 push-ups. The answer: 14 astronaut applicants. Likewise, we continue: How many applicants could do at least 16 but no more than 20 push-ups?



But all this is just the beginning of serious data analysis. In the toolbox of this platform you will find tools that make working with data much easier. However, you have to learn the ropes here first. But the initial investment of time is worth it. Go to the platform's toolbox and search for suitable tools. First, of course, it would be good if you familiarize yourself with the most important terms of data analysis.

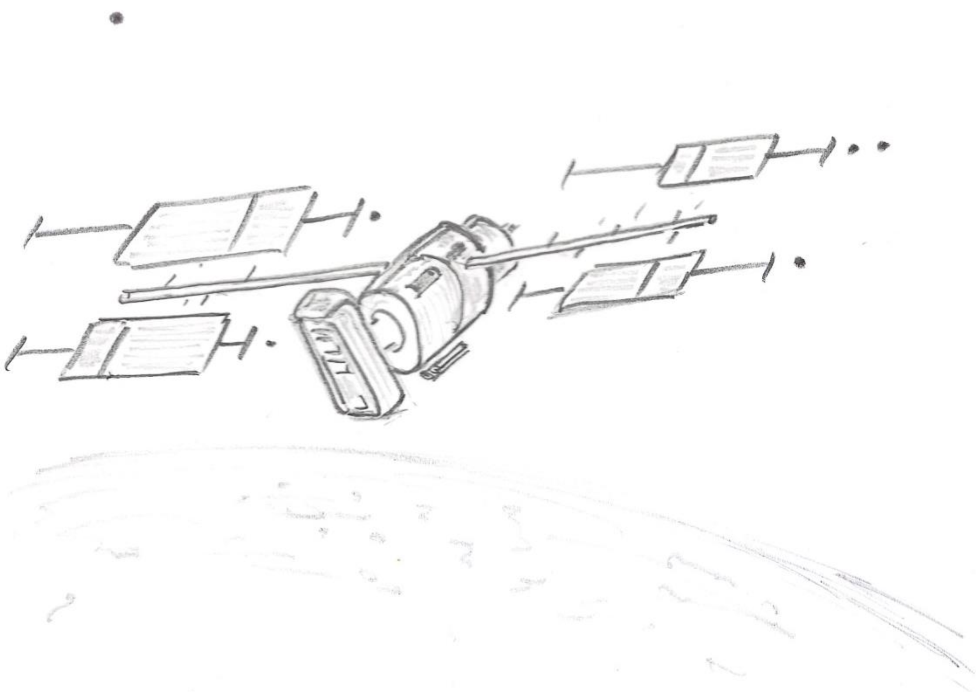
It is a good idea to become familiar with the terms **median, interquartile range, box-whiskers plot and outliers**. Start a research on the terms and see what you can do on your own.



Conclusion & Evaluation

Now, looking at your analysis of the data, can you tell if there is a difference in the maximum number of push-ups between men and women? And what about your own experiment on astronaut training? Do girls have a better reaction time than boys? Does it make a difference if there is noise in the background? What is the median value for push-ups for male applicants? Does the outlier distort the result?

I'm looking forward to your report!



Orienting & Asking Questions

(Background Information for the Teacher)

Orienting: Provide Contact with the content and/or provoke curiosity

It may be advantageous to tie the start of the activity into a story. The overarching arc for the story is the need for rigorous training sessions for astronaut candidates. The Austrian Space Forum can provide such a background for analog astronaut training. On the website of the Austrian Space Forum you can find a lot of information how to apply for the analog astronaut training: https://oewf.org/en/class-of-2019/

For the successful implementation of the training unit "Be an Astronaut!" the distinction between learning objectives to be achieved and task accomplishment is essential. Graham Nuthall's (Nuthall, Graham. *The hidden lives of learners*. New Zealand Council for Educational Research Press, 2007) research shows that the danger of confusing task performance with learning is pervasive. It is possible to complete a variety of tasks and participating in class activities, without connecting concepts to prior knowledge, forming secure schemes, or consolidating new learning. Teachers must be aware of this and place a greater emphasis on clear learning objectives rather than task fulfillment.

With these preliminary remarks in mind, a "Be an Astronaut!" activity is composed of three elements:

- The teacher provides the necessary knowledge for the activity, e.g., "How do you find the median of a particular data set?" or "How can you visualize the summary of this data set?"

- The teacher specifies the task at hand (see examples below).
- The teacher gives a series of hints to scaffold the problem-solving process.

Define Goals and/or questions from current knowledge

Consider your overall curriculum plan as well as your students' prior knowledge when deciding on learning objectives for a series of lessons rather than just one. The learning objectives should include:

- The specific facts, concepts or procedures students should know and understand, building on the knowledge they already possess.
- The necessary processes students should be able to perform independently and fluently.

Hypothesis Generation and Design

(Background Information for the Teacher)

Generation of Hypotheses or Preliminary Explanations

The generation of a hypothesis or preliminary explanation will depend on the subject matter you want your pupils to learn. So, the first thing is to ask: What do you want them to learn? We will walk through this process of an "astronaut training session" with the help of an example. Afterwards quite a few examples with a completely different focus regarding the learning objectives will follow.

First, you must decide whether to use an experimental or correlational design to collect the required data. With an experimental research method students will systematically manipulate one or more variables to see their effect on an outcome variable (in the following example this manipulation will be due some varying level of background noise while measuring the reaction time). An experimental method design implies that data will be able to be used to make statements about cause and effect. In a correlation design method, one observes what naturally goes on in the world without directly interfering with it. This term implies that data will be analyzed to look at relationships between naturally occurring variables rather than making statements about cause and effect. The concept of "Be an Astronaut!" supports both research designs: correlational research and experimental research design.

A rather obvious option for an experimental research design will be to create some levels of distraction, under which the task at hand should be performed. Background noise could be one options, asking unrelated questions while students are trying to complete the task will be a different one. Instead of using perturbations for an experimental design, one can also use supportive hints in varying degrees. So, the question is: Under what circumstances are you able to perform a particular task? The spectrum of circumstances can range from supportive cues to disruptive influences.

Let's look at the process at some details with the help of a specific example:

Learning objectives: To know the physics behind free fall.

What do you want your students to learn? Students should develop an understanding of an object in free fall. A possible question to check for understanding might be: Does doubling the time for a free fall mean that the object falls twice as far? Clearly, a single predefined question is not sufficient to check for deep understanding of the topic at hand. It is at the teacher's discernment to vary the questions so that they reveal the students' understanding.

To further explore the flexibility of the "Be an Astronaut!" concept, we will leave physics and embed the activity in another subject area: mathematics and statistics. This time, we want our students to learn how to summarize a data set using a boxplot.

Second Learning objectives: To know how to draw a boxplot diagram.

What students should learn: The meaning of the terms required to draw a boxplot in a meaningful way such as median, upper and lower quartile, extreme scores, interquartile range.

Design/Model

For the application of the "Be an Astronaut!" activity in the context of statistics in conjunction with a free-fall experiment, we will choose an experimental design. We will measure the reaction time of the students in the presence of different levels of background noise.

For more examples of the use of the "Be an Astronaut!" concept in various curricula, see the following list of examples:

Example 1 (applicable to all STEAM subjects):

The teacher conducts an experiment in one subject area (physics, chemistry, ...). For this, the teacher needs some materials and / or equipment. After the experiment is conducted, students are challenged with the following "Be an Astronaut!" task: What items did we need to conduct the experiment. List as many items as you can!

Example 2 (applicable to all STEAM subjects):

Perform the following estimation! Example: How long does it take to get to outer space by bicycle? What is the distance to the moon - measured in earth diameters? For the "Be an Astronaut!" activity, measure the time needed for the estimation.

Example 3 (applicable to all STEAM subjects):

Teamwork: How long does it take your team to solve the following puzzle question? These classics by Martin Gardner can serve as a good reference for interesting questions: “My best Mathematical and Logic Puzzles”, “Entertaining Science Experiments with everyday Objects”.

Planning and Investigation

(Background Information for the Teacher)

Plan Investigation

The following example refers to the above mentioned "Be an Astronaut!" activity in the realm of statistics and free fall.

The process for creating a boxplot is first broken down into its component parts. Each component is first explained individually before combining the components into an overall picture. Likewise, the experiment is demonstrated so that students can see how they arrive at the data. Have each student collect twenty data points that give them information about their response to catching a free-falling object (a ruler). The time between noticing something (dropping the ruler) and reacting to it (catching the ruler) gives an indication of the reaction time of the catcher. Using the twenty data points, students should create a boxplot - remembering to label the axes correctly - and compare the result to their partner's data set.

Material needed for the activity: A centimeter scale (or inch scale) printed on stiff cardboard will suffice as a ruler.

Before starting the exercise, it is very important to check that each student has the knowledge required for the task: Each student should know how to determine the median, upper quartile and lower quartile, how to draw a boxplot and how to label the axes correctly.

Perform Investigation

The following steps describe the procedure for the "ruler drop test" to be implemented in partner work:

1) Instruct student A to hold the ruler near the end (highest number) and let it hang down. Student B holds out their hand with a gap between their thumb and first finger at the bottom of the ruler and be ready to grab the ruler (however, they should not be touching the ruler).
2) Student A drops the ruler without telling student B and student B must try to catch the ruler as fast as they can after it is dropped.
3) Record the level (inches or centimeters) at which they catch the ruler. Test student B twenty times (varying the time of dropping the ruler so they cannot guess when the ruler will fall).

An instructional video for this activity can be found at this link:

https://www.crick.ac.uk/whats-on/public-events/family-zone/test-your-reactions

For an experimental research design students should perform the experiment under different conditions, such as different levels of background noise.

Analysis & Interpretation

(Background Information for the Teacher)

Gather result from data

The following data set represents the data points from one student performing the above-mentioned experiment:

Example results: (only the first five data points are shown)

Attempt	Distance on ruler (cm)	Distance on ruler (cm)
number	With noise	Without noise
1	25	18
2	38	15
3	36	22
4	31	24
5	38	13

Conclusion & Evaluation

(Background Information for the Teacher)

Conclude and communicate result/explanation

Depending on the particular task chosen for the "Be an Astronaut!" activity, students should be able to correctly interpret the data they receive. If the focus of the activity described above had been more on the physics of free fall, then a correlation design would make perfect sense for the study. In this case, students would pay attention to whether there is a linear or non-linear relationship behind the experiment. If the focus of the activity described above had been more on the physics of gravity, then students could make educated guesses about how the experiment would play out on the lunar surface.

Finally, students could communicate the results of the investigation to their classmates. In the specific example with the falling ruler and the data analysis using a boxplot, the teacher would make sure during the presentation that the following terminology is used correctly:

Median, Quartile, Extreme scores, Interquartile Range, Middle 50%, Top 25%, Axis label.

Evaluation/Reflection

The concept “Be an Astronaut!” can be used for a variety of subjects and learning objectives. The evaluation and reflection of the activity is highly dependent on the subject matter. The importance of domain expertise cannot be overstated. There is no learning without it, but it is insufficient on its own. Each "Be an Astronaut!" activity begins with an overview of the basic knowledge blocks necessary to complete the challenge ahead. For the teacher, it entails asking, "What do my students need to know?" Thus, any evaluation or reflection of a "Be an Astronaut!" activity must examine whether this presupposed knowledge is even present after the activity is completed. But the evaluation of a "Be an Astronaut!" activity cannot end here. The evaluation must also include an examination of the quality of the knowledge. This means to ask, “Is it true?” Debate and argument are used to put the student to the test.

Consider other explanations

Depending on the task, students will learn to consider different explanations for their results in relation to the data obtained during a "Be an Astronaut!" activity. This is not an easy task for a beginner, so the teacher must scaffold the process.

For the teacher, this means creating the necessary frameworks that enable exploration, practice, and assessment (questioning knowledge). This means asking questions like "Does this make sense?" and modifying an experiment to allow for comparison, contrast, and understanding of different perspectives. The teacher encourages students to work in this way.

Assessment using provided assessment questions

The assessment questions should get to the heart of the relevant knowledge of the particular "Be an Astronaut!" activity. For the example activity above, these assessment questions could be:

- What is the significance of the interquartile range?
- Can you contrast an experimental research method with a correlational research method?
- What does a boxplot diagram represent?
- What is an outlier in the context of a boxplot diagram?