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Fostering Citizenship: Systematic Refutation of False Information in Social Media by Senior Pre-University Physics Students Using a Pedagogical Tool

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Abstract

In recent years, citizenship gained significance in secondary education, aiming to equip students for a changing society. This study explores the intersection of citizenship and STEM education, focusing on combatting false information on social media. Specifically, we focused on Flat Earth Society (FES) supporters, who promote beliefs conflicting with the spherical Earth concept taught in physics class. Strengthening students' resilience against such false information is crucial. The central research question addresses this challenge: "How can a pedagogical tool be developed for senior pre-university physics students to systematically refute false information on social media using their basic knowledge and skills?"

Prior to designing this tool, we investigated what grade-11 students already knew about FES. The findings revealed, among other things, a deficiency in argumentative skills and confidence in mathematical or physics knowledge related to the beliefs of FES supporters. Drawing on these findings and a literature review, we identified an existing tool that we adapted to our context. Subsequently, during a pilot study five grade-11 students applied this tool to counter specific beliefs held by FES supporters about a flat Earth on social media. Following the outcomes of the pilot study, we refined the tool. Thereafter, in the second and final study three different grade-11 students used the finalized tool to counter the same FES beliefs.

The findings following from the final study affirm the possibility of developing a pedagogical tool for students to counter false information on social media. This involves formulating a reasoned stance that includes applying basic physics knowledge, possessing sufficient argumentative skills and demonstrating critical thinking. Importantly, this reasoned stance is an indicator of citizenship in students.

We emphasize that applying basic physics knowledge to refute false information in secondary education has not been sufficiently investigated. This research serves as a foundation for further research. Our adapted tool, based on the work of other researchers, may serve as a starting point to counter other forms of false information on social media.

Keywords: *critical thinking, citizenship, false information, physics, pre-university education, social media*

1. Introduction

Citizenship has become globally an increasingly significant theme in secondary education, aiming to equip learners with knowledge and skills from the curriculum to navigate an ever more complex society [1]. This trend is also evident in the Netherlands [2], where this research has taken place.

An issue closely tied to the complexities of contemporary society is the presence of false information on social media and how citizens deal with it [3]. Some of this false information is unintentional, but another part is deliberately crafted to deceive citizens, such as the spread of false information about vaccines leading to autism [4] or the 2021 Capitol riot in the US [5]. These developments can fuel division and mistrust among citizens, posing a threat to society. Therefore, addressing this issue in schools and contemplating how to make students more resilient against false information on social media is crucial. However, how does one become resilient as a student?

In this study, resilience becomes evident when a student can form a reasoned stance and defend it. Critical thinking, involving analyzing information first and then deciding to what extent that information is true or false [6], plays an essential role. Unfortunately, forming a reasoned stance proves challenging for many students [7]. This also applies to the structured articulation of arguments. One way to address these challenges is by providing students with a pedagogical tool, or simply a

tool, in the form of a step-by-step plan, schema, table, or another aid. The tool used in this study is presented in the next paragraph.

2. Specific case for students

This study addresses the central research question: "*How can a pedagogical tool be developed for senior pre-university physics students to systematically refute false information on social media using their basic knowledge and skills?*". Specifically, it focuses on the beliefs held by supporters of the Flat Earth Society (FES) [8]. FES supporters firmly believe that the Earth is flat and extensively use social media to disseminate their views.

For the physics students, a specific case involving Peter Flat, a dedicated FES supporter, is presented. Figures 1 and 2 outline Peter Flat's beliefs about why the Earth must be flat.

To debunk Peter Flats beliefs, students need to formulate a reasoned stance. Importantly, this reasoned stance is also an indicator of citizenship in students. To formulate a reasoned stance, the tool in figure 3 was developed. Students navigate through this tool, which assists them in thinking critically and structuring their arguments in an organized manner. The next section discusses the development of this tool.

Fig.1. Rivers flow in all directions, but always downwards. This can only be explained if the earth is flat.

Fig. 2. Water on a spherical earth would have to flow uphill.

3. Methodology

Prior to designing this tool, we interviewed three grade-11 students and investigated what they already knew about FES. The analysis of the results revealed, among other findings, that students lacked argumentative skills and lacked confidence in their mathematical or physical knowledge. These insights, combined with a review of the literature, led to the following design principles: clarity and unambiguity, a natural facilitation of systematic construction of optimal arguments, and effective encouragement of critical thinking in students. This, in turn, guided the selection of an existing tool [9] that was adapted to our context.

Subsequently, in a pilot study, five grade-11 students used this tool to refute the beliefs of Peter Flat above. In light of the findings, several improvements were implemented. Consequently, three different grade-11 students – Alice, Cleo and Max – used this improved tool to counter the same beliefs of Peter Flat about the flat Earth.

3.1 Navigating the Tool

First, in figure 3, students are asked why, according to Peter Flat, the Earth cannot be spherical. Next, question 2 activates prior knowledge: students write down at least two formulas related to Peter Flat's arguments. One formula or law is then chosen. At question 3, students counter Peter Flat's argument and explain why the Earth can still be spherical. Before this, they are asked to read the example in the appendix (separate sheet) on how to counter an argument. The example of countering an argument is presented below:

> Peter Flat makes the following statement: "*Neighbor, close the door! Cold is coming in!*". You can counter this statement as follows. In the chapter on heat transfer, you have learned that heat flows from a place with a high temperature to a place with a low temperature. Therefore, it is not cold that is flowing but heat. This refutes Peter Flat's statement.

A control question follows: "*Is your explanation convincing?*" The idea here is for students to critically assess their answers, providing a better foundation for question 4. Two answers are possible for the control question: a "*yes*" allows the student to proceed to the final question, and a "*no*" results in the selection of another formula or law, followed by a repetition of question 3. At question 4, students write a clear and organized explanation, considering two focal points – one of which is addressing what, according to Peter Flat, the problem is with a spherical Earth. Finally, students are asked to construct a reasoned stance. To minimize the risk of students getting stuck due to complex language, a brief explanation is included below the scheme. It clarifies the meaning of scientific knowledge, concepts, and refuting an argument.

4. Results

Due to word limit restrictions, we will only discuss student Cleo and not all three. In her reasoned stance in step 4, Cleo states: "*According to Peter Flat, the Earth cannot be spherical because water only flows downwards. This would mean that water cannot go towards the 'North.' However, water doesn't seek a way downwards but rather the lowest point. This is because water is influenced by gravity, which is reinforced by the formula. Water has mass and is therefore attracted to the Earth's core, regardless of its location on the Earth's surface. As water is drawn towards the deepest/lowest point, it can also flow towards the North*." Cleo's response is coherent, structured, demonstrates critical thinking, is scientifically accurate, and addresses Peter Flat's arguments in figures 1 and 2. Thus, she refutes Peter Flat's arguments. Although qualitatively somewhat weaker, the other students also constructed similar arguments.

5. Conclusion and discussion

The answer to the central research question is a 'small yes', but only within our sample size of N=3. This is particularly evident in the specific case concerning Peter Flat’s beliefs. Indeed, different cases may lead to varying results.

In response to Peter Flat’s arguments about a flat Earth, the students countered with a reasoned stance, employing critical thinking and adept argumentative skills to present their points coherently and logically. Moreover, the students demonstrated heightened confidence in applying their physics knowledge throughout the process. Overall, our findings highlight the beneficial influence of the tool on students’ scientific reasoning (for N=3!).

5.1 Current state and further research

Limited research exists on scientifically grounded tools to refute false information in secondary education. Therefore, this study may serve as a basis for further research in this area. Ideas for further research include exploring tools developed by other researchers and adapting them to fit various research contexts. Subsequent research could focus on the extent to which it is possible to refute other false information on social media through slight modifications to our tool.

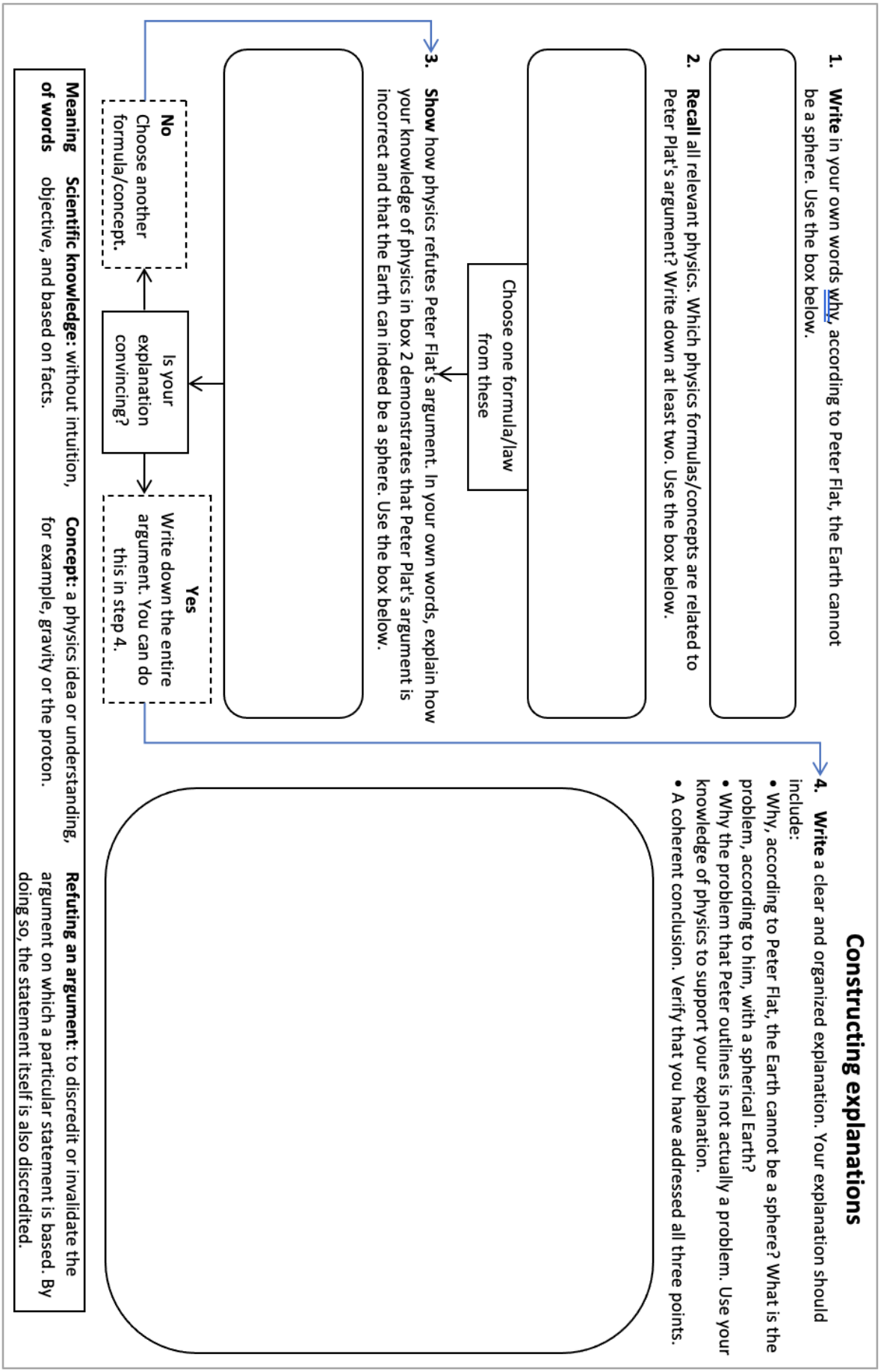

Fig. 3. The pedagogical tool that students used to formulate a reasoned stance.

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