COPUOS: ARGUMENTATION IN A PLANETARIUM SHOW

Guilherme Frederico Marranghello[1]

ABSTRACT: This work aimed to study how a planetarium show, associated with a classroom activity, can contribute to engagement and students' argumentation skills. We conducted a qualitative study based on Toulmin's Argumentation Model with 9th grade students in a city in the south of Brazil. The analysis was performed using the students' speeches during two activities. The results indicate that the activity promotes engagement and active participation during the classroom activity and the planetarium show, helping students to build their argumentation skills. We conclude that a planetarium show associated with classroom activities can help students, not only to understand astronomy concepts but to develop argumentation skills.

KEYWORDS: Toulmin; Astronomy; Space Law; United Nations

COPUOS: ARGUMENTAÇÃO EM UMA SESSÃO DE PLANETÁRIO

RESUMO: Este trabalho teve como objetivo estudar como um espetáculo de planetário, associado a uma atividade presencial, pode contribuir para o engajamento e a capacidade de argumentação dos alunos. Realizamos um estudo qualitativo baseado no Modelo de Argumentação de Toulmin com alunos do 9º ano de uma cidade do Sul do Brasil. A análise foi realizada a partir das falas dos alunos durante duas atividades. Os resultados indicam que a atividade promove engajamento e participação ativa durante a atividade em sala de aula e no espetáculo de planetário, auxiliando os alunos na construção de suas habilidades de argumentação. Concluímos que um espetáculo de planetário associado a atividades em sala de aula pode ajudar os alunos, não apenas a compreender conceitos de astronomia, mas a desenvolver habilidades de argumentação.

PALAVRAS-CHAVE: Toulmin; Astronomia; Direito Espacial; Nações Unidas

[1] Universidade Federal do Pampa (UNIPAMPA), Campus Bagé, Bagé-RS, Brazil. E-mail: guilhermefrederico@unipampa.edu.br

COPUOS: ARGUMENTACIÓN EN UNA SESIÓN DE PLANETARIO

RESUMEN: Este trabajo tuvo como objetivo estudiar cómo un espectáculo de planetario, asociado a una actividad de aula, puede contribuir al compromiso y a la capacidad de argumentación de los estudiantes. Realizamos un estudio cualitativo basado en el Modelo de Argumentación de Toulmin con estudiantes de noveno grado en una ciudad del sur de Brasil. El análisis se realizó a partir de los discursos de los estudiantes durante dos actividades. Los resultados indican que la actividad promueve el compromiso y la participación activa durante la actividad en el aula y el espectáculo del planetario, ayudando a los estudiantes a desarrollar sus habilidades de argumentación. Concluimos que un espectáculo de planetario asociado a actividades de aula puede ayudar a los estudiantes, no sólo a comprender conceptos de astronomía sino a desarrollar habilidades de argumentación.

PALAVRAS-CHAVE: Toulmin; Astronomia; Ley Espacial; Naciones Unidas

1. INTRODUCTION

In today's world, where information is easily accessed in a smartphone, we believe that argumentation is a very important skill to be developed among young students that can help to develop critical thinking and scientific literacy. These ideas are also shared with Aziz and Johari (2023) who studied the effects of argumentation about socio-scientific issues on secondary students. With an extensive review on the subject, Aziz and Johari (2023) describe the benefits of argumentation and the contribution to understanding science. The need for reasoning to discuss with other students improves their learning with different authors discussing environmental, climate change, plastic pollution, biotechnological, local or global socio-scientific issues.

In the same direction, Volfson et al. (2025) promoted a whole-class dialogic discussions with first year engineering students to promote argumentation skills. The authors introduce their work with the conflict of science, built on discussions and argumentation against science classes that present a crystallized structure with no discussions, doubts or debates, claiming that argumentation should play a central role in science education. The authors mention Toulmin's model which will be discussed in the methodology section and define argumentation as "a group activity

in which participants engage in generating arguments and counter-arguments and provide justifications for both sides.”.

One can find different researches that claim the importance of argumentation based on national official documents that guide scientific education considering the relevance of teaching more than facts and/or concepts. That’s the example in England (Simon et al., 2006), USA (Grooms et al., 2015) or in Brazil (Almeida et al., 2022).

In this work we are focusing on argumentation inside planetariums. Planetariums have recently celebrated its 100th anniversary claiming that “The stars were just the beginning” (McConville et al.; 2023). This slogan comes from the great variety of approaches this new era of digital planetarium immersion can provide and how planetariums can contribute to science communication, scientific literacy and much more (Chastenay, 2015). This new era opens the window to a great variety of ways that a planetarium can engage the public in argumentations and it works even better when integrated with classroom activities, as studied by Schmoll (2013) and Rezende (2017).

Here, we implement the argumentation using techniques that come from a simulated jury methodology. Vieira et al. (2015) worked argumentation with pre-service teachers through a simulated jury. This tool has shown a great potential to develop science classes, as also shown by Oliveira et al. (2023) and Stumpf and Oliveira (2016). Considering argumentation as a key ingredient in science class, the potential of simulated jury to stimulate argumentation and the role of planetarium in science education we built our research question as: **How can a planetarium activity integrated with classroom discussions contribute to developing argumentation skills in elementary school science students?** To answer this question we conducted a study in a city in the south of Brazil with 8th and 9th grade students (13 to 15 years old) from public and private schools that visited the planetarium. We collected written documents and oral discussions analysed using Toulmin’s Argumentation Model.

2. THEORETICAL FRAMEWORK

On reporting a research, Osborne et al. (2004) review contributions about argumentation since 1960 when they argued the “important role

language, conversation and discussion have in science learning" was deeply studied only after 1990's, and reinforce the importance of educating kids in a perspective we understand as promoting scientific literacy. It is also important that the student plays a central role in the classroom activities.

Osborne et al. (2004) review authors who believe teaching through argumentation activities can accomplish the task of promoting argumentation and others who believe that argumentation shall be thought separately. Complementing, there are discussions on how the activities shall be conducted, from an open non-structured discussion to a model where argumentation shall be thought and so, the activity shall be conducted in a more rigid form. In any case, the argumentation process, important for science learning, shall be a process with student interactions.

To collect data about educational research on argumentation, we made use of CAPES database. CAPES is the government institution that regulates graduate courses in Brazil. When collecting data from the CAPES thesis database using the term, in Portuguese, for argumentation, we found 17.844 documents that, restricted to Science Education area, reduces this number to 406 master (306) and doctoral thesis (100), with and increasing number in the last years, as shown in figure 1. Most of these works report the introduction of argumentation in science classes (Medeiros, 2018) or argumentation in courses for teachers in training (Almeida, 2018). They also include socioscientific issues (Almeida, 2018) or investigate argumentation in science books (Santos, 2018).

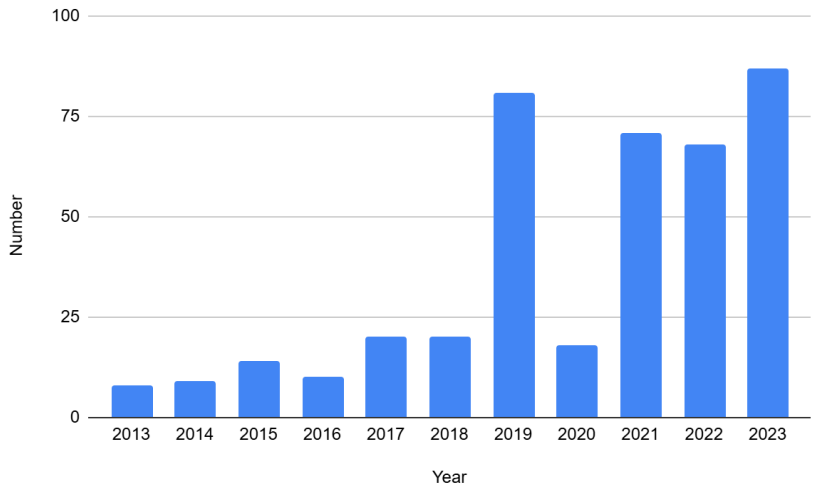

Figure 1: Number of Master and Doctoral Thesis in Science Education mentioning argumentation in CAPES database.

When looking for methodologies that support argumentation, simulated juries appear to be a great choice to implement the process of argumentation with a school group. This practice includes the student in the learning process with an active role. Here, the teacher must prepare the material to be distributed in class, organize the participants' roles and mediate the process. We extend the model studied by Oliveira et al. (2023) by working inside and outside a planetarium dome and by introducing not a jury, but a meeting of the United Nations Committee of Peaceful uses of Space, based on a Pedro Russo (2020) talk. The meeting allows different roles that are not necessarily right versus wrong, and can also allow the different groups to work together for both benefits.

In one of his book editions Toulmin explores the history of argumentation and the concern with constructing a sound argument spans centuries of philosophical thought. Aristotle, in the Organon, established the foundations of deductive logic through the syllogism — a structure in which a conclusion necessarily follows from true premises — inaugurating a tradition that sought in logical form the criterion of valid reasoning. Plato, before him, had already argued that reasoning well required not only internal coherence, but a commitment to the pursuit of

truth through dialogue. Centuries later, Descartes systematized an ideal of argumentation grounded in mathematical certainty and methodical doubt, privileging arguments that could be built from indubitable evidence. This rationalist legacy, however, proved insufficient to account for the complexity of arguments that circulate in the real practices of law, science, and ethics. It is in this context that Stephen Toulmin proposed a radical shift of attention from a logical theory to a logical practice — a working logic — opposing the Aristotelian tradition and taking jurisprudence as his model of analysis, understanding logic as "generalized jurisprudence." For Toulmin, the correctness of an argument was not merely a formal matter, but a procedural one, to be evaluated according to criteria appropriate to each field of knowledge.

First published in 1958 in The Uses of Argument, Toulmin's framework describes the argument as a structure composed of six interdependent elements. The first three — claim, grounds, and warrant — are considered essential in practical arguments, while the qualifier, backing, and rebuttal constitute complementary elements that lend greater robustness and precision to the reasoning. The claim is the thesis being defended; the grounds are the evidence that supports it; the warrant is the logical link connecting both; the qualifier indicates the degree of certainty of the conclusion; the backing reinforces the legitimacy of the warrant; and the rebuttal anticipates possible exceptions or objections. For Toulmin, arguments depend heavily on the context in which they are used and produced, with modal qualifiers playing a central role in justifying conclusions — what he termed "defeasible reasoning." This perspective is supported by recent scholarship in science education: Guimarães and Massoni (2020), demonstrated the relevance of the Toulminian model as a theoretical-methodological framework for fostering intellectual autonomy and critical thinking in educational contexts. By shifting the focus from formal validity to the pragmatic force of the argument, Toulmin offers a theoretical framework capable of evaluating how a convincing, legitimate, and contextually adequate argument is genuinely constructed.

It is important to mention that we didn’t find works specifically discussing argumentation inside a planetarium, the reason we are applying methodologies from adjacent areas of study. We also should emphasize that the planetarium show can last, at maximum, one hour.

We don't expect to develop argumentation skills in such a short period of time but we do believe, as stated by Schmoll (2013) and Resende (2017), that an integrated classroom activity can become a good starting point.

3. METHODOLOGY

This work developed qualitative research with the aim of answering the research question: **How can a planetarium activity integrated with classroom discussions contribute to developing argumentation skills in elementary school science students?** To better understand this task, we try to answer additional questions like: How many kids engage (or not) during the activity? What kind of arguments are revealed during the activity? Does a debate of ideas occur or not? How rich are the arguments, considering Toulmin's Model?

The activity was developed, first in the classroom and later in the planetarium with 8th and 9th grade students of public and private schools, in the city of Bagé, Brazil. We contacted the schools and offered the activities. In the first school, we conducted the activity with two classes of 8th graders, together, in the school auditorium. The second and third schools had only one classroom of 8th graders and another one with 9th graders and decided to group them in the auditorium.

The school activity consists of an introduction about the space race, from the early rocket developments, passing through the technological developments, solar system exploration and reaching recent days where we start to face space pollution with the increasing number of satellites orbiting Earth. We highlight the creation of the United Nations Committee of Peaceful Uses of Space (COPUOS), right after the Sputnik launch and some recent challenges of Space Law. After that, we start a simulated jury, splitting the room in small groups and giving them written orientations. Each group represents a different nation, except one group that is invited to represent the private space company interests. There are different fictitious nations with different space technological achievements, for example, there is a nation with capability to build satellites and launch the system but there are nations

that can only build satellites or launch systems. There are also nations with no space achievements at the moment.

Considering the importance of satellites but also their increasing number on Earth's orbit and the risks it presents, the students are invited to create two laws to regulate the launch and control of new satellites. After that, the laws are read and discussed (or even improved) and voted.

The second activity consists in a visit to the planetarium which consists in a live night sky tour, followed by an interactive planetarium show and a visit in the exhibition area. The planetarium show was based on a talk by Russo (2020) and produced by the planetarium team. It takes place in the United Nations COPUOS, introducing the committee and two subjects that shall be discussed and voted on. The show is split into three parts: besides introducing the committee, the first part explains about mining space objects with commercial interests and the request of a kingdom that wants to start this exploration. The audience is called to vote if we allow (or not) this kingdom to commercially mine and explore solar system objects; in the second part the audience is told that we received an extraterrestrial signal and it appears to come from a known exoplanet. This time, the audience must decide, as members of COPUOS, if we shall reply to this signal and, if yes, what should we send; The third part of the show reports on which part of the show is a reality and which one is fiction. Between each part we promote the debates.

During the school activity we collected the laws in the written form that was attached to the instructions and details about the group's nation technology and their arguments during the debate was recorded and transcribed and analyzed in an exploratory research as reported by Falk and Dierking (2018) and is in accordance with Stebbins (2001) who termed as "methodological progression" - the gradual transition from exploratory approaches to more formalized research designs. In this way, we presented our first results that founded the following analysis in a previous work (Marranghello et al., 2025).

The students visited the planetarium where the second activity took place. It is a small concentric planetarium with 52 seats and a digital system with a single projector in the middle of the room. Due to difficulties in recording inside the planetarium we preferred to have monitors that took notes during the debates. The monitors were instructed to write exactly the speech of each student and identify them as student 1, student 2 and so on. After that we assembled the written material and analyzed it using Toulmin's Argument Model (Toulmin, 2006).

Toulmin (2006) introduces that the basis of a good argument shall include:

1. Claim: In this work, it should be the answer of the discussion subject proposed by the COPUOS in the planetarium show. For example: We should allow the kingdom to mine an asteroid because it will bring benefits to all of us.
2. Ground/Data: We expect the students to recover information from the show but also to bring new information to support their ideas like: Mining on Earth develops pollution.
3. Warranty: The warranty factor describes how the students establish a relation between Data and their claim, like: Since mining Earth pollutes, mining an Asteroid will benefit the whole Earth since we are transferring this activity to a place outside Earth.
4. Backing: In a group debate, we expect people to contribute by amplifying others' arguments, such as: also because some asteroids are richer in elements than Earth's crust.
5. Qualifier: We also expected the students to support their ideas with conclusions that would strengthen their claims like: mining asteroids will also need to develop new technologies on Earth that can bring new advances to our society.
6. Rebuttal: As it said, in a debate, we expect rebuttals such as: unless we generate more pollution with rockets and probes constructions.

This argument structure is synthesized in Figure 2.

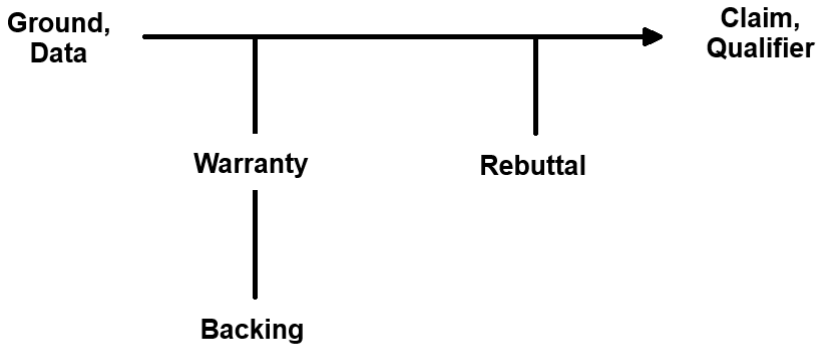

Figure 2: Toulmin Argument Structure (Toulmin, 2006)

4. RESULTS

As the activity was developed as a simulated meeting of the United Nations COPUOS and the students worked in supporting (or rebutting) each other's ideas, we assembled the results in a common argument scheme instead of building each student's argument structure. However, we'd like to first address the results published in a previous work, containing the proposed laws. In only a few cases the students have a good idea of how to write a law. Usually the students write ideas about the laws they want to elaborate as "Nations have to cooperate to prevent military uses of space". In any case, the proposed laws are read for the whole class and discussed how to better elaborate the law before argumentations in favor/against the law to finally vote to approve or not.

An example of law is "Limit the number of satellites". The first idea was to limit the number of satellites for all nations. Quickly the students understood that it would be a barrier for nations that don't have technology yet. The new statement changed to limit the number of satellites per country. This was the law present in all schools.

As an example of a law that was presented, discussed, and restructured before being put to a vote, we highlight the following law:

"No country may launch a satellite for exclusive use. Each satellite must be shared with at least four other countries, these being members of the global community that do not possess their own technology for satellite production and launch, fostering technology transfer."

Some other ideas proposed were:

- When a satellite falls from Earth's orbit, the company that owns the satellite will be responsible for collecting the debris.
- A law that improves global security more than before an impact with Earth should include a super-resistant device that warns people nearby so they can move away and avoid the risk of an emergency.
- It is also important to seek international collaboration to operationalize technological satellites, as well as new resources and ideas to advance our nation.
- Debris reduction design standards.
- Establish exclusion zones around the Earth to prevent satellite collisions.

Considering the planetarium activities, we split our analysis in the first (Mining) and second (Alien Signal) part of the show. It is important to mention that in both cases we had very short answers like “yes”, but we also had more elaborated ones. Student participation varied across the classes. While only a few students engaged in the debate in one class, approximately half of the students participated in another. Both parts were moderated by the planetarian which was essential for creating a debate environment, as there were moments of consensus among students, and the mediator was responsible for introducing contradictory elements to the discussion. The results presented here are collections of more than one participant who replied to each other until they got a better understanding.

Considering the first part, the discussion about mining an asteroid for commercial purposes, the students were basically in favor of scientific exploration of an asteroid but afraid of the consequences like deviating the asteroid from its path and redirecting it towards Earth. We developed two Toulmin representations considering their arguments: in favor (figure 3) or against mining asteroids (figure 4).

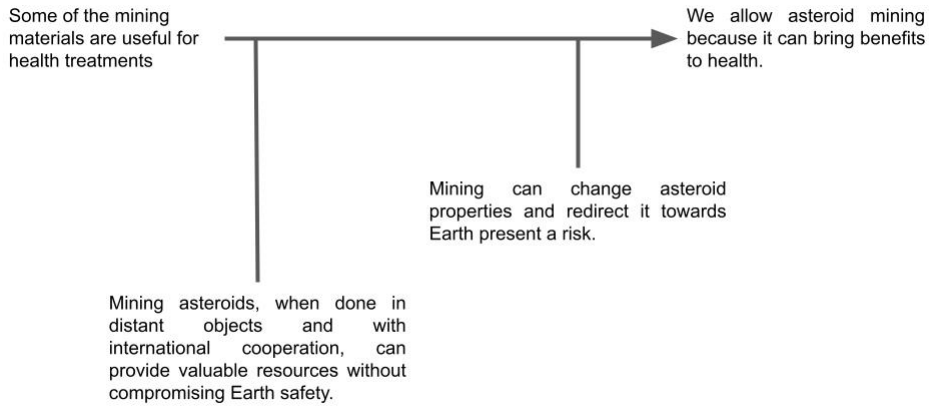

Figure 3: Toulmin Argumentation Scheme for the discussion with claims to allow mining asteroids.

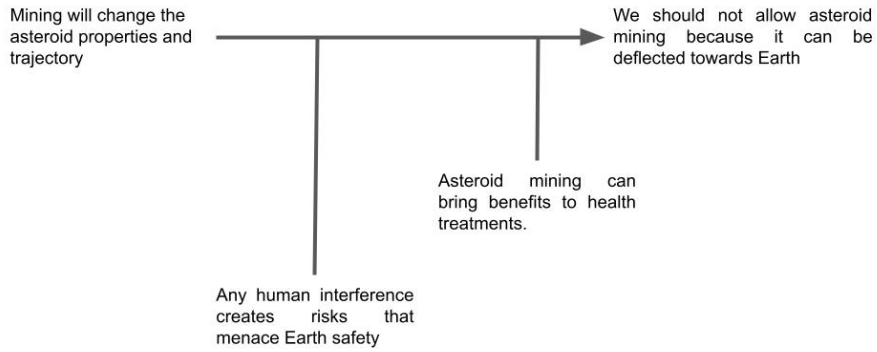

Figure 4: Toulmin Argumentation Scheme for the discussion with claim to not allow mining asteroids.

7. Both argument schemes include discussions about international collaborations and sharing technologies, standards to reduce risks and the potential benefits for health care, however, while the first scheme emphasizes the potential benefits, the second scheme focuses on the risks of deflecting the asteroid towards Earth.

The second topic of discussion, about responding to an alien signal, kids were, in general, in favor of responding, but we needed to

discuss how to respond considering the distance of the planetary system. Some of the kids would like to send space probes and we explained that we should send an electromagnetic signal. Some messages the kids would send are: We come in peace; send an emoji; a hologram; something in Morse code; an image of Earth life or our coordinates. It is important to mention that some kids didn't want to send detailed information so the alien wouldn't know more about our location or fragilities.

During the discussions, the planetarian always played a role in order to keep the discussions, usually using a parallel with historical explorations. If all the kids agree to answer, we reply about recovering European exploration of South America, about slavery and other facts of our own history, but we also explain about the benefits of meeting new cultures or learning about new technologies.

Again, we show two possibilities of Toulmin scheme based on agreement/disagreement of sending a response to the alien signal (figures 5 and 6). In both cases, as expected, there are a lot of uncertainties because we are dealing with a hypothetical situation and we got lots of "if" or "risks".

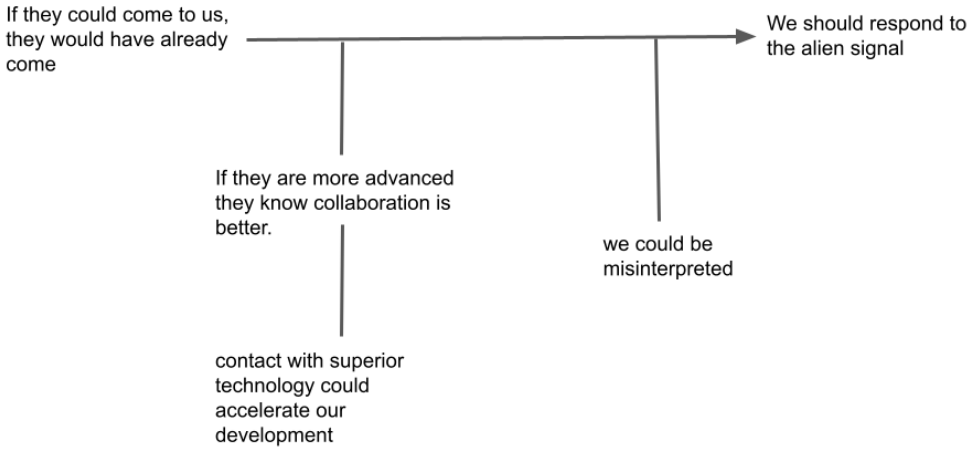

Figure 5: Toulmin Argumentation Scheme for the discussion with claim to respond the alien signal.

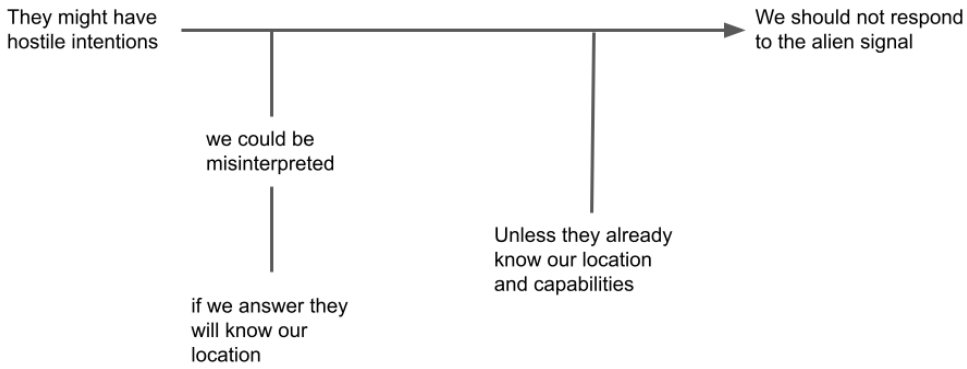

Figure 6: Toulmin Argumentation Scheme for the discussion with claim to not respond to the alien signal.

5. DISCUSSION AND CONCLUSIONS

We have developed activities in different schools simulating a meeting of the United Nations COmmittee for the Peaceful Uses Of Space (COPUOS). In this activity we talked about the space race, discussing technological developments that lead to our ability to conquer space, not only visiting it with astronauts but also with satellite technology to weather forecast, communication, GPS and many more. However, we also mentioned the huge amount of satellites and debris in Earth orbit and the problems related to that, inviting the students to create laws to regulate satellite launch.

After we visited the school, the students were invited to visit the planetarium and participate in a show about COPUOS, entitled Space. During this interactive show, the students were invited to discuss two topics. The first topic was related to a nation requesting permission to mine an asteroid and the second one was to decide about responding to a signal from an intelligent form of life coming from a distant world.

These activities were held with the aim of developing argumentation skills and answer our research question: **How can a planetarium activity integrated with classroom discussions contribute to developing argumentation skills in elementary**

school science students? We used the Toulmin Argumentation Scheme to analyse the students' discussions during the planetarium visit. The students are from 9th grade of fundamental public and private schools.

It is important to mention that the students were not taught about argumentation or how they should answer our questions. They were only invited to participate in the discussions. Also, all the discussions were taken in a group session. We understand these two factors contribute to having shorter answers from students, however, when we grouped the students' answers, the result was a full argumentation scheme with a claim, based on data, with warranties and refutals.

Another subject important to mention is the difference from the school groups. We have met very silent groups from which we had to wait longer for answers or invite them to give their contributions more than once or twice. On the other hand, we have very communicative groups with great contributions. We also have groups where basically two students were responsive and we had to ensure more people could participate.

Considering Gou et al. (2025), we identify how hard it is for the students to argue during a discussion using critical thinking and science content. In Gou et al. (2025) characterization, the individuals would mostly be characterized as level 1, which can only claim in single fields, however, working together, the students could certainly be identified in levels 3 or for, giving pro and contrary arguments in multiple fields.

Guimarães and Massoni (2020) highlight that, although Toulmin's argumentation model is a useful tool for identifying argumentative patterns in discourse, it presents limitations when applied to the analysis of collectively constructed arguments. This is because, in group interaction contexts, arguments frequently emerge from a dialogic and collaborative dynamic, in which different voices contribute to the construction of reasoning. In this sense, Toulmin's model may not fully capture the complexity and interactive nature of collective arguments, which involve multiple intertwined perspectives and justifications.

Nevertheless, the model retains its analytical validity as a framework for evaluating the quality of scientific argumentation, and the present work contributes a further step toward expanding our understanding of its application in non-formal educational contexts.

Considering all these aspects we can conclude that the planetarium show entitled Space is a wonderful tool to promote argumentation with 9th grade students. As commonly accepted, a visit to the planetarium is more fruitful when related to classroom activities and we believe the first visit to the school with space race discussions helped the students to understand the activity in the planetarium, even though we believe the planetarium activity can be held by itself. Even though we didn't have a control group in our methodology, a simple comparison against other school groups that visited the planetarium has helped us to corroborate the results obtained by Schmoll (2013) and Resende (2017).

We have applied the activity with different groups that are not part of this study but it is worth mentioning that adults, based on their lifetime experience, have different opinions and arguments about the topics presented in the show and are much more open to participate than the students. It shows that the activity is useful for many different school groups, from fundamental school to high school or even university students.

ACKOWLEDGMENTS

This work was supported by Conselho Nacional de Pesquisa e Desenvolvimento Científico e Tecnológico, Grant number 302314/2022-9.

REFERENCES

Almeida, M. G. R., Marranghello, G. F., & Dorneles, P. (2022). Argumentação sobre mudanças climáticas no Planetário da Unipampa. *Experiências em Ensino de Ciências*, *17*, 148. https://if.ufmt.br/eenciojs/index.php/eenci/article/view/975

Almeida, M. T. (2018). *Argumentação e raciocínio moral em questões sociocientíficas na formação de professores de ciências: o exemplo da*

eutanásia [Master's thesis, Universidade Federal de Sergipe]. UFSE. https://ri.ufs.br/jspui/handle/riufs/11154

Aziz, A. A., & Johari, M. (2023). The effect of argumentation about socio-scientific issues on secondary students' reasoning pattern and quality. *Research in Science Education*, *53*, 771. https://doi.org/10.1007/s11165-023-10099-5

Chastenay, P. (2016). From geocentrism to allocentrism: Teaching the phases of the moon in a digital full-dome planetarium. *Research in Science Education*, *46*, 43. https://doi.org/10.1007/s11165-015-9460-3

Dawson, V. (2025). Using socioscientific issues to teach argumentation to year 7 science students in a low socioeconomic rural Australian school. *Research in Science Education*, *55*, 989. https://doi.org/10.1007/s11165-024-10224-y

Falk, J. H., & Dierking, L. D. (2018). *Learning from museums* (2nd ed.). Rowman & Littlefield.

Guimarães, R. R., & Massoni, N. T. (2020). O uso do modelo padrão de argumentação de Stephen Toulmin no ensino de ciências. *Investigações em Ensino de Ciências*, *25*(3), 487–502. https://doi.org/10.22600/1518-8795.ienci2020v25n3p487

Guo, X., Shao, F., Hao, X., et al. (2025). Research on students' scientific reasoning and argumentation abilities in socio-scientific issues context: Integrated constructive and critical perspectives. *Research in Science Education*. https://doi.org/10.1007/s11165-025-10288-4

Grooms, J., Enderle, P., & Sampson, V. (2015). Coordinating scientific argumentation and the Next Generation Science Standards through argument driven inquiry. *Science Educator*, *24*(1), 45. https://files.eric.ed.gov/fulltext/EJ1069981.pdf

Marranghello, G. F., Irala, C. P., Kimura, R. K., Lima, D. W., & de Goes, K. S. (2025). Comitê das Nações Unidas para o uso pacífico do espaço: um primeiro relato. *Anais do VII Simpósio Nacional de Educação em Astronomia*, Universidade Estadual de Londrina, Londrina, PR, Brasil. https://sab-astro.org.br/wp-content/uploads/2025/11/VIISNEACO14.pdf

McConville, M., Voss, B., & Marranghello, G. F. (2023). The centennial of the planetarium. *Nature Astronomy*, *7*, 1140. https://doi.org/10.1038/s41550-023-02098-3

Medeiros, A. (2018). *Desenvolvendo habilidades argumentativas em aulas de biologia: uma atividade experimental baseada na perspectiva Predizer, Observar e Argumentar (POA)* [Master's thesis, Universidade Federal do Rio Grande do Norte]. UFRN. https://repositorio.ufrn.br/jspui/handle/123456789/25972

Oliveira, S. B., Araújo, C. S. T., & Lacerda, N. O. S. (2023). Júri simulado como estratégia no ensino de ciências: um breve levantamento. *Anais do XIV Encontro Nacional de Pesquisa em Educação em Ciências*, Caldas Novas, GO, Brasil. https://editorarealize.com.br/artigo/visualizar/93632

Osborne, J., Erduran, S., & Simon, S. (2004). Enhancing the quality of argument in school science. *Journal of Research in Science Teaching*, *41*, 994. https://doi.org/10.1002/tea.20035

Resende, K. A. (2017). *A interação entre o planetário e a escola: justificativas, dificuldades e propostas* [Master's thesis, Universidade de São Paulo]. https://doi.org/10.11606/D.14.2017.tde-30092020-142946

Russo, P. (2020). *Astronomia e Sociedade* [Video]. Encontros de Educação em Astronomia. https://www.youtube.com/watch?v=NIf7D2uRmIw

Santos, G. S. (2018). *Questões sociocientíficas como abordagem metodológica nos livros didáticos de ciências* [Master's thesis, Universidade Federal de Sergipe]. UFSE. https://ri.ufs.br/jspui/handle/riufs/7942

Schmoll, S. (2013). *Toward a framework for integrating planetarium and classroom learning* [Doctoral dissertation, University of Michigan]. https://www.researchgate.net/publication/260553641_Toward_a_Framework_for_Integrating_Planetarium_and_Classroom_Learning

Simon, S., Erduran, S., & Osborne, J. (2006). Learning to teach argumentation: Research and development in the science classroom. *International Journal of Science Education*, *28*(2–3), 235. https://doi.org/10.1080/09500690500336957

Stebbins, R. A. (2001). *Exploratory research in the social sciences*. Sage Publications.

Stumpf, A., & Oliveira, L. D. (2016). Júri simulado: o uso da argumentação na discussão de questões sociocientíficas envolvendo radioatividade. *Experiências em Ensino de Ciências*, *11*(2). https://fisica.ufmt.br/eenciojs/index.php/eenci/article/view/569

Toulmin, S. E. (2006). *Os usos do argumento* (2ª ed.). Martins Fontes.

Vieira, R. D., Bernardo, J. R. da R., Evagorou, M., & de Melo, V. F. (2015). Argumentation in science teacher education: The simulated jury as a resource for teaching and learning. *International Journal of Science Education*, *37*. https://doi.org/10.1080/09500693.2015.1022623

Volfson, A., Fisher, M., Eshach, H., et al. (2025). Physics, Talmud and argumentation skills meet in whole-class dialogic discussions. *Research in Science Education*. https://doi.org/10.1007/s11165-025-10250-4