Exploring the potential of augmented reality in astronomy teaching: An experience report with elementary school teachers and physics undergraduate students

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ABSTRACT

Despite the great fascination that the study of the cosmos can arouse, it can become somewhat vague and difficult to understand. This article is an experience report of the use of Augmented Reality (AR) in the study of astronomy, addressing elementary school teachers and also students of the physics degree course. AR is an innovative tool and its use allows a closer approach to reality, making the study more engaging and immersive, enabling the exploration of astronomical concepts from a new perspective. The methodology employed includes the use of augmented reality artifacts as a means of astronomical observation and exploration, using mobile devices connected to the internet network. In addition, a qualitative questionnaire was applied in order to collect the participants' perceptions. This contributes to discussions about the use and potential of AR in the educational sphere, thus promoting new approaches to the teaching of complex and often abstract concepts.

Keywords: Astronomy, Augmented Reality, Education, Science Teaching, Innovation.

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INTRODUCTION

Astronomy is considered the oldest of the sciences, a source of knowledge and a questioner of the emergence of other knowledge, it studies the formation and evolution of the universe. As a discipline that investigates celestial bodies and cosmic phenomena, it faces several challenges in relation to the approach of these concepts, which often proves to be quite complex to students. As reported by LANGHI and NARDI 2010 "Astronomy Education can take place in several areas, such as formal, informal, non-formal education and in activities called science popularization". The search for tools that help and also enrich the experience of education has led educators and researchers to search for new technologies and teaching methods. According to VALLEJO, 2007 "Contemporary society lives in the so-called Information Society, a society based on the use of New Information and Communication Technologies (ICTs) and the management of large amounts of information".

In complex studies such as the astronomy segment, the possibility of using an innovative solution arises, Augmented Reality has proven to be a promising tool, making the exploration of the universe a more interactive and engaging experience for students. According to ARAÚJO 2009, "this technology allows, from the projection of non-existent objects or phenomena, a greater interaction between the student and the exposed content, enabling a better understanding of what was previously only in the imagination, without, however, requiring a broad knowledge of the technology on the part of the student".

In order to transform the way students interact with the study of astronomy, AR can bring greater immersion and a more tangible understanding of cosmic phenomena, being able to bring reality closer to the abstract, making it easier for students to understand.

This article presents an experience report of the application of Augmented Reality in astronomy education, both with school teachers and with students of the physics degree course. The aim is to investigate how the incorporation of AR can enhance the learning process, stimulate curiosity and enable future educators to impart astronomical knowledge in an engaging way, enhance participants' understanding of astronomical phenomena, as well as investigate the benefits and challenges of this technology.

Throughout this work, we write about the practical activities carried out during the application of AR, as well as the perceptions, opinions and reactions of the participants to the use of this tool. The verification of the results will allow us to explore the pedagogical benefits and the effectiveness of this application in the context of astronomy education. Finally, we highlight the conclusions reached with this experience, consider the implications, highlighting the opportunities that this tool can offer in the contemporary educational environment.

By sharing these experiences and reflections, we aspire to contribute to the discussion on the possibilities of pushing technology to make astronomy not only accessible but also instigate a passion

for the subject, providing educators and students with a new perspective on the cosmos and inspiring future scientific explorations.

PURPOSE AND RESEARCH QUESTIONS

This study aims to find out what are the potentials of AR in the sphere of education and how it is welcomed by the user. Therefore, we investigate how augmented reality can contribute to the process of learning and understanding in the field of astronomy.

The following research questions were addressed using a Likert rating scale:

1. To what extent has Augmented Reality made or will make the class more interesting and interactive?
2. Does Augmented Reality contribute to the understanding of astronomical concepts during class?
3. How would you rate the interface and usability of Augmented Reality devices used in the classroom?
4. Based on experience with Augmented Reality, do you consider the technology to be a valuable tool for teaching in general?

METHODOLOGY

BACKGROUND

In Brazil, the teaching of Astronomy is within the framework of Natural Sciences and follows the National Curriculum Parameters (PCN), it is offered in the 3rd and 4th cycles of elementary school, which is equivalent to 6th, 7th, 8th and 9th grades. Chart 1 summarizes the core contents of Astronomy for the 3rd (6th and 7th grade) and 4th (8th and 9th grade) cycles of Elementary School.

Table 1: Astronomy contents proposed for the 3rd and 4th cycles of Elementary School by the National Curriculum Parameters

Astronomy Contents (PCN)	
3rd Cycle	**4th Cycle**
- Length of the day at different times of the year; - Rise and sunset of the Sun, Moon and stars; recognize the cyclical nature of these events and associate them with cycles of living beings and the calendar; - Conception of the Universe: information about comets, planets and satellites and other stars of the Solar System; - Constitution of the Earth and the existing conditions for the presence of life; - Valuing the knowledge of ancient peoples to explain celestial phenomena.	- Identification of celestial bodies, constellations, planets apparent in the sky during a certain period of the year and the distance they are from us; - Gravitational attraction of the Earth; - Seasons; - Geocentric and heliocentric theories; - Structuring of the Earth; Position of the Earth.

Source: Adapted from Brazil (1998).

With regard to the study of Astronomy in Higher Education Courses, it follows the Pedagogical Project of the Course (PPC). Chart 2 summarizes the Astronomy content of the Physics Degree Course that was the object of this study.

Table 2: Contents of the U.C Fundamentals of Astronomy and Astrophysics proposed for the 4th semester of the Physics Degree Course according to the PPC.

Fundamentals of Astronomy and Astrophysics Content
4th Semester
- Astronomical scales.- Apparent movements of the stars. - Astronomical coordinates and time measurements. - Seasons and eclipses. - Planetary motion.- Determination of distances. - History of Astronomy.- Development of geocentric and heliocentric systems.- Kepler's laws and Newton's Universal Gravitation. - Radiation theory concepts. - Stellar spectres. - Stellar structure and energy sources. - Stellar formation and evolution. - HR diagram. Milky Way. Galaxies and the Universe. -Cosmology. - Current concepts

Source: PPC Degree in Physics (2013).

The study was carried out with two distinct classes: *Class 1* composed of elementary school teachers and *Class 2* formed by students of the Physics Degree Course, both with previous knowledge in Astronomy. Each experimental session lasted approximately 90 minutes, during which participants explored the theme of Astronomy through AR Cards, using mobile devices. Part of the process was recorded and later transformed into a video made available on the Youtube platform (GIÁCOMO ANTÔNIO ALTHOFF BOLAN- 2023).

"Augmented reality serves to complement the real world with virtual (computer-generated) components, making real physical objects and virtual objects coexist in the same space of the real world" AZUMA, 2001. Also according to AZUMA 2001, "an augmented reality system must have three properties: combining real and virtual objects in the real environment; be interactive in real time and align real and virtual objects with each other, putting them on the same plane." "Thus, we can say that augmented reality is a complementary system to the real world, adding virtual components, such as sounds, images and videos to real objects, enriching the user's experience with that environment and/or real object through technological tools, such as tablets and smartphones" KIRNER, 2011.

The Augmented Reality Cards focusing on the theme of Astronomy is a tool developed by the Laboratory of Computational Technologies of the Federal University of Santa Catarina, it allows the student to explore the cosmos in an interactive way. Each card has its own peculiarities to be explored, stimulating the curiosity of the user who, through a mobile device, will access three-dimensional images. With the cards it will be possible to immerse yourself in the visualization of the core of each planet, understand its particularities, observe the movement of the solar system, get to know space stations and unveil countless curiosities about the universe.

PARTICIPANTS

In all, 31 members participated in the experiment, divided into two groups. Class 1 composed of 10 elementary school teachers (mean age 39 years). Class 2 consisted of 21 students of the Physics Degree Course (average age 25 years, excluding one 61-year-old participant, who was not considered in the calculation).

While participants were familiar with digital technology in everyday life, many had no prior knowledge of augmented reality concepts nor knowledge of the differences between virtual reality, mixed reality, and augmented reality. Faced with this gap, we have made a brief explanation to introduce these concepts, followed by a practical demonstration of the application of the AR Card. All those involved in the study participated voluntarily with authorization for image use and research.

DATA COLLECTION

After the delivery of the Augmented Reality cards, a period of time was dedicated for the participants to experience and take advantage of all the possibilities offered by the material. In this process, the involvement of the participants was noticed, who made a point of recording their findings and showed considerable enthusiasm with the new tool. Even though they have a certain affinity with the proposed theme - astronomy - those involved highlighted the richness of the experience provided by Augmented Reality. A culminating moment of the R.A. workshop was the use of the *quiz* proposed on the cards, which by recommendation we asked to leave this activity for the end, after having explored all the material, at this point everyone was able to apply the knowledge in an interactive way. followed by the application of a brief questionnaire consisting of four questions using the Likert rating scale. In *Appendix 1* we will find the model of the questionnaire applied in both classes. This interactive element not only reinforces the concepts covered, but also enriches the engagement, allowing participants to test and broaden their understanding.

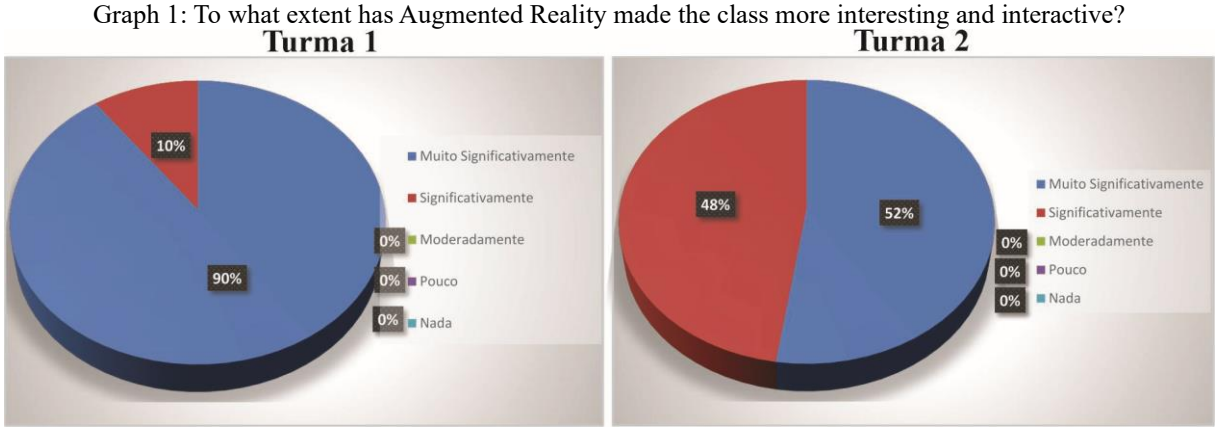
To obtain data about the experience, participants were asked to complete a questionnaire consisting of four questions, covering aspects of their experience with augmented reality. The questionnaire, based on the Likert rating scale, offered a valuable opportunity to capture nuances in participants' perceptions, thus enriching data collection.

For a better understanding of the methodological approach and the participants' responses, see *Appendix 1*, which includes the questionnaire model applied in both classes. This appendix provides a detailed overview of the issues that have guided the evaluation and reflection on Augmented Reality experiences in astronomy education.

ANALYSIS OF RESULTS

The analysis of the results was conducted in a segmented way by class, since we wanted to observe separately the perception of teachers and undergraduate students, the latter future teachers. The sequence presented below reveals graphs that highlight the percentage distribution of responses obtained for each question.

Graph 1: To what extent has Augmented Reality made the class more interesting and interactive?



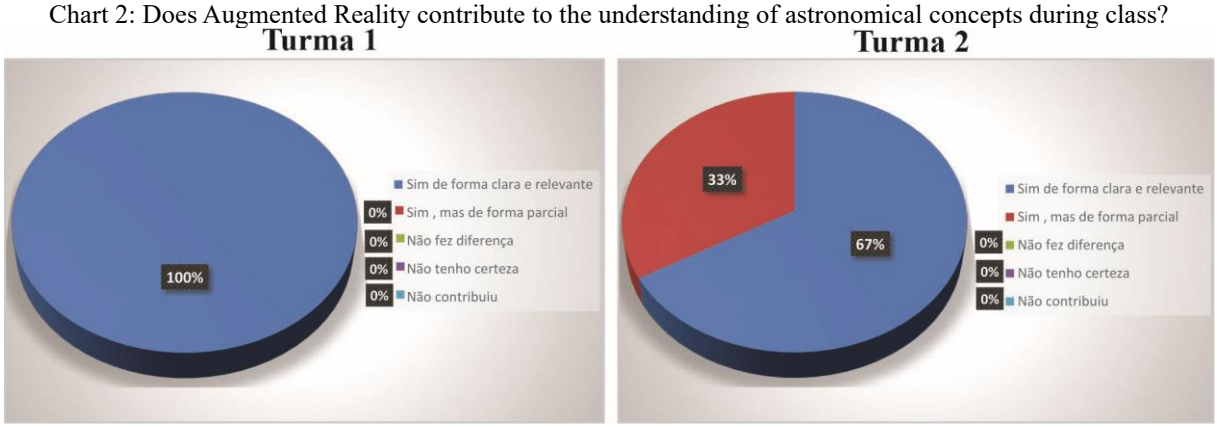
Graph 1 shows that in the first question, *Class 1* answered in its vast majority, that Augmented Reality gave the classes greater interest and interactivity *Very Significantly,* alternative *A* by 90% of the interviewees. However, in *Class 2*, this rate is 52%. Also in this question, 10% of *Class 1* say that the R.A. made the class more interesting and interactive *Significantly,* alternative *B,* while *Class 2* chose this answer in 48% of the cases. Alternatives *C* - Moderate, *D* - Little and *E* - Nothing were not selected in any of the classes.

The analysis of the results of this question revealed a remarkable difference in cognition between *Class 1*, formed by elementary school teachers, and *Class 2*, by undergraduate students in physics. *In Class 1*, the response was very positive, with 90% of the participants indicating alternative *A* that augmented reality brought a *Very Significant increase* in the interest and interactivity of the classes, indicating the capacity for strong receptivity to this innovative approach. In addition, the fact that 10% of *Tuma 1* participants chose alternative *B – significantly*, suggests that, even among them, augmented reality has a markedly positive effect, albeit perhaps in a reduced way.

In *Class 2*, where future teachers were present, the rate of 52% for alternative *A - Very Significant* showed that a smaller percentage of students noticed the same interest and interactivity than in *Class 1*. At the same time, 48% of responses to alternative *B-Significantly* indicated that a significant portion of group 2 also recognized the positive impact of augmented reality, albeit to a lesser extent, compared to group 1. The absence of responses to alternatives *C-Moderate, D-Little,*

and E-Nothing, in both classes suggests that most participants noticed improvement in classes through the use of augmented reality.

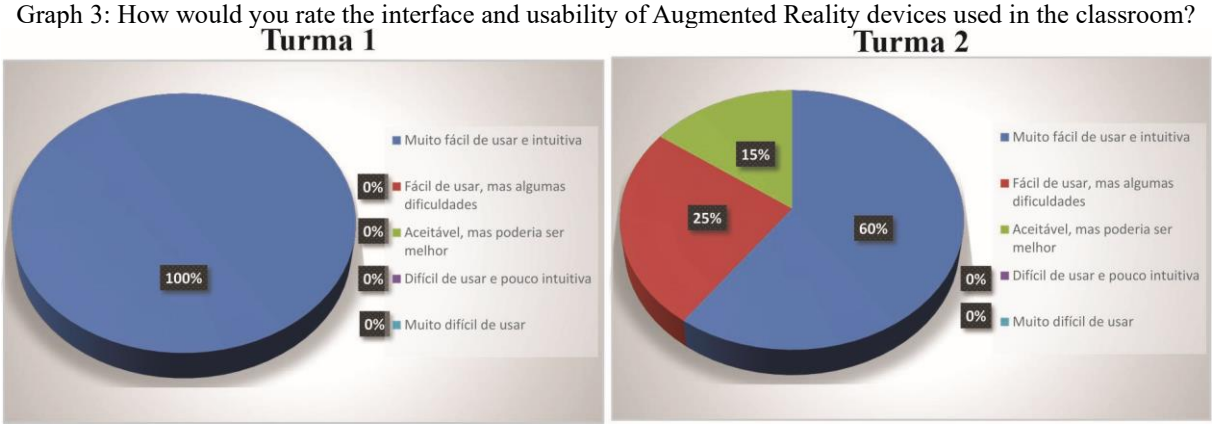
Chart 2: Does Augmented Reality contribute to the understanding of astronomical concepts during class?



In question number 2, where it is questioned whether Augmented Reality contributed to the understanding of astronomical concepts during class, we observe through Graph 2, that subtleties arise between the two classes involved. *Class 1* expressed great appreciation regarding the understanding of astronomical concepts, with 100% of the answers to alternative *A* - Yes, in a clear and relevant way. This suggests that the class understands that this technological tool has notorious efficacy in fostering a more effective and complete assimilation of the topics addressed. On the other hand, in *Class 2*, 67% of the participants also opted for alternative *A*, evaluating Augmented Reality as an aid in understanding the concepts. This response may represent the ability of these future teachers to recognize the positive impact of technology on the absorption of concepts, as they prepare to act as facilitators of learning. In the same question, 33% of *Class 2* chose alternative *B* - Yes, but partially. This choice may indicate that, despite acknowledging the contribution of Augmented Reality, some students identified limitations in its application, perhaps observing that the tool did not cover all particularities of the content. Alternatives *C*- Didn't make a difference, *D* - I'm not sure, and *E* - Didn't contribute, were not selected by any of the classes. This suggests that the general consensus is that Augmented Reality has indeed influenced the understanding of astronomical concepts, despite the differences in nuances of perception among participants.

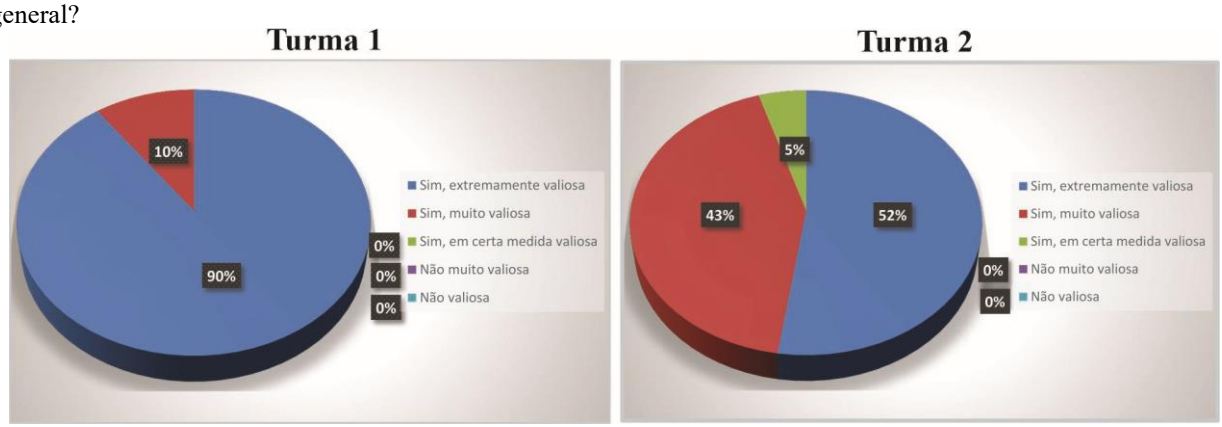
The difference between the responses of the two groups may be related to the different perspectives and experience levels of the participants. The fact that *Class 1* teachers consider the impact to be more apparent may be influenced by their teaching methods and their perception of students' needs.

Graph 3: How would you rate the interface and usability of Augmented Reality devices used in the classroom?



In the third question, we observed through Graph 3 that the teachers of *Class 1* opted 100% for alternative *A*, Classifying the interface and usability of Augmented Reality devices - Very easy to use and intuitive, demonstrating a high degree of satisfaction with the usability of the tool. This suggests that these participants felt comfortable with the technology, and that the educational institution where the experiment took place had an adequate technological infrastructure and effective internet connectivity. With the students of *Class 2*, we had 60% of the participants also choosing alternative *A,* demonstrating a relevant degree of accessibility and ease of use of the technology. In addition, 25% opted for alternative *B* - Easy to use, but with some difficulties, demonstrating that, despite having a mostly positive experience, some specific obstacles or challenges are encountered when using the device. We noticed that 15% of the students in *Class 2* chose alternative *C* - Acceptable, but it could be better. This response indicates the possibility of improvement, and that even if the perception has been positive, there is room for improvement. None of the participants chose alternative *D* - Difficult to use and unintuitive and the alternative *E* - Very difficult to use. Demonstrating that even when faced with specific challenges, none of the participants found the technology inherently difficult or inaccessible. The analysis of these results highlights the importance of preparing technology for the educational environment, as this is still the biggest limiting factor in the context of the adoption of new technological tools. In addition, it demonstrates that although most have positive experiences with the ability to use AR, the existence of varied responses suggests that continuous adjustments can be made to improve the user experience and integrate this technology into an educational context.

Chart 4: Based on your experience with Augmented Reality, do you consider the technology a valuable tool for teaching in general?



We can see in Graph 4 that *Class 1* considered AR technology to be a valuable tool for teaching in general. In this class, 90% of the teachers opted for alternative *A* - Yes, extremely valuable, denoting a consensus regarding the contribution of the AR in the teaching process. In addition, 10% of this same class considered alternative B-Yes to be very valuable, which emphasizes the positive perception of the tool.

In *Class 2*, a similar trend is evident, but with some nuances. Alternative *A* - Yes, extremely valuable, an option of 52% of students, reflects a strong acceptance of Augmented Reality as a pedagogical tool. In addition, 43% of the participants in *Class 2* chose alternative *B* - Yes, very valuable, significantly sharing the opinion that technology is beneficial for the learning process. However, 5% of the students chose alternative *C* - Yes, to some extent valuable, which suggests that the participants see potential in AR applied in the classroom, but also perceive limitations, which demonstrates that the technology can be improved. Options *D* - Not Very Valuable and Option *E* - Not Valuable was not selected by any participants. This shows in a consensual way that Augmented Reality is a technology of great value both in the opinion of teachers and future teachers.

The presence of some variation in responses may have been affected by previous levels of exposure to different technologies, individual expectations, and level of familiarity with innovative pedagogies. These results indicate that AR has the potential to enrich and enhance educational experiences, thus promoting greater engagement and understanding in the classroom.

DISCUSSIONS AND CONCLUSIONS

This research explored the perceptions and experiences of Elementary School teachers and Physics students about the use of Augmented Reality as a teaching tool in Astronomy. The results show many important things about how technology can help in education.

To begin with, it is notable that Augmented Reality has been well received by participants as a means of increasing interest and interactivity in astronomy classes. This finding indicates that technology can attract students' attention and improve the learning process by offering an innovative

and effective way to teach. The answers are mostly positive, and it proves that Augmented Reality can help and increase student engagement.

The results obtained with both classes, but especially with *Class 2*, show that an adequate technological infrastructure is necessary for a successful implementation of Augmented Reality in schools. Participants' emphasis on ease of use and ease of use of devices underscores that having an effective internet connection and high-quality devices are essential to optimizing the experience for students and teachers. It is noted that the perception of the effectiveness of Augmented Reality may vary according to the experience and needs of the participants, as demonstrated by the divergences in the answers between the classes. The Physics Degree students, while knowing that technology is useful for teaching, noted the details of the applications and possible improvements, despite the overall flexibility of the technology as a benefit to teaching. This indicates that teachers' knowledge of technology helps is extremely important for the success and applicability of the tool.

It is important to highlight that the class formed by teachers observed several forms of applicability of the material, not only in the classroom, but as a tool that can be taken home and explored with the family, applying individual or team work. They also raised the possibilities that R.A. can offer in various subjects and disciplines, such as mathematics, bilingual education, history, geography, animal world, in fact the perception is that there are no limits to the topics that can be addressed with the use of this technology.

This study provided useful information on how Augmented Reality can be used in education, particularly in astronomy education. Participants' perceptions show how Augmented Reality can increase student participation, interactivity, and understanding. The predominance of positive evaluations shows that technology can improve pedagogical strategies, even if there is variation in responses.

The reality that a technological infrastructure plays an important role in the effective use of Augmented Reality shows that investments in this area must be made to maximize the use of this educational tool, as this proves to be one of the barriers to be overcome. In addition, the variety of responses among classes indicates that technology training is important to enable more efficient and comprehensive integration into educational curricula.

Finally, we believe we have achieved the objective initially proposed, since in this study it was demonstrated that Augmented Reality has the potential to change the way of working in the classroom, as it can make learning more interactive, fun and effective. However, in order to successfully achieve this potential, it is necessary to consider not only the technology of the tool in question, but also the teacher's need and the technological infrastructure available. Teachers, technologists and educational managers must work together to create a favorable environment for the

use of Augmented Reality as an educational tool that can effectively contribute to the educational process.

THANKS

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APPENDIX 1:

FEDERAL UNIVERSITY OF SANTA CATARINA CAMPUS ARARANGUÁ GRADUATE PROGRAM IN INFORMATION AND COMMUNICATION TECHNOLOGIES

Age of the interviewee: _____

1. To what extent has Augmented Reality made the class more interesting and interactive?

a) Very significantly
b) Significantly
c) Moderately
d) Little
e) Nothing

2. Did Augmented Reality contribute to the understanding of astronomical concepts during class?

a) Yes, clearly and relevantly
b) Yes, but only partially
c) It made no difference
d) I'm not sure
e) Didn't contribute

3. How would you rate the interface and usability of Augmented Reality devices used in the classroom?

a) Very easy to use and intuitive
b) Easy to use, but some difficulties
c) Acceptable, but could be better
d) Difficult to use and unintuitive
e) Very difficult to use

4. Based on experience with augmented reality, do you consider the technology to be a valuable tool for teaching in general?

a) Yes, extremely valuable
b) Yes, very valuable
c) Yes, to some extent valuable
d) Not very valuable
e) Not valuable