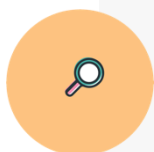


Educational toolkit and toolbox: Critical and innovative thinking skills workshop - Measuring the circumference of a ball



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INTRODUCTION – NOURISHING CRITICAL AND INNOVATIVE THINKING SKILLS DURING STEM ACTIVITIES

Critical and innovative thinking skills are directly linked to decision making. During a STEM activity, giving students several degrees of freedom will challenge them to use these skills to make informed decisions. Inviting students to make their own hypothesis, designing an experimental setup on their own instead of being given a ready-made one, as well as designing the experimental process themselves instead of following a step-by-step guide are excellent ways to help them be creative, use their imagination, their resourcefulness, and their innovative thinking skills. Getting in the process of testing their ideas and deciding whether they work will prompt them to become reflective thinkers and engage in reasoned decision making.

Brief Description of the workshop:

(WORKSHOP DURATION 75 MINUTES)

This workshop is about demonstrating through a simple challenge what it means to give degrees of freedom to students when doing an experiment to help them be creative and innovative. The objective is to challenge participants to perform a simple task without a fixed set-up or detailed guidelines available. The participants will have to think critically and innovatively to design the best possible experiment after considering a number of possible options.

Participants, divided in groups, will be given a simple task: to measure the circumference of a ball. The clue of the activity is that they will not be given neither specific instructions nor the exact tools they will need to use. Instead, they will be given a collection of tools which they will need to combine in order to find a way to measure the circumference. The tools are such so that there is more than one way to perform the task and not all tools are to be used simultaneously. Thus, participants will need to deploy their skills to select the tools they want and find the optimum way to perform the task without specific guidelines.





USE OF CRITICAL AND INNOVATIVE THINKING SKILLS:

This workshop focuses on developing these skills during the experimentation part of an activity. Participants will have to deploy their resourcefulness and creativity to figure out how each tool can be used, how they can be combined to perform the task and how many different ways there are to perform the task at hand. They will also need to use their application skills to make the measurement accurately and precisely and understand which are the possible sources of error. Finally, they will need to use their reflective thinking and reasoned decision-making to decide which is the optimum set up and procedure in order to obtain the most accurate measurement.

ACCOMPANYING FILES:

- ANSWER_KEY_Critical_and_Innovative_thinking_workshop
- PRESENTATION_Critical_and_Innovative_thinking_workshop
- TOOLS_Critical_and_Innovative_thinking_workshop
- WORKSHEET_Critical_and_Innovative_thinking_workshop

PREPARATION BEFORE THE WORKSHOP:

- Print the 'WORKSHEET_Critical_and_Innovative_thinking_workshop' document. You will split the group in teams (preferably of 3 or 4 people). Print as many copies for each document as the number of teams
- Read the answer key 'ANSWER_KEY_Critical_and_Innovative_thinking_workshop' so you are prepared for the workshop.

MATERIALS AND INFRASTRUCTURE NEEDED:

- Computer with internet connection and projector.

Per group:

- A big ball (could be an inflatable Earth for example)
- 2 triangle rulers
- A flash-light
- A bucket (it is supposed to be filled with water and it has markings for measuring volume)
- A piece of string (smaller than the circumference of the ball)

Note: Depending on your resources you can perform this workshop as a mock-up set-up. Participants will not do the experiment; they will only design it. Thus, no real tools





are needed. To avoid costs, use the accompanying pdf, 'TOOLS_Critical_and_Innovative_thinking_workshop' and print as many sets as the number of teams. Cut the white space around them and have them laminated if possible so you can use them for future workshops as well. The only tools you need to find is a ball (this cannot be a 2D print) and a piece of string.

ACTIVITY DESCRIPTION

WELCOME AND INTRODUCTION TO THE WORKSHOP (10 minutes, slides 2-9)

Welcome the participants and tell them that in this workshop we are going to discuss and have a hands-on activity related to transversal skills. Take some time to present the domains and the basic transversal skills related each domain, focusing on the domain of critical and innovative thinking. Explain that the present workshop is about developing creativity and innovative thinking skills.

HANDS-ON AND MINDS-ON ACTIVITY (20 minutes, slides 10-13)

Divide the participants in small groups and give a set of tools and a ball to each group. Now present them with the challenge: Each group must measure *as accurately as possible* the circumference of the ball, using the tools provided.

When inviting the participants to design their experiment and presenting the tools, the tutor can (but is not obliged to!) mention that they are not required to use all the tools, they can pick whichever they want. Finally mention that if a group comes up with more than one ideas, they will need to record them all and decide which they believe is the best one. Ask them to write the process (or processes) they thought of and the one they decided to follow on the worksheet. Give 15 minutes to the groups to come up with a plan.

PRESENTATION AND DISCUSSION OF GROUP WORK (10 min, slides 14-19)

Ask each group to present the different ways they thought of and which one they chose to measure the circumference. Discuss with them the possibilities and decide which





one is the best way and why. When the participants present their ideas, always be positive. Keep the guidelines below in mind:

- Never dismiss an idea as being wrong as it may discourage or embarrass the participant. Instead, when a wrong idea comes up, spot the mistake and ask a question that will lead the group to understand the mistake (don't point out the mistake directly).
- Remember that a wrong idea sometimes can be even more valuable than a correct one, provided that the participant identifies the mistake.
- Try to give the floor to as many participants as possible.
- When trying to promote the best option, make indirect comments and questions to lead people to that option. In our case, try to point out the sources of error and the pros and cons of each option through questions.
- Participants may propose ideas which include interventions on the ball or the use of tools that are not on their list. In this case try to explain that it's best not to damage the object of examination because if something goes wrong, there is no turning back. In the case of using tools that are not provided, welcome the idea and mention that in class they could choose to give their students unlimited options and have them deploy any tool they like. Thinking outside the box is always welcome. However, many times when people are asked to deal with a problem, they only have a limited number of options. Giving your students a limited number of options helps them learn how to adjust to certain circumstances and work with constraints. This is an important aspect of acquiring and developing problem solving skills as they will need to be inventive and work with what they have. Additionally, an unlimited number of options could be confusing to the students. The reason why we provide only a limited number of tools is because we want them to understand this idea of working under specific circumstance.

Pay special attention to how you react and comment on the groups' presentations as you will use your reactions later as an example.

If the entire group doesn't come up with all 4 options, mention to them the ones they didn't think of as well. Conclude this part by deciding as a group which is the best way to measure the circumference.

LINKING TRANSVERSAL SKILLS TO THE ACTIVITY (10 min, slides 20-24)

Ask participants to reflect on the activity and think about which skills they deployed during the activity. Give them 3 minutes to think and share their thoughts. Here are some prompt questions:

What skills did you use to decide which tools to use? (*Creativity*)





What skills did you use to deploy each tool? (*Resourcefulness*)

What skills did you use to decide which way is the best to measure the circumference?
(*Reflective thinking, reasoned decision making*)

Show the DOTS mind map of Transversal skills and focus on the list of basic skills under the domain of transversal skills under discussion. Compare these skills to the list provided by the participants. This exercise involves group work so you participants might also bring up skills related to the Interpersonal Domain. If participants missed some skills invite them to think which of these skills they deployed during the exercise and how. Note that for creativity and resourcefulness although they may overlap, they are also quite different. In our case, creativity comes in the part of imagining a way of making of measurement. That doesn't necessarily follow that the original idea uses the tools available. Resourcefulness comes in when students look at the tools available and think of way to use them to apply their idea.

Now refer to the objective of this workshop again: To demonstrate how students can practice their critical and innovative thinking skills during a STEM activity. In STEM activities, open inquiry can facilitate students a lot more in developing their critical and innovative thinking skills, compared to a guided experimentation model. Giving to students several degrees of freedom and the opportunity to make their own decision during the inquiry process will help them learn how to make informed decision using rational arguments and by exploring multiple options using several skills under the critical and innovative thinking domain.

Offering to students an array of instruments to choose from to set up an experiment will challenge them to think critically as they will need to think and decide which is the optimum set up for their experiment. By offering little (or not at all, depending on the case) guidance students will need to decide themselves which is the best way to use the instruments and how to combine them to perform the experiment.

Finally, explain that aside from the experimentation part of the activity the basic principle of giving students a certain degree of freedom applies to all other parts of the activity. For example, when it comes to presenting their findings, students don't need to follow a specific format, they can choose their own means of expression.

MAKE A CONNECTION TO A REAL CLASSROOM (20 minutes, slides 25-33)

Going back to the hands-on activity, explain that in a classroom, students don't always go for the obvious or most accurate process. Some students may come up with the most elegant plan (potentially option 1 in this case) some others may go for one that has potential but is unnecessarily complicated (option 3) and some others may go for one that looks good but has potential 'traps' (option 4). Finally, some (if not most) may go for the simplest one, which however is not the optimum way (option 2).





Ask the participants what they would do if their students proposed many different ways to explore something. Would they let them try out their own idea and then discuss results or would they discuss ideas, find the best and then have everyone try the best one? The best way to go in a class, is to let the students try out their own ideas. They need to be free to try anything they want with little guidance and make up their minds about their procedure based on their results, and the comparison of their results with their peers' results and a theoretical value if possible (learning by trial and error).

Point out that giving the opportunity to students to think critically and innovatively is directly linked to two crucial points that have to do with teachers' behavior:

1. THE DEGREE TO WHICH TEACHERS FEEL COMFORTABLE TO GIVE CONTROL TO THEIR STUDENTS.

In a modern class, students need to be active participants and co-designers of the learning process. They need to have the opportunity to make decisions and shape the learning process according to their particular needs. That means that a learning process cannot be 100% pre-defined. Students need to be able to follow different paths depending on their skills, their performance and interests. However, many teachers want to have complete control over the learning process and feel uncomfortable with giving degrees of freedom to their students. However, in order to nourish these essential skills of students, teachers need to feel comfortable with giving control (partly at least) of the learning process to their students.

Challenge participants to reflect on their teaching style. How often do they give their students room to try their own ideas or deviate from a proposed process?

Teachers may feel overwhelmed with the option of switching to open inquiry. To that end it is essential to explain to them that this is a gradual process and they can take small steps, making sure they feel comfortable with the changes they introduce in their teaching style:

Allowing students to make their own choices is a gradual process and it depends on many things, like the age of the students, their experience with open inquiry and the subject at hand. Teachers can start small giving little room and increase the degrees of freedom as students gain experience and become more and more accustomed with this type of learning. In addition, teachers don't necessarily have to switch immediately to a completely open inquiry. Instead, at any point of the learning process teachers can give a limited amount of options. For example, in an experimentation process, the teacher can offer 2 or 3 different experimental set-ups and ask the students to choose the one they prefer.





2. THE WAY TEACHERS REACT TO STUDENTS' IDEAS.

A teacher's reactions to students' thoughts and ideas is a very important factor. For example, reactions to wrong answers or invalid ideas should not include a simple dismissal or a reaction that would make a student feel incompetent. Teachers need to be positive and make sure they never discourage their students. Encouraging and supporting students during a creative process is a key element. Ask participants to recall your reactions and how you behaved during the presentation part of the activity and refer to the bullets of the above section.

Invite participants to reflect on their teaching style again. How do they react to wrong answers or crazy ideas? What challenges do they face?

WRAPPING UP THE WORKSHOP (5 minutes, slides 35-37)

Wrap up the workshop by mentioning again the objective of the workshop and how the hands-on activity meant to serve as a simple example of how to help students develop critical and innovative skills during an experiment. Thank the participants and invite them to introduce changes to their teaching style based on their experience during the workshop.

