

Seeing by proxy: a detailed analysis of an educational interaction at the telescope

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Astronomy education research is a growing field but the attention given to informal educational activities, such as telescope observations, museum visits or planetarium sessions, is still relatively scarce. In consequence, the area is poorly studied and understood. Addressing this gap, this present paper examines informal educational practices in an astronomical observatory through detailed analysis of a complete turn at the telescope by a small child, who is observing the Sun with the assistance of a guide. Using Ethnomethodology and Conversation Analysis this study investigates how this activity was produced in terms of structure and methods, the skills the participants have, and how the interaction between the visitor and the guide occurs. The study of these naturally occurring activities is done in-depth by the repeated inspection of video data, in order to identify the characteristics of the interaction, the organization of the talk and its implications as an educational event. The interactional nature of linguistic exchanges is highlighted; and the study of these activities reveals the practical methods used by guides and public. The present study contributes to our understanding of telescope observations as informal education activities; and shows the importance of research methods that are sensitive to naturally occurring events.

Keywords: Informal education, telescope observations, ethnomethodology, conversation analysis

1. Introduction

Astronomy education research is a growing field of inquiry [1], and studies have shown that it is mainly focused on specific astronomic content and conceptions of students at school and university levels [1, 2]. However, the informal¹ education of astronomy - the activities conducted in museums, science centres, observatories etc, with some structure and planning but also flexible, visitor-centred and collaborative [5] - is poorly studied [6, 7] and, in consequence, not widely understood. Specifically regarding activities involving the use of telescopes, such as star parties or observations of the Sun, the research is virtually non-existent [8].

With the exception of one study of families at star parties [8], and another of solar observations at an educational observatory [9], the only studies found involving telescopes and education are the ones using remote-telescopes, but not *in situ* manipulations [e.g. 7, 10, 11]. There are also studies concerning the construction of simple telescopes for the study of optics or teachers training [e.g. 12]; and the advising on which activities work or fail while conducting astronomical observations of the night sky with telescopes [13]. However, these studies do not explore data collected during actual observations. This comes as a surprise, as telescope observations constitute

a widely conducted outreach activity in astronomy education, in museums, science centres, observatories, and star parties. It is an activity with great potential to promote “compelling learning” as it involves multi-sensorial interaction (listening, seeing, touching) associated with “sharper focus and more memorable experiences” [14] (p. 203).

Moreover, researchers advocate the introduction of more observational activities to enhance learning of astronomy [12, 13, 15-17]. Even so, there is no knowledge about, for instance, how these activities are produced in terms of structure and methods, the skills guides have, or how interaction between the visitor and the guide occurs.

In the general field of informal education, attention starts to be given to guided visits and the work of the guides [18, 19] and it is acknowledged that their work is not simple as it involves a set of specific knowledge and skills [20]. Here also the research is scarce [18, 21, 22] “and specifically in the domain of science, limited attention has been paid to the role and practice of museum educators” [20] (p. 131). Some studies focus on the guides’ conceptions of learning, their beliefs and reflection on their work [e.g. 23]; on content and pedagogic strategies [e.g. 24]; the role of these professionals inside their informal education institutions [25]; or their ideas about visitors’ learning [26].

Some research also compares more or less structured guided interactions [27] or studies “how guides and their audiences produce spaces for showing and seeing” [28] (p. 2). Skills such as “communicating information, adapting

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¹ The term *informal education* is the most used in international literature [3], however, in Brazilian literature the term *non-formal* is preferred [3]. For a good review of these terms in Portuguese in relation to astronomy education, see [4]

to a specific audience, and maintaining a sense of humor” [29] or using questions to guide the interaction and generate conversation and changing intonation to keep the attention of the public [19] are referred as important. Also, methods for object presentation are proposed [30].

Nonetheless, there is still little research about the real practices, methods and interactions that produce a guided visit *in situ*, and virtually none, as already mentioned, concerning telescope-guided observations.

Therefore, we propose an ethnomethodological study [31], through the detailed analysis of a recorded real event of outreach activities at the telescope, aiming at contributing to this not widely studied scenario by revealing how it is produced, on a moment to moment basis. Our interest in this paper is to indicate and describe the (collaborative) work involved in an instructed observation at a telescope. The participants (guide and visitor) are involved in an activity to observe the Sun and its sunspots as part of an outreach program, which takes place at an astronomical observatory in Coimbra, Portugal. The main questions we pursue here are (i) how do the guide and visitor work in cooperation to successfully achieve the goals of the observation? and (ii) what are the methods and skills used by the guide to orient the visitor to see the phenomenon (sunspots) that was observable on that day?

This paper continues with a brief summary of our praxiological approach, followed by the methodology and the description of the setting and data collected. We then make a detailed analysis of the studied event and a discussion of the findings. We conclude with some potential contributions that this study can offer to the field of astronomy education.

2. A praxiological approach to educational telescope observations

In this paper we explore the ordinary ways in which a scientific observation is enacted and the mundane practices of doing a scientific observation with a child, who, as it will be possible to observe in our data, has little or no previous experience on how to manipulate a telescope. However, what do we gain in exploring the ordinary ways of teaching a young boy how to observe phenomena in the sky in an astronomical observatory?

The topic of scientific literacy is increasingly important, with studies suggesting that as much as half the knowledge in scientific fields is learned outside the school formal education settings, with science learning being a ‘lifelong’, ‘life-wide’ and ‘life-deep’ process [32]. Based on Garfinkel [31], the founding father of ethnomethodology, by describing and explicating how people produce scientific literacy, we are gaining access to the alternate and usually neglected legacy of the objective reality of science education. In other words, we are describing the taken-for-granted “things” that participants do in order to get ‘things’ done in a guided visit to an astronomical observatory. These ‘things’ are practical orientations or

ordinary methods that participants use to make sense of each other’s actions. These methods revealed during their work are accountable episodes of their very own practices, i.e. these are self-explicating; these *in situ* accounts are preserved, for analysis, in the recordings.

This is why a radical praxiological approach is necessary to identify the taken-for-granted, common details of the work produced by the participants involved in this activity. Otherwise, these details will go unnoticed, as they are in our everyday practices, and will not be retrievable as topics of inquiry in their own right. According to Garfinkel [31] (p. 104, parenthesis added):

“Almost four decades of Ethnomethodological investigations provide evidence that a domain of things escapes from accountability with the same methods of technical formal analytic reason that are used to describe them adequately and evidently. The domain of things that escape from FA (formal analysis) accountability is astronomically massive in size and range.”

This “astronomically massive domain of things” is what can be studied by a radical praxiological approach, which uses “retrievable data” [33] to study the missed domain of instructed actions. Among these topics, we have identified a particular one for this article, which is the strategy that the guide uses to orient a boy’s observation while he is at the telescope spotting the Sun. As the telescope has only one eyepiece the guide needs to know what the boy is looking at so that he can explain the phenomenon that should be highlighted during the boy’s turn at the telescope. Through a set of methods (question-answer (QA) sequences; displays of engagement, silences, etc.) the guide can make sense of what the boy is actually seeing and then can turn the boy’s observation to the phenomenon which was clearly visible on that day – the sunspots.

We call this move ‘seeing by proxy’, since the guide does not have direct access to what the boy is seeing, whereas the boy, who has direct access to the image of the Sun, does not have enough knowledge to orient his view towards the sunspots and make sense of what they mean. Therefore we will explore here a point of intense cooperation between participants, which will make visible the “dark matter” of instruction [34], that is, the description of the taken-for-granted interactional contexts produced by participants in educational settings that provide for and surround the instructional events that become a focus of analysis for educational research. ‘Seeing by proxy’ refers both to the equipmental enhancement provided to the human eye by the telescope, and crucially, to a defining characteristic of astronomy education, in terms of viewing astronomical objects as instructed actions.

3. Methodology

As mentioned above, this paper reports an ethnomethodological analysis of a boy’s turn at the telescope oriented

by a guide in an astronomical observatory. To do so, the observation at the telescope was video recorded. These data (video and audio) were analysed in detail and a transcription of the interaction, using a notation system developed by Gail Jefferson [35], was produced (see Table 1, for the transcript and its translation; see Appendix I for the notation system). The recording of naturally occurring events allows multiple visualizations and in-depth study of the interactions and its particularities [36]. Through close examination, it is possible to produce a detailed analysis of the sequentiality of the interaction, including the pauses, the silences, the gestures, the smiles and looks, the manipulation of the telescope and the situated content of that interaction, which, all together, produce the event in question. The ethnomethodological approach provides us with devices to bring the procedures of this educational activity (at its very details) to the explicit attention of the analyst [37]. By examining the turn-taking organization of talk we are able to make explicit what is currently tacit [38].

Therefore, ethnomethodology takes ‘cognitive’ or ‘perceptual’ activities (such as ‘seeing’) as interactionally organized practices rather than individual ‘perceptual’ or ‘mental processes’ [39]. This means that the effort to see phenomena in the sky does not depend on the guide or the child alone, but on a cooperative effort of both. It is through (and in) their conjoint actions that they will produce an observation at the telescope that indicates how teaching and learning are accomplished in practice, through an intense cooperation of the participants.

This intense cooperation will be explored in this paper, exhibiting not only the detailed description of the participants’ practices but also explicating such practices in a way that readers can have access to instances of educational practical work and adapt its locally produced particularities to their own distinct circumstances.

According to Goodwin [40] (p. 607), the advantage of using what are referred to above as retrievable data is being able to make “repeated, detailed examination of actual sequences of talk and bodied work practices in the settings where practitioners actually perform these

activities”. Such an approach to data and data analysis offers a practical view on the work of science educators, who can benefit from the demonstration of successful educational accomplishments.

4. The setting and the data

The data analysed in this article were recorded at the Geophysical and Astronomical Observatory of the University of Coimbra² (OGAUC), in Portugal.

The OGAUC is a centenary observatory and a prestigious scientific institution for the study of the Sun and has one of the largest and most complete collections of heliograms (pictures of the Sun), obtained daily for research purposes, since 1926. It is also a complete centre of informal education for organizing astronomical visits for the general public and schools. The Observatory complex includes a museum with astronomical instruments and artefacts, a planetarium, a dome with a telescope, used for observations of the Sun and the night sky, and a spectroheliograph (special equipment used to photograph the Sun) that can be visited. The guides who conduct the visits and activities are trained university students or professional astronomers who also work and do research in the observatory.

The data are comprised by a 2.02 minutes excerpt of the beginning of one visit to the astronomical dome with families and individual visitors. More specifically it is the turn of the first visitor at the telescope, a young boy, who (with the help of his mother and the guide) is ready to do the observation of the Sun through the telescope.

The dome is a circular building with a round ceiling. The ceiling rotates horizontally and has a window, which goes from the rotating base up to the top and can be opened. Inside the building there is a cylindrical platform in the middle where the telescope is positioned. The plat-

² <http://www.astro.mat.uc.pt/novo/observatorio/site/index2.html>. The permission to use the material analysed here was sought and the approval was issued by the mentioned institution. The official consent is available from authors.

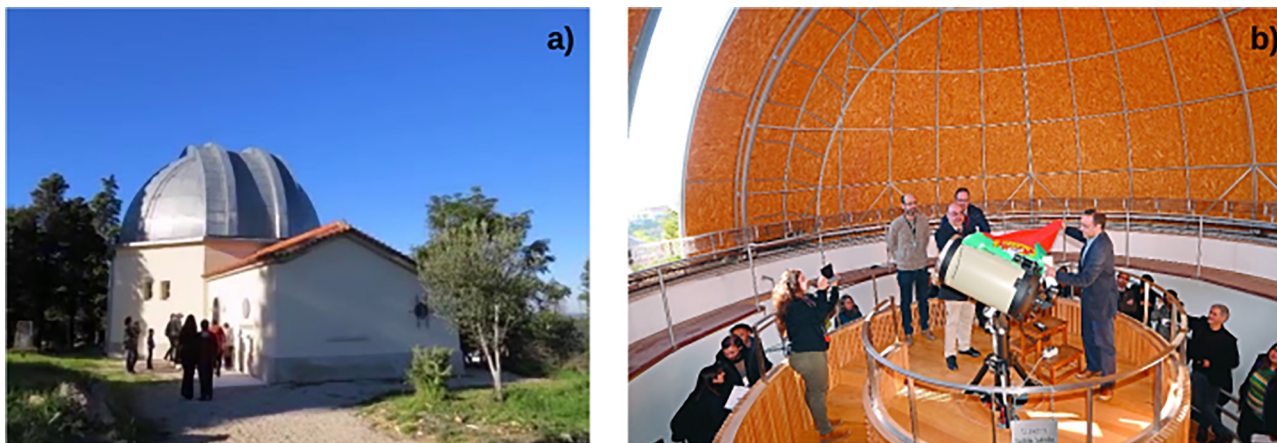


Figure 1: Astronomical dome: a) outside view; b) interior view. Credits: OGAUC

form can be accessed through a round staircase. These details can be seen in Figure 1.

Prior to the visitor's turn, the guide - a professional astronomer - set the telescope and the dome ready for the observation. While doing so, the public is already inside the dome, forming a queue and awaiting their turns along the stairs. When everything is set the guide starts calling visitors one by one to look through the telescope eyepiece and observe the Sun. If the visitor is a young child he or she can use a wooden step to reach the eyepiece with the help of an adult (in this case, the boy's mother).

When using this kind of telescope with a filter, the Sun will look like a yellowish disc. Depending on the day, it can also show some dark spots - the sunspots. That was the case of the observation recorded. The sunspots are not always present and they come and go within days. They represent a phenomenon ruled by the complex magnetic activity of the Sun, when parts of its surface are colder than the rest. Consequently, when observed, they look much darker than its surroundings. Sunspots are always a positive feature when doing science outreach since they add details to an otherwise simple yellow solar disc. The sunspots pattern that the visitors observed on this particular visit can be seen in Figure 2, which is a black and white image from the spectroheliograph recorded at the Observatory on that exact day of the observation.

5. Analysis: a turn at the telescope

In this section, we present a detailed analysis of the complete turn of a boy at the telescope, for observing the Sun. As mentioned before, it is a special turn because it is the first one of the day, serving not just to instruct the visitor doing the observation but also to demonstrate it to the others in line who are able to see and hear



Figure 2: Picture (photoheliogram) of the Sun on the day of the observation. Credits: OGAUC

the interaction between the guide and the visitor. Being the first one in line also means that the explanation is done for the first time. As such, this turn serves as a series of “explicative transactions” - an interactional event “in which what one does next will be seen as defining the importance or significance of what another did before” [41] (p. 228). The guide provides instructions and explanations for the boy but in doing so provides also instructions and explanations for overhearing visitors who are waiting for ‘their’ turn at the telescope.

First, we will be looking at the parts of the interaction as sequential constituents of a complete turn at the telescope. This allows us to look at its internal structure first and focus on its details later, when we highlight specific features of interest exhibited by the data.

Looking closely at this first turn, we propose that it can be divided into different sequential sections (see Table 1). It begins with an **initiation** (lines 1-3), an invitation to come and look through the telescope. Then we have the **setting up** (lines 4-16), that is, the instructions on seeing and positioning to see. After that, we have the seeing part, or the **getting to see** part (lines 17-38). This is followed by the **explaining the seeing** (lines 39-51), where the boy is still seeing, but now makes sense of the phenomenon in view. From line 52 to line 59 the guide and the visitor “engage” in the **stopping seeing part**, and finally the **closing** part, where the turn comes to an end (lines 60-65). From line 66 onwards the boy is already out of the bench and going away whilst the guide positions the telescope again for the next visitor.

We will now look closely at what is happening in each of these parts and explicate their boundaries. Of course, these are not tight and rigid. Consequently, these should not be viewed as discrete entities.

5.1. Initiation (lines 1-3)

The turn starts with an initiation sequence, done after the preparation of the dome and telescope for the observation (before the beginning of the transcription). With a gesture (line 1) and an invitation (“*would you like to be the first/ to come u:p?*” - lines 2 and 3) the guide calls the first person in line to approach. However, this invitation and gesture (see figure 3) are more than just marking the beginning of the boy's turn. Pointing to the bench and saying “*would you like to be the first to come up?*” turns out to be also the first instruction the guide gives the boy - to step on the bench. The position of the eyepiece is too high for the boy's height. Visitors in this situation should climb the bench in order to reach the eyepiece in a comfortable position to use the telescope. In our current case the instruction is also directed to the mother, who helps the child to climb the bench, and indirectly to the other visitors waiting in line for their turns.

Table 1: Transcript of the observation. A translation into English is provided in *italic*. We have added numbered ‘phases’ to the sequence of talk for ease of viewing. Captions: C = child; G = guide; M = mother

1. Initiation	1	G	((com um gesto G chama C, que está à frente da fila <i>((with a gesture G calls C, the first one in line esperando com a sua mãe))</i> querei ser o primeiro <i>with his mother)) would you like to be the first a subir:?</i> <i>to come u:p?</i>
	2		
	3		
2. Setting up	4		(1.5) ((enquanto posiciona o banco e C sobe ao banco. M ajuda-o a subir)) <i>(1.5) ((while positioning the bench and C climbs the bench. M helps him climb))</i> muito bem <i>very well</i>
	5	G	
	6		(0.5) (C termina de subir) <i>(0.5) (C finishes climbing)</i>
	7		agora pode spreitar= <i>now you can look through=</i>
	8		= eu vou pôr de lado <i>= i'm going to put it on the side</i>
	9		quando espreitares não agarres no tubi:nh <i>when you look through don't grab the small tu:be</i>
	10		porque senão treme mais, <i>because if so it will shake more</i>
	11		e quanto mais treme (0.5) menos a gente vê. <i>and the more it shakes (0.5) the less we see.</i>
	12	C	(acena afirmativamente com a cabeça) <i>(nods head)</i>
	13	G	°vou puxar isto mais um bocadinho (para aqui) <i>°i'm going to push this a bit more (to here)</i>
	14		pode segurar nele? <i>can you hold him?</i>
	15		(3.6)((barulho do banco a ser ajustado)) <i>(3.6)((noise of the bench being adjusted))</i>
	16		assim. <i>like this.</i>
3. Getting to see	17		(2.4) ((C começa a espreitar pela ocular)) <i>(2.4) ((C starts looking through the eyepiece))</i>
	18	M	()
	19	G	que vê:s:? <i>what do you se::e:?</i>
	20	G	()
	21	M	(riso) <i>(laugh)</i>
	22		(0.6)
	23	G	tas a ver a lua amarela?= <i>are you seeing the yellow moon?= =vou por um bocadinho mais (1.9) °xx =i'm going to put a little bit more (1.9) °xx</i>
	24		
	25		(2.6) (ajusta a ocular ao olho de C) <i>(2.6) (adjusts the eyepiece to the eye of C)</i>
	26	C	[sim <i>[yes</i>
	27	G	[tas a ver? <i>[are you seeing?</i>
	28		é uma bola amarela? <i>it is a yellow ball?</i>
	29	C	(0.5) sim <i>(0.5) yes</i>
	30	G	ou é vermelha? <i>or is it red?</i>
	31	C	(1.0) é amarela e um bocadinho vermelha <i>(1.0) it is yellow and a little red</i>
	32	G	ta bem. Entao é cor de laranja? <i>ok. so it is orange?</i>
33	C	sim <i>yes</i>	
34	G	ah e: tem- é toda amarelinha ou tem la eh manchas? <i>ah a:nd has- is it all yellowish or does it have eh spots?</i>	
35	C	Uau! tem umas manchas <i>wow! it has some spots</i>	
36	G	e de que cor é que são as manchas? <i>and of what colour are the spots?</i>	

	37	C	uhm pretas <i>uhm black</i> (2.0)
4. Explaining the seeing	39	G	acabaste de ver manchas solares. (0.9) <i>you just saw sunspots. (0.9.)</i>
	40		nem todos os dias o sol tem manchas. (0.8) <i>it's not every day the sun has spots (0.8)</i>
	41		hoje até tamos a ver muitas. <i>today we can even see many.</i>
	42		(1.9)
	43		e os- as manchas <i>and the- the spots</i>
	44		>o sol é quente ou frio?< <i>>is the sun hot or cold?<</i>
	45		(1.5) °o qué que achas? <i>(1.5) °what do you think?</i>
	46		(1.3) achas que o sol é quente ou frio <i>(1.3) do you think the sun is hot or cold</i>
	47	C	(0.6) quente ((para de espreitar enquanto responde)) <i>(0.6) hot ((stops looking while answering))</i>
	48	G	ah::, o sol é quente. <i>ah::, the sun is hot.</i>
	49		as manchinhas pretas são os sítios <i>the little black spots are the places</i>
50		onde o sol está mais frio (0.6) <i>where the sun is colder (0.6)</i>	
51		por isso é que ficam pretas <i>thats why they become black</i>	
5. Stopping seeing	52		(2.5)
	53		e agora tao a fugir de sitio né? <i>and now they are getting out of place right?</i>
	54		já na ves o sol todo, <i>you cannot see all the sun anymore,</i>
	55	C	(1.3) °não <i>(1.3) °no</i>
	56		(2.3)
	57	G	que ele vai andando <i>'cause he keeps moving</i>
	58	M	°ahn (1.3) super rápido então= <i>°ahn (1.3) super fast then=</i>
	59	G	=anda muito sim <i>=moves a lot yes</i>
60	C	(2.0) ((para de olhar pela ocular e olha para G, sorrindo)) <i>(2.0) ((stops looking through the lens and looks at G, smiling))</i>	
6. Closing	61		Ahn? (sorrindo para C) <i>Ahn? (smiling to C)</i>
	62		(.)
	63	M	pron:to= <i>ok::=</i>
	64	G	=pronto. <i>=ok.</i>
	65	M	vamos dei[xar outro menino ver ((ajudando C a descer do banco)) <i>lets le[t other boy see it ((helping C step down from the bench))</i>
7. Intermediate sequence	66	G	[vamos ca pôr o (.) sol mais no meio, <i>[lets put the (.) sun more in the middle</i>
	67		(2.7) ((olha pelo telescópio)) <i>(2.7) ((looks through the telescope))</i>
	68		Eh la <i>Eh la</i>
	69		(8.2) ((barulho do telescópio a ser ajustado. <i>(8.2) ((noise of the telescope being adjusted.</i>
70		C fala no fundo)) <i>C talks in the back))</i>	
8. Next turn	71	G	Ora, seguinte, fregês se faz favor ° <i>So, next, customer please</i>

5.2. Setting up (lines 4-16)

The setting up starts with the bench positioning at line 4 and ends at line 16. Some preparatory work needs to be done before the actual observation starts. This work has two distinct parts: there are instructions on seeing and positioning to see. From line 9 to 11 the guide instructs the child on how to deal with the telescope - “when you

look through don't grab the small tu:be /because if so it will shake more /and the more it shakes (0.5) the less we see” – basically, it is not to be touched. Line 7 is also an instruction on how to see – “now you can look through =” (the eyepiece). But this utterance has a double function. It is also related to the positioning of the boy, so that the guide can evaluate if the boy is ready to start. It turns out that he is not, and the bench



Figure 3: Frames of the inviting sequence.

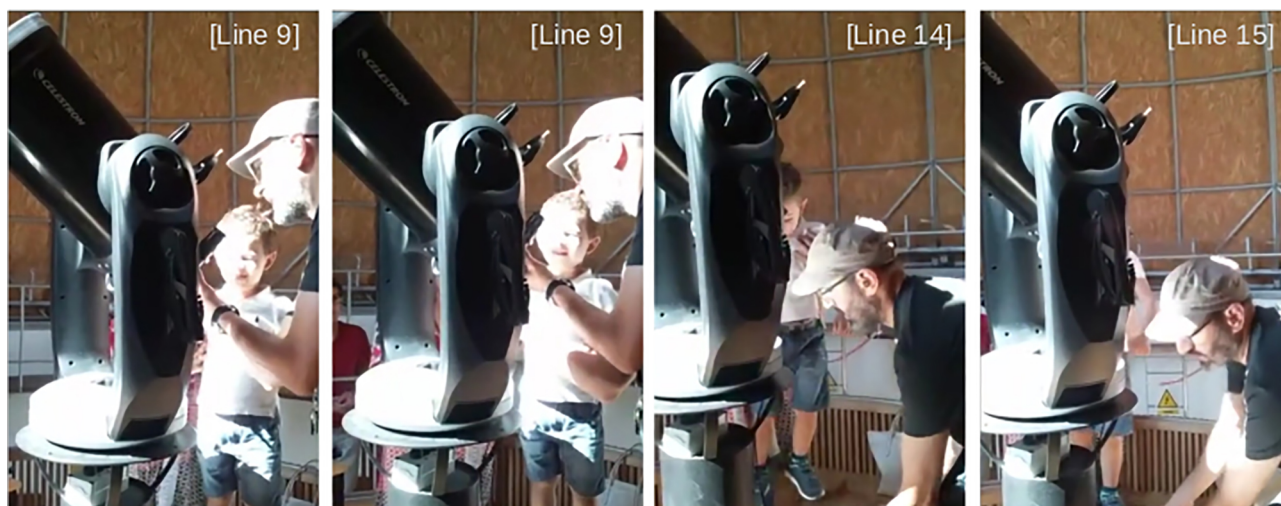


Figure 4: Frames from the sequence of positioning the eyepiece and then the bench.

needs to be moved again. The bench is then moved (see right frames of figure 4), the eyepiece is repositioned, and everything is apparently ready “like this” (line 16) to start the observation.

Looking at the instruction given from lines 9 to 12 more closely, the instruction (line 9) is to not touch the telescope, which he justifies (lines 10-11). Line 12 is the second part of the adjacency-pair ‘instruction–confirmation’, i.e. a confirmation of understanding of the instruction (a nod from the boy). What is of interest here is the changing of subject from the instruction to the justification - “when you look through don’t grab the small tube /because if so it will shake more /and the more it shakes (0.5) the less we see” (lines 9-11). The instruction is directed to the child, which serves as an “explicative transaction” [41], because as an instruction it is directed to the cohort of visitors. If the small tube (the eyepiece) is grabbed the telescope will shake and there will be a negative consequence (seeing less) - “the more it shakes (0.5) the less we see”(line 11). Who is addressed with

this “we”? “We” is an indexical (or contextual) reference; to whom is it referring? One potential inference is that “we” is the boy plus the guide, another one is that it is all the visitors together.

Therefore, the consequence of shaking the eyepiece does not affect only the child but also other people. This is even clearer if we take into consideration the other two features of the interaction: the short pause (0.5 seconds) before the delivery of the consequence (line 11) working as a boundary between two recipients; and the eye contact of the guide. The guide is adjusting the eyepiece while talking to the boy, looking at the telescope until line 10 (see left frames of figure 4) and changing his gaze to the boy while uttering line 11. This also allows him to seek confirmation of the instruction, which is delivered by the boy at line 12. This use of “we”, being more or less inclusive, also gives a sense of co-observation to the interaction: the boy will not be doing the observation alone. This will be further discussed in this article.

5.3. Getting to see (lines 17 to 38)

Finally, all seems ready and clear, and the observation can start. At line 17 the child starts looking through the eyepiece but only starts the observation at line 26. An activity like this one may require adjustments along the way. The guide understands that the boy cannot properly see the object and further adjusts the eyepiece until the “yes!” at line 26 is heard. Two things inform the guide about the non-seeing status. First, the silence to the questions at line 19: “*what do you see?*” and again at line 23: “*are you seeing the yellow moon?*”. Second, the body language of the child: between lines 17 and 25 the child is moving his head trying different positions and angles for looking inside the eyepiece (see left frames of figure 5).

These movements are subtle but clearly show to the guide that the child is still not seeing well, since the lens is positioned on a level that is too high for the height of the boy’s eyes. He then adjusts the equipment (line 25 - second frame from the left on figure 5) until the boy shows that he is seeing something by answering the question uttered at line 23. Looking closely at the two questions the guide asks the boy, we can see that he was also testing another hypothesis - that the boy was seeing but did not know how to describe it or what he was supposed to see. If that was the case, the silence to the open question “*what do you see?*” (line 19) was also justified; and the solution of asking another question with a “candidate answer” [42] - “*are you seeing the yellow moon?*” (line 23) also points to the same possibility. Moreover, this offering of a candidate answer is done almost simultaneously with the adjustment of the eyepiece. This leads us to conclude that the guide is testing different solutions at the same time.

The level of certitude of what the boy is actually seeing through the eyepiece increases with a series of prompts. The guide does not have direct access to what the child sees, because a limitation of the telescope is that it only

allows for viewing by one person at a time. We may say that he, the guide, views by proxy, but to do so he needs to find ways to gain access to what the child is seeing. He does that by questioning the boy (lines 19, 23, 27, 28, 30, 32, 34 and 36) whereby ‘getting to see’ is recognized by question-answer adjacency pairs [43]. However, the questions and answers are varied. Looking at lines 19 and 23, we can see that the open question (line 19 - “*what do you see::e:?*”) did not receive an answer so a different question was asked (line 23 - “*are you seeing the yellow moon?*”). This question gives a target to the boy and is asked in a very specific way, designed for that specific recipient. They are not seeing the moon but the Sun. However, astronomical concepts such as the shape of the Sun, Earth and Moon are connected and are influenced by observation [15, 44]. So, the boy is probably more familiar with the sight of a big round yellow moon in the night sky and this analogy might help. What is being said is something like “do you see a round yellow disc like the Moon?” or “what you are supposed to be seeing is similar in colour and shape to the Moon”.

The guide continues with simple analogies at line 28 “*yellow ball*”, and the boy answers again affirmatively. We can see that the question at line 28 is the first one after the adjustment period. Lines 26 and 27 (the boy saying “*yes*” and the guide asking “*are you seeing?*”) are almost simultaneous so the guide (and viewers of the recording of this interaction) can say that it is only now that the child is seeing something. The question formulation at line 28 shows exactly that - “*is it a yellow ball?*”. The indexical term “it” refers here to “that thing that you are seeing”. The boy promptly answers the question affirmatively. The guide keeps asking about the colour, giving the boy a different option at line 30 (“*or is it red?*”), because he needs to be sure what the boy is seeing. Answers such as “yes” or repetitions of what was said previously are claims, rather than displays of understanding [45-47], or in our case ‘displays of seeing’. As Jefferson [48] states, claims are recognizable features



Figure 5: Frames from the seeing through the eyepiece and adjusting sequence.

of “passive reciprocity”. What the guide is looking for is an “active” display to move forward. A claim is not enough. Similar to “understanding”, seeing is also “a practical achievement of participants through talk” [47] (p. 93). It is crucial for the guide to adjudicate successful observation that the viewer (in this case, the boy) does not just claim that he is seeing but that he displays that he is seeing. In the question-answer pair under analysis, knowing that the image of the Sun is yellow, the guide would be eventually expecting for a negative answer, but the boy pauses for a full second, observes and returns with a description - “*it is yellow and a little red*” (line 31) (see right frames of figure 5).

Seeking understanding to move on, the guide formulates what the child said offering a “candidate reading” [46] - “*ok. so it is orange*” (line 32). A formulation acts “producing a transformation or paraphrase of some prior utterance. Such paraphrases preserve relevant features of a prior utterance or utterances while also recasting them. They thus manifest three central properties: preservation, deletion and transformation” [46] (p. 129). As these authors in [46] also suggest, a formulation asks for a confirmation, disconfirmation or more generally a decision (p. 141), which the boy gives at line 33 (in this case a confirmation). At this point there is no doubt that the child is seeing the yellow disc of the Sun in his field of view. Together they arrived at that observation, together they are seeing the Sun - the boy directly and the guide by proxy.

The boy knows that the disc is yellow because the guide tells him so (lines 23, 28 and 34). For the boy the disc might look a little more orange, or he is just not yet very good at distinguishing colours. Yet the guide has enough elements to evaluate this exchange as a display of seeing/understanding. He then moves on. Since the big picture was identified, the guide calls the child’s attention to the details of the image, and points out that there are other things to be seen. He continues the QA sequence (lines 34 and 36). It allows him to redirect the look of the boy and at the same time investigate if the boy is really seeing what he was ‘supposed to see’.

The guide first asks if the image is all yellow, or if it has spots (line 34). The boy exclaims “*wow! it has some spots*” (line 35). This conclusion is not enough for the guide, who proceeds to ask about the colour of the spots. “*uhm black*” (line 37), says the boy, observing carefully. The question here is that the guide is not just trying to find out if the boy is seeing it, he is instructing him, guiding him to see the phenomenon, which makes the experience pedagogically meaningful. He “gives” him the spots and then asks him to look at them in detail and describe their characteristics, in line with what they have been doing previously with the colour of the solar disc.

This can also be considered a teaching-learning moment based on the way scientific observations and discoveries at the telescope look like and work - you look closely, you identify and you describe. As Lynch [49] states, “simple or common examples enable insight into

the complex and rare skills of the scientist, and their use suggests that scientific observation is a matter of learning to see things under specialized circumstances” (p. 90).

As discussed, the getting to see part of the interaction is an instructed action [31]. The technique the guide uses is progressively going from the disc to the spots, from the big to the detail. Interactionally, child and guide communicate, not looking at each other, not seeing the same thing, but progressing in the observation together. The child, attending the instructions and answering the questions, was able to see the Sun and the spots. The guide, giving instructions and asking questions, was able to lead the boy to see them and to be sure he was actually seeing what he was supposed to see. We highlight that instructions and questions, and also seeing and answers, were reflexively related and occur in quick succession. Instructions were given in the form of questions, that were also ways of gaining access to the boy’s view. Seeing meant successfully following the instructions and answering the questions. In other words, seeing was a display of understanding [50].

At the end of what we considered to be the ‘getting-to-see part’ the guide gives the child a moment to absorb and contemplate the content of the instructed seeing (line 38). This pause marks a transition. The seeing part gets done (although the observation continues). Now it is time to explain what had just been seen.

5.4. Explaining the seeing (lines 39-51)

The boy claims to have seen some spots, but he still needs someone to explain what they mean. This part of the event starts with the formulation “*you just saw sunspots*” (line 39) - a “formulation of upshot” [46] produced by the guide, commenting upon what the child saw. This device, more than summarizing and clarifying, marks that they arrived at a critical point, a point where the ‘product of their seeing’ was not enough to make sense of the observed phenomenon. More than that, seeing sunspots is special. The boy is told that the Sun has spots, that it is not every day that the Sun has spots (line 40) and that he is so lucky because today there are many of them (line 41). All this information is delivered slowly, with pauses in between, while the child continues to look through the eyepiece lens. The work of the guide is not just to show (to lead the boy to see) that the Sun has spots, but also explaining the special character of what is being seen.

The guide highlights the importance of the sunspots and transforms this observation into a memorable moment. By the boy’s display of enthusiasm at line 35 (“*wow! it has some spots*”) and his complete engagement when looking through the telescope, we can say that not much extra work is necessary to make this a special occasion. The boy observes the Sun for 1:17 minutes almost non-stop (from line 17 to 59 the child moves his eyes away from the lens only once, at line 47). However, when looking at the practical issues involved in the *in vivo* collaborative seeing of the guide and the boy, we will find that a lot of work was still necessary to account

for the locally and endogenously achieved completeness of their observation [31].

The boys' engagement in the activity of seeing through the telescope is visible in the next few utterances (from line 43 onwards). After a big pause (line 42) the guide is ready to start a new part of the explanation.

First, the guide seems to start that explanation at line 43 (“*and the- the spots*”) but rapidly changes his strategy. This looks like it is because the child is so ‘entertained’ with the equipment that he does not look at the guide when he starts his explanation. Instead of providing more information, the guide makes a quick question “*is the Sun hot or cold?*” (line 44). He waits, but gets no answer. He then gets closer to the boy and asks again, and again, and finally gets an answer. At this point (line 47) the boy withdraws from the telescope and answers the guides’ question very quickly (“*hot*”), immediately getting back to his business of looking at the Sun and sunspots through the telescope. The change of strategy proves to be a good way of capturing the child’s attention back. Once again, the guide made a good reading of the situation and reacted accordingly.

Questioning in this case seems to be a more interactive form of communication, and allows the guide to find out the level of knowledge of the child. The child obviously knows that the Sun is hot, answering with a tone that can be heard as “that is obvious and/or here is your answer and now leave me alone”. The guide, on his side, makes a long “*ahhh*” (line 48), like a “I finally got an answer”. He then repeats and summarizes it (formulates it) and finally explains what the sunspots are. He is very skilful with his pauses - at line 50 another one can be identified, separating the cause (see line 50) and the effect (see line 51) of the explanation.

Again, a big pause marks the end of the explanation (line 52). The sunspots have been seen and explained. It is time to conclude this activity and move on to the next visitor.

5.5. Stopping seeing (lines 52 to 60)

One last thing is taught - the image of the Sun moves and gets out of place due to the Earth’s rotation. As explained to another visitor later during this same visit, this telescope does not have a movement of compensation for Earth’s rotation and therefore, within about 2 minutes, the image of the Sun starts getting out of the eyepiece’s field of view. That is what is happening, and is commented upon during lines 53 and 59. The experience of the guide allows him to estimate that the image is probably starting to get out of sight (and may also mention this phenomenon as an excuse to bring the boy’s turn at the telescope to a close). In other words, the guide is opening up a closing [43], since the topic of the talk (the sunspots) is being replaced by another one (the displacement of the image). There is a long pause of 2.5 seconds (line 52) that depicts this shift of topic.

The guide then continues to ask questions to gain access to what the boy is seeing (line 53 and 54), to see

if it matches what the guide predicts is happening - the image of the Sun is going out of view. Before any answer from the child, the guide starts moving the telescope using the remote control, without being able to see the consequences of his actions. Is he trying to correct the displacement or to make it bigger? The boy eventually claims that he is not seeing the full image of the Sun anymore, but even so he still waits 5 seconds to move his eyes away from the eyepiece. It seems that the boy cannot get enough of it. However, the movements and the displacement had that dissuasive effect, making the boy stop his ‘seeing’. The displacement of the image is big, as it is possible to infer by the “*eh lá*” interjection made by the guide at line 68 (this interjection is used in Portuguese to show surprise when something sounds exaggerated) and the long adjustments that the guide has to make later, when he regains access to the equipment (line 69).

The boy is not looking through the telescope anymore. The turn is almost brought to an end.

5.6. Closing (lines 61 to 65)

The child is not looking through the telescope anymore and briefly looks at the guide, smiling, waiting for guidance. The ‘nextness’ that the boy’s action triggers is very clear: someone needs to end his turn at the telescope for him. The guide and the mother do it together. First the guide, at line 61 looks at the boy and gives him a big smile at the same time of a “*ahnn?*” (see left frame of figure 6). This utterance can be considered a pre-closing clause [43]. The interjection and the smile directly looking at the boy, who is also smiling, has the value of wrapping up, of asking for an evaluation, such as saying “it is something ahnn?”. The guide does not ask him if the experience at the telescope was worth it, he knows it was (by the boy’s reactions). Instead he shows him a shared enthusiasm, the evaluation of the experience that he has inferred from the child attitude so far. The evaluation signs the ending of the activity.

The mother picks on that and intervenes (line 63) using an expression in Portuguese: “*pronto*”, which means “done”. The guide repeats it at line 64 reinforcing the conclusion of the activity and the mother finally helps the boy step down from the bench at line 65 (see second frame from the left of figure 6). By saying “*let’s let the other boy see it*” (line 65), the mother is justifying the need to stop the observation. It is a well-known ‘parent’s excuse’ to get a child to stop doing something as it has a normative value in it. In effect it is saying “other people are waiting in line to see, let’s not keep them waiting longer”.

This move helps the boy follow his mother’s claim, by putting himself in the position of the person waiting for him to finish. All this happens quickly, in about 3 seconds, and is produced jointly by the mother and the guide, following this sequential order: evaluation (line 61)-completion (line 63)-reinforcement (line 64)-justifying ending (line 65)-moving out (line 65).

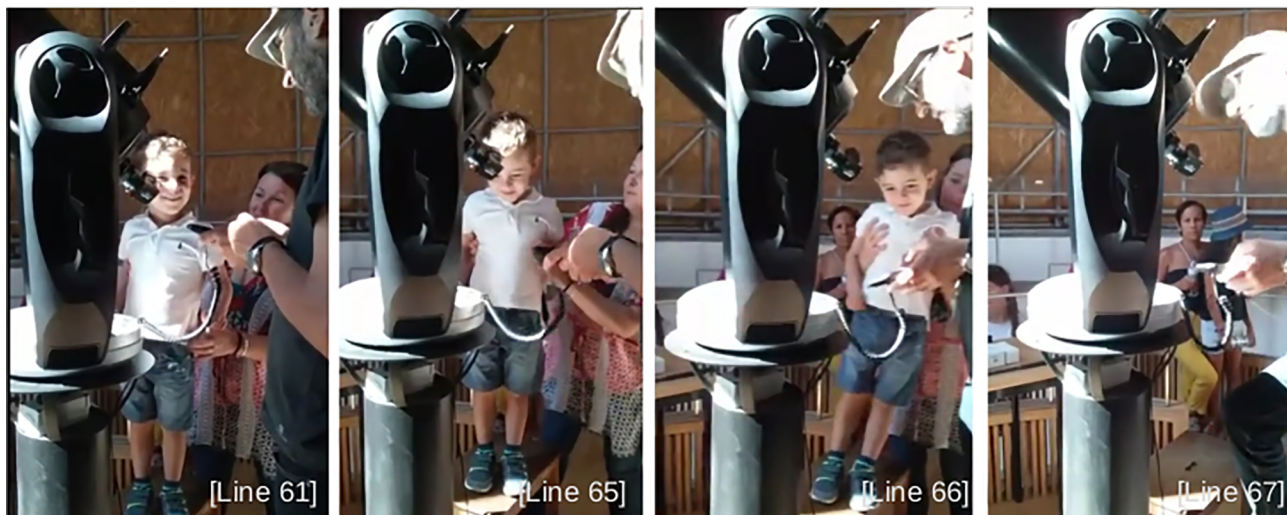


Figure 6: Frames from the sequence of coming down and starting the telescope adjustment.

With this first turn finished, it is time to adjust the position of the telescope again (see right frames of figure 6) and invite another visitor. That is done from line 66 to 71 during what we called the **intermediate sequence** (lines 66-70) and the beginning of the **next turn** (line 71).

6. Discussion

6.1. Mediation, asymmetries and seeing by proxy

Expertise and non-expertise are core issues in instructional and educational environments such as the one studied here. Both phenomena are visible in numerous accounts, but more than that, the fundamental pair expertise–non-expertise holds asymmetries in knowledge and asymmetries in perception [51], that educational events such as this seek to reduce. Therefore, exploring how such knowledge imbalances are made visible, how expertise and non-expertise are displayed, is crucial to understanding learning and instruction in informal educational activities.

Nonetheless, the observation at the telescope reveals not just a one-way asymmetry of knowledge but two, making it very particular. On one side we have the guide with the knowledge about the institution, the telescope manipulation and the astronomy phenomena. On the other we have the visitor, who has the knowledge of what he is seeing, in other words, the “ownership of his experience” [52]. Being equipmentally mediated by a telescope, this interaction has the particularity of not allowing the guide to see what the visitor is seeing because it is physically impossible to have two persons looking through the same eyepiece at the same time. So there is a double asymmetry of knowledge and of points of view that are fundamental to shape the interaction at the telescope.

The guide, in order to make this observation happen needs to gain access to what the boy is seeing, and the boy needs to provide enough information so that the instructional order can happen, so that he can be guided. The guide is doing what we call “seeing by proxy” and to do so he uses a set of methods: (i) the guide ‘reads’ the boy’s body movements and long pauses between question and answer sequences. At line 25, for example, the guide adjusts the eyepiece, acknowledging that the boy was not seeing anything. He adjusts it until the child finally says “yes” (line 26), claiming that he is now seeing; (ii) the guide asks sets of questions. A closer look at the questions asked by the guide shows that these produce two different things: on one hand, they are an assessment of the boy’s observation, which allows the guide to continue the instructional seeing. On the other hand, these questions are also produced to inform the guide’s indirect seeing. They instruct the boy’s actual seeing and inform the guide’s “seeing by proxy”.

That is related to what Goodwin [40] calls “professional vision”. The objective is to see the sunspots against the background (the Sun) and the spots as sunspots, as seen by a member of a particular professional community who can identify them. They are not spots on the lens, they are not clouds, but specific features of the Sun: phenomena on its surface with certain characteristics. The guide, as a member of the astronomy community, sees that when he looks through the eyepiece. The boy does not have access to the same expertise, and needs to be told what he is looking at.

6.2. Educational and instructional methods

Imbued in the production of this interaction is its instructional and educational nature.

First there is the instruction on how to use a telescope and the teaching about its functioning. It starts right before the turn studied here, with the demonstration of how to align and point the telescope to the Sun with

all its particular details, and continues throughout the interaction (e.g. lines 7, 9-11). We can say in a simple way that the main educational objective of this interaction was to show the Sun and its spots and describe their characteristics briefly. This involved teaching the boy to observe and not just to see; what Eriksson et al. [53] call to have discernment - “coming to know what to focus on and how to appropriately interpret it for a given context” (p. 168). We can also say that the instructional objective was to lead the visitor to look through the telescope properly and see the Sun disc and the visible sunspots. To achieve this, the guide needed to work in cooperation with the visitor, guide his observation (instruct the seeing), and clarifying or “seeing” what the visitor was actually seeing (seeing by proxy) by gaining indirect access to the visitor’s point of view. All of these accomplishments are co-produced by the participants in the event.

From an educational point of view, the way the guiding occurs, from its initiation until its close, seems to have reached its objectives and leave a satisfied and smiling “client”. Also, looking at the nature of the event, we cannot forget its continuation, its insertion into a bigger event - the observation of the whole group. While directed to the boy, the guide knows that the rest of the group is listening and learning. This can be seen by the absence of instructions given for the rest of the visitors waiting in line. This careful and detail guiding does not happen again, since it works as an “explicative transaction” [41] for the other visitors who are waiting in line.

Taking into consideration that broader audience, the guide could have used this opportunity to talk about the relative size of the sunspots (many sunspots are as big as the Earth) as it is done in the activities studied elsewhere [9, 54]. The guide, throughout the observations of the other visitors that come after the child’s turn described here, talks about the sunspots’ characteristics and origin, and in general about the activity of the Sun, but he doesn’t mention the size of the spots. The moment when the child sees them for the first time, being also the moment the group “sees it” for the first time, would be a good opportunity to bring it up. As mentioned before, while providing explanations to the boy, the guide is also providing these to the other visitors who are listening to the interaction while waiting in line. Size and distance scales in astronomy are crucial ideas to be communicated and taught [54]. The boy at the telescope was too young to understand these - research suggests that, at best, only in primary school but most likely around 12-14 years old, concepts of relative size and distance begin to be grasped [54], but giving that information to the rest of the visitors while talking to the boy would provide the rest of the group with another dimension of the phenomenon when seeing the sunspots with the telescope - a feeling of the size of the spots, a feeling of the size of the Sun.

Focusing on the educational and instructional methods used by the guide, we were able to identify a number of diverse features and devices present in the conversation.

First of all, we highlight the **pauses**. They have an important role in shaping the structure of the interaction. These devices are mainly of four different types: i) the long pauses between the main parts of the interaction (lines 4, 17, 38, 52, 60). These pauses seem to mark the changing of what is being done in the interaction, signalling that and helping in the transition; ii) the waiting pauses. These are pauses used to wait for the viewing to occur or to check if it is occurring (e.g. lines 17, 22, 26). These seem fundamental to allow time for the observation to happen and have feedback; iii) the pauses during the explanations. These pauses split the explanations into different sections; again, organizing what is being communicated and highlighting its different parts (e.g. lines 11, 39 – 41, 50 - 51) or giving time for explanations to align with contemporaneous observations (e.g. lines 42, 52, 56); iv) the pauses after questions, allowing time to answer. The guide skilfully uses pauses with that purpose (e.g. lines 22, 29, 45, 46, 55).

These different pauses are used with precision. As seen, a close analysis shows they are not randomly placed. They are devices used as part of a method to achieve something. We further note that some of the pauses have multiple purposes.

Another instructional method used is the **question-answer** pair. This is a well-known method used in guided visits and present in guide-training literature [30]. Questions are ways to gain access to information and the interaction builds and progresses around that update of information. Camhi [30] lists this as one of the methods observed in guided visits interactions and highlights that “there are many categories of questions, each with its own underlying educational or communicative rationale” (p. 283). In this case we identified two types of questions: i) questions to gain access to the seeing (e.g. lines 19, 27, 28, 34, 36, 53). These can be open, or questions with candidate answers. The guide chooses the preferred question type in a moment-to-moment basis, depending on the feedback from the boy, as discussed earlier in this paper. ii) questions to gain access to previous knowledge (e.g. lines 44-46). As seen before, question-answer devices make the production of the event more interactive between guide and child. They also adapt ensuing instruction to the specific recipient, being produced based on the knowledge of the boy and on what he is experiencing.

The third instructional method identified is **formulation**. Formulations are used here to gain access to the understanding (e.g. line 32) and to display understanding (e.g. line 31). That is important for the instructional and educational sequence of this event. Understanding needs to be achieved to move forward effectively. Formulations are also used to teach, as a way of making sense of what is being seen, like in line 39 - “you just saw sunspots”.

A fourth instructional method is related to the two previous methods - the **search for displays of understanding**. The pursuit of displays of understanding (and seeing) is crucial for the objectives of showing the Sun and the sunspot to the visitor. This – seeing by proxy –

involves knowing the phenomenon that is sought, knowing the contingencies of the Earth's rotation and how it affects the observation, and knowing how the equipment operates, in detail.

Analogies and non-scientific language [16], which can be seen as methods for designing recipient design mechanisms, are also methods used throughout the interaction captured here as data. Examples of this occur at line 9 “*don't grab the small tu:be*”, referring to the eyepiece; at line 23 “*are you seeing the yellow moon?*”, and at line 28 “*it is a yellow ball?*”, referring to the Sun; and at line 34 “*does it have eh spots?*” referring to the sunspots.

Another instructional method used in this interaction is the **progressive focusing** of the observation. The guide goes from showing the big picture first (the Sun disk) to end with the details (the sunspots). Finally, the specific **structure** of the whole interaction. Step by step the guide shows, makes ‘discoveries’ with the boy, and then explains. He does so guiding the boy, also allowing him space and time to learn and do it by himself, in the discovery of where to look, how to position the body to see, what to look for, how to describe it, how to look for details, contemplate, and learn what was discovered. This course of action conducts the child into a self-discovery, making the experience more meaningful for the visitor.

6.3. Skills and display of expertise

In this paper we do not assume this guide's expertise based upon his occupational role. The guide exhibits expertise in the use of the telescope and astronomical observation throughout the visit. Prior to the guide's interaction with the first visitor, the group is already in the dome, forming a line and watching the guide prepare all the equipment to the observation of the Sun. That is the first exhibition of expertise. He then continues giving instructions to the boy, first to stand forward and step on the bench, second to look through the eyepiece but not touching it with his hands. He carries on further adjusting the eyepiece to the eye of the visitor. He does that even without a direct request from the boy or complain that he is not seeing well. He seems to understand it by simply evaluating the boy's reaction and the position of the eyepiece in relation to the boy's eye.

Providing information about the instruments or the observation of the Sun and sunspots are other explicit situated accounts of expertise. For example, at lines 49-51, explaining what the sunspots are, or line 59, stating that the Sun moves very fast. At line 53 there is another exchange showing knowledge being applied. Saying “*and now they are getting out of place right?*” the guide displays his knowledge of the functioning of this particular telescope, knowing that without a motor compensating for the movement of the Earth's rotation, at that point the image is starting to “run away”.

Furthermore, the guide mobilizes a set of skills, exhibited in and by his actions and interactions in this educational event. Looking at the literature concerning the skills of educators in museums, Tran and King [20]

propose a group of six components – “context, choice and motivation, objects, content, theories of learning, and talk” (p. 138). Also, Barros, Langhi, and Marandino [19] highlight the importance of generating conversation to understand the level of knowledge of the public, the use of questions in conducting the interaction, and the flexibility to adapt the topic to different public as skills of the guides. Our praxiological analysis reveals how such skills are constituted “in its circumstantial detail” [55], i.e. the concretization of formal-analytic notions that rely on unexplicated, common sense practices, describing them in their specifics, and accounting for them as *in situ*, *in vivo* work. Praxiological analysis “respecifies” components derived from formal-analytic instruments such as surveys and desk reviews, demonstrating what “professionalism” and “expertise” actually involve and thus provides for more sensitive discernment of the skills of astronomy education as its lived work. Some of these skills identified include being able to:

- “read” the body language of the visitors, for instance to understand the right position to look through the eyepiece. That implies the expertise of knowing how to observe and the functioning of the telescope;
- describe the characteristics of the image displayed or ask for descriptions of it. That implies knowing the characteristics of the objects observed;
- describe the functioning of the telescope and the actions required to prepare it for the observation;
- use “adequate language”, or to “recipient-design” [56] descriptions for the specific cohort of visitors, which will be different with each tour;
- wait, to give visitors time to observe, and to give them time to answer questions;
- guide the observation up to a point where it is possible to have a sense of discovery (this requires withholding some of the answers and, through using guided QA sequences and instructions, carry the visitor through the observation);
- give simple and appropriate explanations while the visitor is looking through the telescope.

7. Final remarks

As a participant of this educational and outreach event, this boy was fortunate to have been at the head of the queue to look through the eyepiece of the telescope. He was gently guided in a discovery of the same phenomenon - the sunspots - that Galileo saw in the beginning of the seventeenth century³. This kind of informal educational setting, with a real telescope, allowing a real astronomic observation to get done, has the “ability to create memorable, meaningful, and highly contextualized experiences” which “facilitate learning” [14] (p. 177).

However, as seen, producing a telescope observation of the Sun is complex business. On the visitors' side it

³ For a summary of the early history of sunspot observation, see: <http://galileo.rice.edu/sci/observations/sunspots.html>

involved the right positioning and manipulation of the telescope, looking properly through the eyepiece, seeing the yellow disc, identifying some spots on the yellow disc, learning that the yellow disc is the Sun, learning that the spots are actually on the Sun and are sunspots. Doing all this in less than two minutes, before the image is out of view due to the rotation of the Earth.

For many people the encounter with a telescope in informal educational settings is a first-time experience. Looking through the eyepiece is intuitively available, yet how to look properly and see, how to position the eye, how to adjust, what to expect to see, is learned at the moment of the observation, with the help of the guide. As Meyer et al. [29] state, being a good guide is not just mastering the content of the observation, but also requires "the skills to convey the content in an accessible and engaging manner" (p. 55). Studies suggest [20] that informal educators are paying attention to the visitor's particularities and thus adapting these particularities to their specific needs and interests. The single-case analysis we provide in this paper confirms these findings, but it does so in concrete detail. The guide is a professional astronomer and he is also an expert in communicating and understanding a visitor's level of knowledge. Through seeing by proxy, the reflexive relation of observation and lines of questions, the guide ascertains what needs to be said in order to take the visitor through the observation, to help the visitor address the eyepiece correctly, to guide the visitor's seeing the phenomenon observable on that day, and explain to the visitor what is being seen, and its significance. We suggest that this seeing by proxy aspect of guided observations at the telescope is a central characteristic of informal astronomy education events, which must be taken into account while studying or preparing telescope observations.

An ethnomethodological look at these activities reveals an array of practices that constitute activities, which are mostly taken-for-granted and would go unnoticed [57] if we do not analyse a single turn at the telescope within an astronomy education event in its details. The detailed study of this turn at the telescope highlights its mechanisms, parts, cooperative work, methods, skills and expertise mobilized to make astronomy education happen. In our view this is fundamental to understand this activity and should be the starting point to study it. In consonance with Zemel and Koschmann [58], studying real events, real observations and guide-public interactions "allows for the analytical inspection of how instructed experiences are accomplished" (p. 165). We suggest the results presented and discussed here contribute to the study of astronomy educational activities at the telescope. The identification of the characteristics of the interaction at the telescope - the asymmetries of knowledge, methods and how it happens in practice - help us get a better understanding of this enterprise.

Moreover, both skills and accounts of expertise can be used as guidelines for evaluating the activities and the work of guides. Together with the structure and methods

identified, these skills and accounts can also be useful in the design of training programmes of those guides and in the planning of activities, including supporting materials and instruments such as written instructions and audio guides.

Future research should focus on how to better understand these informal educational activities - in particular the skills of the guides and the *in situ* practices of both guides and visitors while producing an astronomical observation. Our praxiological approach takes every event as unique, as "another first time" [57] (p. 9), but reveals the massive presence of ordinary, bespoke practices that the participants use to accomplish it, allowing us to learn from them and describe the area.

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9. Supplementary material

The following online material is available for this article:
Appendix I - Transcription convention.

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